Proceedings of

CONASTA 56 and ICASE 2007
World Conference on Science and Technology Education

Sustainable, Responsible, Global

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The Sheraton Hotel and Mercedes College, Perth, Western Australia

Editors
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I Foreword

The World Conference on Science and Technology Education is the result of an international collaboration between several partner organisations including:

- The International Council of Associations of Science Education (ICASE);
- The Australian Science Teachers' Association (ASTA).
- The Science Teachers' Association of Western Australia (STAWA); and
- United Nations Educational, Scientific and Cultural Organisation (UNESCO)

Individuals and smaller associations of science teachers, laboratory technicians, science education advisors and officers and science education researchers have contributed in a range of ways. The collaboration of these organisations and individuals has resulted in the combination of several major conferences including:

- ICASE 2007 (Conference of the International Council of Associations for Science Education)
- CONASTA 56 (Conference of the Australian Science Teachers' Association)
- CONSTAWA (Conference of the Science Teachers' Association of Western Australia)
- PRISSEM (Conference for Primary Science Teachers' of Western Australia).

The International Council of Associations of Science Education (ICASE) is the world body coordinating the World Conference and providing international links and networks. It is a totally voluntary organisation that produces a quarterly refereed journal and a regular primary science publication, as well as conducting professional development and seminars with associated members in all parts of the world. ICASE was established in 1973 to extend and improve science education for children and young people throughout the world. Today, ICASE is a huge network of science education associations, institutions, foundations and companies, facilitating communication and cooperation at the regional and international level.

ASTA is a federation of the eight Australian state and territory Science Teachers' Associations and is the national professional association for teachers of science. ASTA is a powerful voice to influence policy and practice in science education in Australia. It is administered by a National Secretariat in Canberra and governed by a representative Federal Council. ASTA was a foundation member of the International Council of Associations for Science Education (ICASE) in 1973 and has been an active member ever since.

STAWA is an incorporated not-for-profit Association founded in Western Australia in1953, which presently represents more than 750 teachers of science, principally at the primary and secondary education levels. STAWA has an excellent tradition of involvement in the science education community and is skilled in matters relating to science teacher training and professional development, research in science education, school administration, and curriculum initiatives for primary and secondary science students.

UNESCO composes an Education Sector and a Natural Sciences Sector. UNESCO is the United Nations' specialized agency for education, believing that education is key to social and economic development. UNESCO works for a sustainable world with just societies that value knowledge, promote a culture of peace, celebrate diversity and defend human rights, achieved by providing education for all. The mission of the UNESCO Education Sector is to provide international leadership for creating learning societies with educational opportunities for all populations, and to provide expertise and foster partnerships to strengthen national educational leadership and the capacity of countries to offer quality education for all. The Natural Sciences Sector covers a broad range of science-related activities and programmes, ranging from basic sciences to science policy and sustainable development related issues. The Sector's programmes include those of the Intergovernmental Commission (IOC), the International Hydrological Programme (IHP), the International Geoscience Programme (IGCP), the Man and the Biosphere (MAB) Programme and the newly created International Basic Sciences Programme (IBSP). The mission of the Sector is to further the advancement and sharing of scientific knowledge and to promote the application of this knowledge and its understanding to the pursuit of sustainable development.

The conference themes include:

- Education for Sustainable Development (as part of the UNESCO World Decade of Education for Sustainable Development 2005-2015);
- World Health (including AIDS, malaria, other diseases and health challenges such as clean water);
- Science for Life and Citizenship; and
- The Way Forward (Educational directions and priorities established by ICASE)

The conference brings together of over 1000 participants world-wide, notably policy makers, teacher educators and, very importantly, teachers themselves to jointly consider the latest research, curriculum development and practical activities for science and technology education The proceedings of the World Conference in Science and Technology Education 2007 presents full papers and/or abstracts provided by some of the keynote and invited speakers. The proceedings also presents a collection of over 70 science and technology education research synopses from delegates from a total of 19 countries that were accepted for presentation through a review process.

The synopses included in this proceedings were blind reviewed by two independent reviewers. The criteria for review included the 1. objectives, 2. theoretical or conceptual framework, 3. research design and procedure; and 4. findings and the significance of the research. A total of 142 synopses were reviewed and 78 were accepted by the editorial committee for puplication in this proceedings. Some synopses were withdrawn by authors due to an inability to attend the conference.

The responsibility of editing the content and language was primarily with the authors and only minor format editing has been made to the accepted synopses presented in the proceedings.

We hope you enjoy the conference and that the proceedings is a suitable record of the many excellent research papers presented.

Editors
Grady Venville (University of Western Australia)
Vaille Dawson (Edith Cowan University)

Referencing

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Robin Groves
Elaine Horne

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V Message from the Conference Convenors

A very warm welcome to the 2007 World Conference on Science and Technology Education. We hope this will be a major professional highlight for many of us and are very excited about the developing and growing nature of the Conference. Many wonderful people have interacted in the process.

In 2004 STAWA, supported by ASTA, put in a successful proposal to ICASE. Since then we have been very proud to be convenors of the World Conference on Science and Technology Education, which is also CONASTA 56 and ICASE2007. Building links between local, national and international people and organisations should be a major benefit.

The Conference is the culmination of nearly three years of organisation, interactions and correspondence. Many thanks to all the people, partners and sponsors involved, especially the loyal and hard-working Perth Management Committee and the Government of Western Australia, without whom the Conference would not have been able to proceed.

We decided early on that this World Conference could have goals in addition to providing exceptional input in the form of speakers, papers, seminars, workshops and social functions.

First, it is a goal to promote and lead the thinking regarding science in schools as part of the UN Decade on Education for Sustainable Development.
Another goal is for science in schools to consider the local environment and conditions that too many people on the Earth live with each day, such as HIV/AIDS and lack of access to clean water and food. We hope the conference will play a role in building two-way interactions where communities are involved in science education and science education supports communities. These goals

and actions come together with *The Way Forward,* the plan for science education emanating from the Penang ICASE World Conference in 2003.

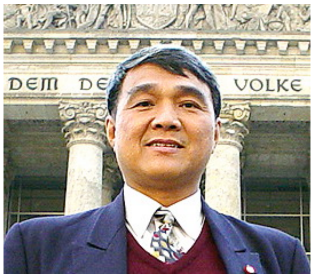
All of these and other goals can be achieved through discussions at the conference culminating in *The Perth Declaration*.

Immediately following the World Conference, UNESCO and ICASE will convene an International Science Education Policy Forum, contributing to the direction and strategies for science education within various countries and regions for several years. The World Conference will provide many ideas for the Forum to take into account

We have an ambitious program, which hopefully will resound through science in schools around the world for years to come. It will only happen with everyone's participation and great ideas. We look forward to harmonious and productive interactions and significant results.

Elaine Horne and Robin Groves
Conference Convenors

VI Message from the ICASE President



As ICASE President, I am delighted to welcome all delegates to the 2007 World Conference. For those unfamiliar with ICASE (often the case for teachers attending international conferences), ICASE is the worldwide, umbrella organisation linking science teacher associations, science education societies and institutes involved in science education. If you like, it is the NGO (non-Governmental equivalent) to UNESCO in the field of science education. It does not have individual members, but tries to offer support to its member organisations in areas perceived to be of need for each individual member. Besides a journal and newsletter, conferences such as this 2nd ICASE international conference are the main channels of communication.

I do hope you find the opportunities to listen to the variety of presentations and discuss with science educators from other parts of the world, both rewarding and interesting. A major ICASE message at the conference is the promoting of partnerships and your insights and suggestions are very much appreciated. In these times of concern for the image of school science, especially among students, ICASE encourages both bilateral and multilateral partners involving all potential stakeholders and looks forward to the role it can play, together with its member organisations, in promoting sustainable development (a theme of a conference in 1990) and a Way Forward.

Janchai YINGPRAYOON, Dr.rer.nat.
President
ICASE

VII Message from the ASTA President

Welcome to CONASTA 56,

It is with great pleasure that I welcome you to the 56th Annual Conference of the Australian Science Teachers Association (ASTA), CONASTA 56. This year's CONASTA is a unique one as it is a World Conference and is hosted jointly by ASTA and ICASE. CONASTA is convened each year on behalf of ASTA by one of ASTA's 8 state and territory member associations, with this CONASTA convened by STAWA.

CONASTA provides professional development relevant to the needs of teachers of science at all levels of schooling from pre-school to tertiary as well as researchers in the field of science education and those supporting science teachers in their work. While CONASTA normally attracts delegates from all state and territory member associations, as well as other individuals locally and nationally, this year, the added dimension of an international conference provides delegates with the opportunity to network with other science educators across the globe.

While the electronic age provides us with opportunities to seek input from afar, there is no substitute for a face-to-face gathering of the minds to discuss big picture issues such as those currently facing teachers of science. This conference provides an excellent vehicle to engage with such issues on an international scale and the conference will culminate in the Perth Declaration, a statement growing out of the conference, which will provide future directions for the worldwide science education community.

It is a wonderful opportunity to host this conference in partnership with ICASE and I congratulate all those involved in producing such an exciting program, especially the Conference Convenors and their committee, and look forward to engaging sessions and stimulating discussion over the days ahead.

Paul Carnemolla
President

Australian Science Teachers Association

VIII Message from the STAWA President

As the President of the Science Teachers' Association of Western Australia I would like to welcome you to Perth and to the International Conference on Science and Technology Education, incorporating CONASTA 56 and ICASE 2007. I would like to welcome our international visitors, our colleagues from other states and our local science educators and laboratory technicians. I would also like to welcome our keynote and highlighted speakers as well as all our presenters, I hope you enjoy your experience and learn something.

A conference of this magnitude cannot happen without a huge effort by a group of volunteers. The Management Committee, led by Elaine Horne and Robin Groves, has worked for over three years to bring this conference to fruition and as the President of the Association that has been charged with organising the conference I would like to thank them. I would also like to show appreciation for the efforts put into this Conference by the employees of STAWA's office.

Please enjoy our home city; I think it is a beautiful, fun, friendly and safe place. Try to find some time to visit the beaches, Fremantle or the vineyards and wineries of the Swan Valley. Get up to Kings Park and enjoy our unique flora, fauna and views, or visit the Zoo or Rottnest Island. Eat well but not too much, drink plenty of water, stay healthy, walk around and meet some new people, make some new friends, enrich your understanding of the way the world works and enjoy the Conference.

Kind Regards

Greg Moran
President
Science Teachers' Association of Western Australia

Part 1: Keynote Speakers' Papers

(In alphabetical order by speaker's surname)

MULTIPLE INTELLIGENCES: THE FIRST 25 YEARS, THE NEXT 25 YEARS

Professor Howard Gardner,
Hobbs Professor of Cognition and Education, Harvard Graduate School of Education, USA

Abstract: Howard Gardner reviews the principal ideas in the theory of multiple intelligences; the major changes that have occurred over the past 25 years; and his expectations about future research and applications.

The Future
A major anniversary provides an occasion to stand back, to survey the terrain, to attempt to make sense of what has happened since "the event," and to anticipate possible futures. In the case of the theory of multiple intelligences, forecasting the scene in 2030 or 2040 may be as challenging as it would have been to anticipate the scene of 2007 back in 1980. Still some of the suggestions put forth here may help to guide those researchers and practitioners who choose to work with the theory in the years ahead.

In this keynote presentation, I begin with a brief sketch of phases in the study of intelligence, as I've come to think of them. I then take a look over time at the various audiences that have found MI theory of interest in the United States and abroad. In conclusion, I describe the lines of work that I expect to be undertaken in the future, under the aegis of the theory.

Eight Phases in the Study of Intelligence
l. Lay Conceptions. Until 1900, the word "intelligence" was used by ordinary individuals to describe their own mental powers and those of other persons. Like most lay terms, the characterization "intelligence," "smart," or "clever" was used unreflectively. And so, in the West, an individual was spoken of as "smart" if that person were quick, or quick-witted, or capable of mastering and remembering lots of materials. In non-Western societies, the word "intelligent" (or the closest equivalent) might be used to denote persons who were good listeners, obedient, moral, or wise. No formal efforts were undertaken to determine whether those considered "bright" by one individual or group would be so considered by others.

2. The Scientific Turn. In a sequence of events that I've chronicled in earlier chapters, the crucial event in the history of study of intelligence occurred at the beginning of the twentieth century. French psychologist Alfred Binet responded to a request from the authorities in Paris to create a measure that would predict which students were likely to need special attention in school. In effect, Binet created the first intelligence test, which soon gave rise to the concept of IQ (mental age divided by chronological age). Binet's work was supported by cognate efforts in Europe, particularly Britain and Germany, and soon spread to the United States, where standardized tests of intelligence were created. By the 1920s, intelligence tests were ensconced in the educational landscape of the United States and a number of other countries. In general, this work supported a view of intelligence as singular, strongly influenced by hereditary, and susceptible to measurement by a brief intervention.

Work on such mental measurement instruments continues today, both among those who accept the traditional *g* view of intelligence and those, like me, who are critical thereof. Efforts to create paper and pencil tests are being supplemented by computer-administered measures, as well as efforts to measure intelligence through neuro-scientific and genetic means. Until recent years, progress on a theory of human intelligence has been less notable among those who favor the traditional view.

3. The Pluralization of Intelligence. While Binet did not take a position on the number and types of intellect, most of his contemporaries and successors chose to believe that intelligence was a single construct that could be adequately determined by a brief test. However, there has been for some time a minority of researchers who are sympathetic to the view that human beings possess a number of intelligences, which are relatively independent of one another and which merit separate assessment. Typically these researchers based their assertion on the statistical technique of factor analysis. This technique—a form of correlational analysis—indicates which sets of items in a test "hang together" and which ought to be considered as distinct from one another. Among the researchers who embraced this pluralistic view were L. L. Thurstone (1938) and J. P. Guilford (1967). Other researchers, dating back to Charles Spearman (1904), take a hierarchical view of intellect, one which posits an overarching general factor, as well as specific factors aligned in a subsidiary position (Carroll, 1993; Thomson, 1939; Vernon , 1971).

As outlined in earlier chapters, my theory of multiple intelligences differs from these psychometric efforts. Rather than creating a series of items and subjecting them to factor analysis, I instead surveyed an ensemble of research literatures spanning evolutionary biology, neuroscience, anthropology, and psychology. I defined an intelligence as an information-processing potential to solve problems or create products that are valued in at least one culture. I laid out a set of criteria for what counts as an intelligence and applied it to various candidate capacities. At present, I believe that human beings possess eight or nine relatively separate intelligences, each of which undoubtedly is itself composed of a number of separate sub-capacities.

Much of the criticism of MI theory within psychology derives from the unorthodox way in which I have identified the intelligences; critics would have been mollified had I developed tests for each intelligence and demonstrated their psychometric independence. Scattered evidence exists for the relative autonomy of intelligences, but the major scientific work on the plurality of intellect remains to be done.

4. The Contextualization of Intelligence. Most psychologists, including me, have a propensity to think of intellect as an attribute of the individual mind, indeed, the individual brain. This position has merit inasmuch as human intellect cannot be conceived of independent of a mind or brain in which that intellect is exercised.

However, researchers have recently called attention to aspects of intellect that are best construed of as external to the individual thinker; they refer to the contextualization of intelligence. Even if the intellectual potential of a human being is contained inside his or her genome, the way in which it will be expressed, and the extent to which it is expressed, will depend on the specific culture in which the individual happens to be born and the experiences that he happens to have within that culture.

A vivid example is the case of Bobby Fischer, probably the most gifted chess player of the last century. Clearly (if not tautologically), Fischer had the potential to be a great chess player—and others may have that potential as well. But Bobby Fischer is extremely fortunate that he happened to be born in the United States at a certain time, that he had the opportunity to learn the rules of chess when young, and that the time and resources were available so that he could become a master at an early age. Bobby Fischer could not have invented the game of chess—it took hundreds of years to create chess. And it is not at all clear that Bobby Fischer would have emerged as talented in another game—say, bridge or Go—or in another pursuit, say politics, business, or physics. Indeed, subsequent events suggest that Fischer is a misfit for every activity save the game of chess. As we argue in chapter 11, intelligence or intelligences are always an interaction between biological proclivities and the opportunities for learning that exists in a culture.

This perspective is useful for considering a recent controversy—whether women have less aptitude to carry out science. Empirically, there is no question that there have been fewer scientists, and fewer great scientists, among women than among men. While there is presumably no potential to be a scientist (a purely cultural category), there may be iffering potentials to master spatial or logical reasoning. Even if women on the average prove less skilled at one or another forms of reasoning, however, it is a huge stretch to infer that the limits are genetic or that they constrain scientific achievement. Women have fewer role models; they are often discouraged from pursuing science; the decision to pursue science may be confounded with many other factors, ranging from motivation to win prizes to willingness to neglect one's children. We could not determine women's suitability for science unless these and other relevant factors were controlled for—just as we could not determine whether there are any differences in black-white intelligence unless we lived in a society that were truly color-blind.

5. The Distribution of Intelligence. Closely related to, but distinct from, the notion that intelligence must be contextualized is the contention that intelligence should be thought of as distributed. The term "distribute" denotes the claim that intelligence is best thought of as extending beyond the skin of the individual. Specifically, one's intellect is not simply the ideas and skills that the individual has herself obtained and can access. Rather, one's intellectual facility depends equally, perhaps especially, on the various material and human resources to which an individual has access.

Starting close to home, consider an individual like me who is writing a book about intelligence. From one perspective, inasmuch as I am the acknowledged author, the ideas and skills are mine. And yet, left completely to my own devices, I would find this task onerous, if not impossible. On the one hand, I depend on all kinds of material resources, such as notes, pencils, computer files, the Internet. On the other hand, I depend equally on all kinds of human resources, ranging from the experts whom I consult on various issues to my outstanding student Seana Moran, who conducts research on various topics, critiques my manuscript, and carries out various other important tasks, sometimes in cooperation with my extremely able assistant Lindsay Pettingill. And once the manuscript leaves our Cambridge office, many persons connected with the publishing and marketing of the books take over the birthing process.

In the work undertaken at Project Zero described in earlier chapters, I've sought to indicate our own commitment to the contextualization and distribution of intelligence. In Project Spectrum (chapter 6), the provision of a rich environment is a necessary step for evoking and developing the several intelligences of the young child—a dramatic demonstration of contextualization. In the project work at the Key School (chapter 7) and in the portfolios and processfolios featured in Arts PROPEL (chapter 9), we see at work the role played by material resources (such as works of art and video-recording equipment) and by human resources (such as supportive teachers and critical peers) in bringing a complex project through to completion.

6. The Individualization of Intelligence. The further we move from a unitary view of intellect with each person just a point on a single bell curve, the more apparent it becomes that each individual has a unique intellectual configuration. Indeed, thanks to neuro-imaging, we now know that even identical twins use different brain (and mental) resources in attacking the same problem. Just as we look different from one another and have different personalities and temperament, so, too, we each have different kinds of minds (Levine, 2002).

Confirmation of the uniqueness of each intellect is fascinating from an observer's perspective and challenging to the teacher and the parent. Life is more interesting when each person's mind is unique; and that diversity probably contributes to the robustness of the species (Gould, 1989). However, the uniqueness of minds poses a challenge to those charged with education and nurturance. We must decide how much effort to devote to a determination of the particular configuration of each person, and how to use such information. In a totalitarian society, differences are overlooked or condemned, and efforts are undertaken to make nearly all individuals into carbon copies of one another. The leading apparat controls the context totally, including the resources to which individuals are exposed. However, such an option cannot, or at least should not, be pursued in a democratic society.

7. The Education of Intelligence. Until this point, the phases of intelligence have been largely descriptive; they have not contained within them any imperative. Once one begins to speak of differences across persons, however, the issues surrounding action become patent. Should we cultivate differences among individuals? Should we tolerate them? Or, as in a totalitarian society, should we attempt as much as possible to eradicate these differences, and produce a society of clones, or, perhaps, a "brave new world" featuring a hierarchy of types of clones?

In this book, I have taken a strong position on the education of intelligences, a position that is avowedly progressive. In my view, psychologists have spent way too much time assessing individuals and not merely enough time helping them. In the past fifty years, societies all over the world have undertaken an enormous shift. No longer is the purpose of education simply to pick out those students who are intelligent, on one or another definition, and give them special access to higher education. Rather, the purpose of education is now to educate an entire population, for we cannot afford to waste any minds.

And so we face the question of how best to educate a diverse population. We could attempt to minimize the differences among individuals—and this option has typically been followed in East Asian societies with notable success. But I call for a contrasting approach—what I have termed individual-centered education. The assumption here is that individuals have different profiles of abilities; they and the society will be better off if those individual proclivities are honored and nurtured rather than ignored or minimized.

How to educate individuals so that each develops his or her potential to the fullest is still largely a mystery. (Interestingly, the grant from the Bernard Van Leer Foundation that funded research on MI theory was designed explicitly to discover the range of human potentials). I hope that in the preceding chapters I have identified some promising paths.

8. The Humanization of Intelligence. According to the analogies introduced above, the several human intelligences can be thought of as separate computers or separate muscles. It is up to us how we use these computers, how we develop these muscles. A computer can be used to compute targets for battle or to plan a campaign to eradicate disease; a muscle can be used to rescue a drowning person or to knock out a person in the course of an argument. As a student of intelligence, my job has been to figure out how these intelligences work, whether or not I happen to approve of how particular individuals use that particular intelligence.

In recent years, however, I have turned my energies to the uses to which human beings put their capacities. Working with my close colleagues Mihaly Csikszentmihalyi and William Damon and collaborators at several universities, I have been exploring the nature of "good work"—work that is at once excellent in quality and also socially responsible. We have been trying to understand how individuals who wish to carry out such ethical and excellent work proceed at a time when things are changing very rapidly (thanks in part to technology); when market forces are very powerful; and when few if any forces can counter that market dominance (see Gardner, Csikszentmihalyi, & Damon, 2001; goodworkproject.org).

Earlier in this volume (chapter 2), I questioned the existence of a moral intelligence. I don't think that, in themselves, intelligences are moral or immoral. It is the *ends* to which intelligences are put that involve goals and values. I still believe this to be the case. But I contend that the challenge for society in the future is not simply to produce individuals who are intelligent, or more intelligent, however defined. Rather, it is to yoke our intellectual capacities to a sense of ethical responsibility—in short, to humanize intelligence. In whatever time I have left in my own professional life, that is the goal toward which my own work will be directed.

Audiences for MI Theory

When I committed myself to a 400-page, rather technical book, I thought that it would be of interest primarily to psychologists. Indeed, I thought that my audience would be largely developmental psychologists, my closest colleagues, and, to a lesser extent, neuropsychologists and cognitive psychologists, with whom I had recently been working. While there was some interest among colleagues, particularly those with whom I had personal relations, the book did not have much of an audience among psychologists, to whom it seemed somewhat exotic. And, as I have noted earlier in the volume, the book aroused antipathy among psychometricians. Basically wedded to a singular or hierarchical model of the intellect, they did not find convincing my assertion of several relatively autonomous intelligences. They did not like the excursion to personal forms of intelligence. And they were particularly unable to accept an approach based on the synthesis of various kinds of information from different disciplines. Quoting early researchers, they believed that "intelligence is what the tests test"; and they looked to the psychometric evidence for support or refutation of my "speculations."

I should add that, while scarcely a major concern, MI theory has not encountered hostility in the areas of brain science or computer science. Lacking a commitment to a "singular" view of intelligence, researchers in these traditions have found the idea of multiple intelligences intriguing if not convincing (Damasio, 2003; Posner, 2004). Indeed, as a highly differentiated and modularized view of the brain has gained in persuasiveness, MI theory has seemed a natural, if somewhat general, fit (Geary, 2005; Pinker, 1997; Tooby & Cosmides, 1990).

I had never assumed that the principal audience of MI theory would be educators, and its principal applications in classrooms, first in the United States and gradually in other parts of the world. This reaction, which has continued to this day, surprised me. I can point to certain trends, which could be idiosyncratic, though for me they are revealing (Gardner, 2004a).

Initially, three groups were drawn to the theory. Probably first were special educators—those who deal with individuals who are outside the mainstream in schools. Sometimes these special educators dealt with individuals with specific learning abilities—those who had selective problems in reading, in mathematics, or, less frequently, in understanding other persons. With their own eyes, these educators daily observed jagged profiles of intelligence, and they were challenged somehow to get these youngsters through school. MI spoke to them loudly, clearly, convincingly.

On the other end of the "special education" spectrum were those involved in education of the gifted and talented. Here there was a mixed, almost bimodal reaction. On the one hand, those who had been calling for a broader definition of gifted and talented (Marland, 1972; Renzulli, 1988) found sustenance in the delineation of multiple talents, and the recognition of certain non-scholastic abilities. Early efforts were made to develop assessments of some of the noncanonical intelligences (Kornhaber, 1997; Maker & Nielson, 1996). Yet, among those of a psychometric leaning, there was extreme unease with the theory. For much of the gifted establishment, the high IQ is sacrosanct—one's ticket to membership in Mensa and ever more exalted heights. Anything seen as a challenge to IQ was a threat to be removed. And so some of the earliest interest in MI theory was among individuals who wanted to expunge it.

A second group attracted early to the theory were individuals in independent (private) schools. I think that this attraction occurred for three reasons. First, teachers and administrators in those schools are more likely to track new research, to read the book review press, and to see themselves as members of the "chattering classes." (When I travel abroad, I am much more likely to be invited to international or independent schools than to government schools). Second, relatively free of government control, these schools have the luxury of carrying out experiments, including ones in the MI tradition. Third, youngsters sent to independent schools are more likely to need and desire individual attention—because they have either special gifts or special problems. The classes are smaller, and teachers are expected to attend to each child, whose parents are spending considerable sums. MI ideas are more readily understood and adopted when one is working with ten to fifteen members in a class, than when one has a class of thirty, fifty, or even more pupils.

The third group attracted to the theory in its early years were those who work with young children—primary grades, kindergarten, preschool. At those ages, the heavy scholastic curriculum has not yet been imposed—or at least had not been imposed in the 1980s. Teachers of these young students are more developmentally oriented, they value play and exploration, and they have latitude in how they set up their classrooms spatially and temporally. Many already had richly stocked classrooms (the children's museum model) that featured learning or play centers. There was less of a stretch to embrace MI ideas, and more of a feeling that they were already carrying out education that was "MI" in spirit, even if the terms and the taxonomy were not familiar.

While MI ideas first attracted these three groups, they did not long remain restricted to them. In each case, there was a fairly predictable order of interest and, to some extent, endorsement. While MI first was attractive to special educators, it soon became of interest to mainstream educators. While MI was first attractive to those who teach or administer independent schools, it became of interest to those in the public sector as well. And while MI was first attractive to those who work with young children, it gradually spread to other age groups as well.

A word on this "trickle up" phenomenon. While I cannot provide exact figures, I can state the following trend with confidence. MI first was of interest to those in the preschool and primary grades; next to those in middle school; next to those in high schools and community colleges that address diverse and underserved populations. By the 1990s, I was getting many inquiries about MI theory from secondary schools and colleges (Coreil, 2003; Diaz-Lefebvre et al., 1998; Weber, 2005). I noted, however, that the inquiries tended to come from schools with a diverse, often multi-racial population, one that exhibited various learning difficulties. These institutions were looking for any kind of help that they could get with these challenging populations, and they saw MI theory as a possible aid. Also, of note, those involved in adult education, particularly of populations that had received little formal education, found MI a promising entry point and tool (Kallenbach & Viens, 2004).

By implication, then, I have identified the educational institutions that have shown the least interest in MI ideas. These are institutions that are highly selective—so they can choose the most scholastically gifted—and that follow a standard academic curriculum. They might well say, "If it ain't broke, don't fix it." Within these ranks I would certainly place my own university, Harvard, whose leadership was central in the development of IQ and SAT instruments and continues to value them today. Nonetheless, leaders of the Admissions Department at Harvard College often cite MI theory. And I believe that these admissions officers are not being disingenuous. Harvard is interested in having a student body that is intellectually and culturally diverse, and so it is on the lookout for individuals who stand out in the various intelligences—providing that there is evidence that they can handle the workload.

What of interest beyond educational institutions? MI theory has proved an easy sell to museums and other cultural institutions. Lacking a captive audience, these institutions are interested in providing activities and exhibitions that will attract a diverse public and encourage return visits. MI theory has been especially attractive to children's and other hands-on museums all over the world, many which have mounted exhibitions on multiple intelligences or built their exhibitions around the different intelligences. But even in arts museums, MI ideas have had appeal because of the notion of different entry points to the same object (chapter 8). Materials suited to art museums have been developed in particular by my colleague Jessica Davis (1996).

It is worth noting that MI ideas have in the past decade come to the attention of leaders and managers of businesses. Part of this interest stems from the vast attention being paid to emotional intelligence, thanks to the pathbreaking writings of Daniel Goleman (1995, 1998). The interest also comes from the need to attract, maintain, and develop a diverse workforce, one that may not conform to the standard scholastic model of intellect. Finally, other applications of MI theory—including the use of portfolios and the presentation of key ideas in multiple formats—have also proved attractive to business persons both in the United States and abroad.

Finally, a steady stream of books and articles about MI appear throughout the world. In most cases, I have little to do with these publications, though I note their accumulation on relevant search engines. An author gets a special rise when his ideas are featured "off the book page." MI theory has been featured in novels (by Richard Powers), television programs (ER), double crostic puzzles (*New York Times*), examinations of the intellect of horses (by Jane Smiley), and the popular board game Cranium, among other loci.

MI Tours the World

Whatever its merits and demerits, MI theory has been generous to me. Responding to those who want to hear more about the theory from its originator, I have had the opportunity to visit many of the United States and also to travel to many other nations. It has been fascinating to discover the ways in which the theory has been interpreted and the activities that it has catalyzed. In preparation for this book, I took notes for a year—May 2004-May 2005—on some of the intriguing things that I learned as I toured the geographical and the virtual worlds on the MI bandwagon.

Different Messages. Before visiting China in 2004, I had no idea how popular MI theory had become. In 2002 there was an MI conference in Beijing attended by over 2500 educators from nine provinces and seven countries, including Taiwan. There were seven plenary presentations by noted educators and 187 papers accepted for presentation! My colleague Zhilong Shen estimates that over 100 books on multiple intelligences have been published in Chinese.

In Shanghai I asked an English speaking journalist if she could explain the great popularity of the theory in her country. "It is quite simple," she told me. "In the United States, when people hear about multiple intelligences, they think about the special genius of their child—her unique configuration of intelligences, the potential that should be developed. In China, it is quite different. If there are eight separate intelligences, that is now eight things that all of our children need to become good in."

A Healthy Start. In Macau, I received a tour of the island from Mr U. The next morning, he picked me up for my presentation at the Ministry. "Look what my wife picked up yesterday at the grocery store," he said to me. He showed me a multicolored flyer, which depicted each of the intelligences on a separate leaf. The flyer, replete with illustrations, charts, and figures, was an advertisement for Fisogrow processed milk. The consumer was told, "If you drink our milk, you will develop each of the different intelligences." Never before had it occurred to me that the MI in the theory might stand for MIlk!
Strange Bedfellows. Shortly after my visit to Macau, Mr. U. traveled to North Korea. In Pyongyang he visited the library and found only two books in English. One was the social critic Michael Moore's *Stupid White Men* (2004). The other was my 1983 book, *Frames of Mind: The Theory of Multiple Intelligences.*

The Project Zero Mosaic. At Project Zero, the research group with which I have been affiliated for almost forty years, we have focused on education for understanding. Some of this work has involved the use of multiple intelligences curricula and assessments in order to enhance student understanding. The combination of these thrusts has been featured in various American schools, such as the Ross School in East Hampton, Long Island and Glendale Community College in Glendale, Arizona.

I was pleased to see similar efforts abroad. At the Montserrat School in Barcelona and at the MI International Foundation School in Philippines, I saw impressive integration of multiple intelligences ideas under a rubric of education for understanding. And in the National College of Ireland in Dublin, President Joyce O'Connor has brought tertiary education to a previously underserved population, making use of ideas of understanding, multiple intelligences, and alternative assessment that have been developed at Project Zero.

Multiple Intelligences and Good Work. After the development of multiple intelligences theory and its various offshoots, my principal scholarly work has been the study of "good work"—work that is both excellent and ethical. For the most part, these two lines of investigation have been pursued independently of one another. But on recent trips I encountered impressive combinations of these themes.

In Bangkok, Thailand, at the Concordian School, young students are taught three quite distinctive languages—Thai, Chinese, and English. It is a daunting challenge. Also featured at this school is an effort to develop the several intelligences and to inculcate virtues of responsibility, integrity, and trust. Conversations with Thai businessmen and with the revered Crown Princess of Thailand convinced me that the themes of internationalism, diversity, and ethics were a concern of the nation, and that the idea of multiple intelligences might be catalytic in pursuing these themes.

In the Philippines, I spent a week with Mary Jo Abaquin, head of the MI International Foundation School. She mounted an impressive MI conference, bringing together educators from all over the Philippines as well as other countries in the Asian Pacific region. At the conclusion of the conference, she presented awards to eight outstanding Philippine citizens, each who stood out in a particular intelligence. In addition, each of these citizens had used their intelligences in ways that were ethical and humane: for example, a musician who worked with children in poverty, and a naturalist who was trying to preserve the environment. The awardee in the interpersonal category was Corazon Aquino, the "People Power" president, who now runs an educational foundation. I was moved to see this pioneering effort to bring together the themes of multiple intelligences and good work.

Hot Topic. I had known for some years that educators in Denmark were interested in multiple intelligences. But I had not been aware of heated debates in the press about whether this theory was a proper one to introduce in classrooms. I was asked to "weigh in" on the side of MI. As mentioned in chapter 4, the Schools Minister in the United Kingdom credited a rise in test scores to teachers' greater consciousness of the multiple intelligences of children. Again, this statement evoked considerable discussion among pundits. And in France, slow to respond to the idea of multiple intelligences, the prestigious paper *Le Monde* devoted a supplement to the question: "Why has multiple intelligences not had the influence in France that it has in other countries?"

Corporate World. As mentioned earlier, MI ideas are beginning to be used in business settings. In Colombia, I encountered Gerardo Gonzalez, CEO of Skandia International, a financial management company. Gonzalez gave a powerful cognitive analysis of corporate culture. He then drew on multiple intelligences theory to explain the ways in which one might change the theories, stories, and skills that permeate the employees of a multinational corporation. According to him, it is necessary to present the desired change in culture in as many media and formats as possible, thus using the idea of "multiple representations" and "multiple entry points" that I expounded in chapter 8.

Recommendations, Regulations, and Legislation. Coming from a country where policymakers are loathe to discuss multiple intelligences, I have been amazed to learn of jurisdictions where the terminology of multiple intelligences has been incorporated into white papers, recommendations by ministries, and even legislation. Admittedly I have rarely seen the wording of the documents. But I have heard from reliable sources that multiple intelligences approaches are part of the policy landscape in such diverse lands as Australia, Bangladesh, Canada, China, Denmark, Ireland, and the Netherlands. A project undertaken by the European Union, called the Leonardo Project, has also featured MI ideas.

They Got There First—Schools. For almost twenty-five years, I have been an enthusiastic supporter of the remarkable preschools of Reggio Emilia in Northern Italy (see chapter 5). Our respective groups at Reggio and Project Zero have exchanged ideas, materials, and visits for many years. In 1996, we undertook a full blown collaboration with Reggio Children, a particular focus falling on issues of group learning and documentation of learning. This collaboration culminated in *Making Learning Visible: Children as Individual and Group Learners* (Guidici, Rinaldi, & Krechevsky, 2001). Reggio has used the attractive banner "the hundred languages of children." While we share many of the same educational goals and enthusiasms, it is important for me to indicate that Reggio had developed most its ideas and practices before becoming familiar with MI ideas. Project Zero's principal contribution has been to articulate, and to provide something of a theoretical rationale for, the indispensable example of the thirty-three schools in Reggio.

They Got There First—Ideas. In addition to these first hand observations, I also benefit from correspondents in various lands. From Ireland, Brian McEnery introduced me to the idea of "duchas"—forty different modes of intelligence that were identified in early Celtic history. From India, Vasanthi Thiagarajan has told me about the ten heads of Ravan. Each of the first nine heads represents a different intelligence that can be yoked to my proposed intelligences. The tenth is the intelligence that is "beyond intelligence—the intelligence of non-existence."

Lines of Further Study and Practice

Identification and Delineation of Intelligences. Once the idea of multiple intelligences had been put forth, it was as if the genie had been released from the bottle. Writers and wags have now proposed a whole potpourri of intelligences, including financial intelligence, moral intelligence, spiritual intelligence, emotional intelligence, and sexual intelligence, just to name a few. Not surprisingly, I am comfortable with an expanded notion of intelligence. My major strictures are that there need to be criteria for an intelligence (otherwise, anything goes), and that intelligences need to be described independent of how they are used (otherwise, description is confounded with prescription).

From my vantage point, the most important inputs for this endeavor will be from the biological sciences. As we learn more about the development and functioning of the human brain, we will be able to identify those capacities that are "hard wired" into the nervous system, as well as those that are relatively plastic—more flexible, more susceptible to experiences. We also will know in what ways individuals who exhibit unusual performances and unusual profiles differ from the norm in terms of neurological structures and functioning. By the same token, as we come to identify the roles of various genes and gene complexes, this information will serve as another constraint on how we describe human capacities. These studies are likely to reveal whether specific intellectual strengths (such as musical or spatial intelligence) are under the control of specific genes or gene complexes; and studies of identical and fraternal twins reared together and apart will enhance our understanding of the extent to which different intellectual profiles are heritable.

I am reasonably certain that, twenty-five years from now, our thinking about the nature and boundaries of various intelligences will be highly differentiated and quite different from the current topography. Biological evolution proceeds in its own way, which defies both logic and the categories offered by common sense. But I am confident that the idea of multiple intelligences will survive, despite the accumulation of much relevant information. That is because, whatever evidence may accrue to support notions of "general intelligence" we still need to account for the vast differences across individuals and for the variegated profiles of strengths and weaknesses. Both of these require an account in terms of multiple intelligences. Moreover, by that time, we may well know whether it makes sense to speak of a separate existential intelligence, perhaps lodged deep in the temporal lobes.

So much for "wetware." Intelligences are computational mechanisms; work in the "dryware" computer realm is likely to enhance our understandings as well. While we cannot carry out certain kinds of experiments on human beings (a state of affairs for which we should be grateful), it is possible to model various intellectual capacities on paper and through various kinds of simulations on computers. And through such modeling it is possible to determine which tasks can be carried out with one kind of mechanism, which can be carried out with other mechanisms, which might require a combination of mechanisms or even a new kind of mechanism. These simulations of human intellectual capacities will provide another invaluable lens on the organization of the mind, the extent to which it is best modeled through a variety of mental modules, and how best to describe these modules.

The Nurturance and Education of Intelligences. Of course, computational studies and the biological sciences may not be restricted to the identification and modeling of human intelligences. They may also enhance them in various ways. Computers may be used to teach materials in a multiplicity of ways. They can serve as prostheses, enhancing capacities that may be compromised in certain individuals. Thus, for example, computers can enhance bodily-kinesthetic capacities in individuals who are physically handicapped, even as they can display and manipulate geometric images for those whose spatial capacities are impoverished. They can also allow individuals to simulate experiences that are too difficult or too expensive to enact in a classroom—such as an expedition to a remote time or a distance place.

My guess is that the best educational interventions will continue to come from ingenious educators, using simple materials and their wits. Famed mathematics educator Robert Moses (2001) teaches algebra to seventh and eighth graders in Boston, drawing on their knowledge of the Boston public transportation systems. Educator Annick Winokur has coined the term *sportsometry*, to describe how she teaches mathematical and spatial reasoning through studying the bounces of a basketball (Garriga, 2004). Professor Christopher Conkey has set up www.physicssong.org: the site features musical fragments that have proved effective in conveying concepts in physics to college students (Conkey, 2005).

The Power of Ideas. The original title for my book, *Frames of Mind,* was *The Idea of Multiple Intelligences*. I still like this title because "multiple intelligences" is basically an idea—a seemingly simply one that turns out to be unsettling, provocative, even radical. Even now, after twenty-five years, it is still difficult for me to embrace it totally, and to reject the hegemonic idea of a single intelligence. At the start of the 21st century, the idea of a single, one dimensional intelligence holds sway, at least in most of the developed Western world. Critics would say that is because it is essentially correct; I would say it is because it is so difficult to dislodge a concept once it has been entrenched in language and thinking.

No one understood this point better than the great economist John Maynard Keynes. In a famous passage, he observed: "The ideas of economists and political philosophers, both when they are right and when they are wrong, are more powerful than is commonly understood. Indeed, the world is ruled by little else. Practical men, who believe themselves to be quite exempt from any intellectual influences, are usually the slaves of some defunct economist" (Keynes, 1935, p. 383). Even more pointedly, Keynes once remarked: "The real difficulty in changing any enterprise lies not in developing new ideas but in escaping from the old ones" (Keynes, 1935, p. viii).

In attempting to change the minds of persons, the scholar (or the activist) has available a number of levers (Gardner, 2004b). These range from the scholar's tools of reason and research, to the powerful person's ability to manipulate rewards and punishments, to the teacher's capacity to take advantages of real world events and to appear resonant, likeable, and trustworthy. Attempts at mind changes, however, are unlikely to succeed in the long run unless the "mind-changer" is aware of and able to counter the many resistances that an individual has to the idea in question. As Keynes notes, the old ideas are difficult to scuttle.

As a scholar who is seeking to popularize an idea, I have used a variety of levers but have relied largely on reason and research. On their own, these levers may throw doubt upon the traditional view of intelligence, but they seldom suffice to reach a "tipping point" (Gladwell, 2000). In my own experience, individuals are likely to become converts to MI theory on the basis of more personal experiences: being able to think of themselves or someone they love in a new way, or seeing a new way of teaching or learning succeed where others have failed. Even then, however, the old idea, the old theory rarely disappears entirely. In the best circumstance, a new paradigm is more likely to be adopted by the next generation of individuals, who are less under the sway of the old idea and who find the new idea –like "multiple intelligences"—to be the more natural one. At this point, in the phrase of historian of science Thomas Kuhn (1962), a paradigm shift has occurred.

All the time, I see this struggle taking place between the old and the new views of intellect. One day I read in the newspaper that a prisoner in Virginia may be executed because his IQ has risen from 59 in 1998 to 74 in 2005 (Liptak, 2005). What a way to make a decision, I groan. Another day I read that an excellent secondary school teacher of diesel engineering in Ohio is being retained, even though he has failed a written Educational Testing Service test on "principles of effective instructional strategies." In its wisdom, the state of Ohio has decided to declare a moratorium on the use of such tests for vocational educational teachers (Winerip, 2005). A step forward, I relax and shrug my shoulders. I hope that your experience with my key note presentation has moved you a few steps forward toward a more differentiated, more nuanced view of intelligence, or that it has at least generated a few spirited discussions within yourself and/or with others.

EDUCATING FOR SUSTAINABLE FUTURES

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We are all engaged in the act of creating the future. One goal of education should be to equip young people to play a constructive role in shaping their future. Since several global studies have shown that the present approach is not sustainable, education must enable the transformations needed to achieve a HEALTHIER future. This involves new scientific understandings, enhanced technical capacity, improved social awareness and an ethical commitment to future generations. These needs have implications for both the content and the process of formal education. Specifically, we must recognise that formal education is the first step in a process of life-long learning and move away from the traditional emphasis on mastery of a body of knowledge. Our goal must be to enable leaners to engage in creative ways with the complex problems they will face. It is no exaggeration to state that the survival of human civilisation depends on our success.

TOWARDS HEALTH PROMOTING SCHOOLS IN AFRICA: AN EXAMINATION OF SELECTED HEALTH ISSUES IN AFRICAN UNIVERSITIES AND SCHOOLS

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Abstract: Professor Barnabas Otaala will outline the HIV/AIDS challenge, both globally and particularly in the Sub-Saharan African region and clarify the EFA Goals, as enunciated in Dakar (2000) and the Millennium Development Goals. He will describe the current situation in universities and schools in Africa and propose a way forward, including collaboration and partnership with UNESCO, COL, SARUA, AU/NEPAD, the Commonwealth Secretariat and AAU.

Introduction

"HIV/AIDS is unequivocally the most devastating disease we have faced, and it will get worse before it gets better", Dr Peter Piot, Executive Director (UNAIDS) November 2001.

> "Education is at the core of one of the great challenges facing humanity: winning the fight against AIDS. Education is life-sustaining. It furnishes the tools with which children and young people carve out their lives, and is a lifelong source of comfort, renewal and strength. The world's goals in promoting education for all and in turning back the AIDS epidemic are mutually dependent. Without education, AIDS will continue its rampant spread. With AIDS out of control, education will be out of reach."

This paper will provide an overview of the HIV/AIDS situation globally and in Africa. It will then provide the present status of HIV/AIDS in higher education institutions and schools in Africa, including examples of good practice with respect to teaching, research and community service, and present barriers and challenges.

The section entitled "where do we go from her?" deals with how higher education institutions might dramatically increase their efforts to comprehensively "Challenge the Challenger", the HIV/AIDS epidemic. The paper ends with concluding remarks reiterating the position of the Association of African Universities adopted at their Nairobi, Kenya, meeting in February 2001. References as well as appendices are provided.

Overview of the HIV/AIDS situation Globally and in Africa

> AIDS is turning back the clock on development. In too many countries the gains in life expectancy won are being

> wiped out. In too many countries more teachers are dying each week than can be trained. We will mainstream AIDS in all World Bank work …
>
> The President of the World Bank, James D Wolfensohn, address to the U.N. Security Council, January, 2000.

HIV/AIDS is without doubt one of the most tragic and challenging health problems of our days. Africa certainly carries the heaviest burden with respect to HIV/AIDS. For a continent representing one tenth of the world's population, nine out of ten HIV positive cases originate from Africa (FAO, Focus 2000).

The pandemic is a "threat that puts in balance the future of nations" (Nelson Mandela, 1997). AIDS kills those on whom society relies to grow the crops, work in the mines and factories, run the schools and hospitals and govern the countries … It creates new pockets of poverty when parents and bread winners die and children leave school earlier so support remaining children – themselves affected and infected by HIV/AIDS!!!

The statistics make grim reading. HIV/AIDS is the deadliest scourge on the African continent. And for those who are unable to contemplate the scope of the disaster, these numbers will shock. An estimated 25.8 million people are currently (2005) living with AIDS in Sub-Saharan Africa and that's nearly two thirds of all AIDS cases reported globally; in 2001 there were 2.4 million new infections and 2.3 million deaths.

The AIDS pandemic killed 2.4 million Africans in 2005. More than 13 million children under the age of 15 have been orphaned by HIV/AIDS, and this number is projected to double by 2010. Southern Africa including Namibia is the region worst affected by the disease.

At the sub-regional level, the continent harbours 21 countries with the highest prevalence of HIV in the world, while in at least 10 countries, prevalence rates among adults exceed 10 percent. To bring the matter down to individual level, 44 percent of pregnant urban women in Botswana were HIV+ in 2001; one in four adults in Zimbabwe and Botswana carries the virus and of the 13 million AIDS orphans worldwide, 10 million of them are in Sub-Saharan Africa (Africa Today, Vol.9 No.5, May 2003, p.19). Madavo emphasizes this tragic situation differently. He states: "Let us not get caught up only in numbers - - HIV infection rates, HIV prevalence rates, mortality rates. Behind these numbers there is flesh and blood. Behind these numbers there are husbands, wives, parents, children, farmers, teachers, doctors. It's the wellspring of African knowledge and wisdom being drained before our eyes. According to a West African proverb, every time an elder dies, it's as if a library has burned down."

TABLE 1: GLOBAL SUMMARY OF THE HIV/AIDS EPIDEMIC DECEMBER 2005		
Number of people living with HIV in 2005	**Total**	**40.3 million**
	Adults	38.0 million
	Women	17.5 million
	Children under 15 years	2.3 million
People newly infected with HIV in 2005	**Total**	**4.9 million**
	Adults	4.2 million
	Children under 15 years	700 000
AIDS deaths in 2005	**Total**	**3.1 million**
	Adults	2.6 million
	Children under 15 years	570 000

TABLE 2: ADULTS AND CHILDREN ESTIMATED TO BE LIVING WITH HIV AS OF END OF 2005, BY CONTINENT	
1. North America	1.2 million
2. Caribbean	300 000
3. Latin America	1.8 million
4. Western and Central Europe	720 000
5. North Africa & Middle East	510 000
6. Sub-Saharan Africa	25.8 million
7. Eastern Europe & Central Asia	1.6 million
8. East Asia	870 000
9. South & South-East Asia	7.4 million
10. Oceania	74 000

TABLE 3: ESTIMATED NUMBER OF ADULTS AND CHILDREN NEWLY INFECTED WITH HIV DURING 2005	
1. North America	43 000
2. Caribbean	30 000
3. Latin America	200 000
4. Western and Central Europe	22 000
5. North Africa & Middle East	67 000
6. Sub-Saharan Africa	3.2 million
7. Eastern Europe & Central Asia	270 000
8. East Asia	140 000
9. South & South-East Asia	990 000
10. Oceania	8 200

TABLE 4: ESTIMATED ADULT AND CHILD DEATHS FROM AIDS DURING 2005	
1. North America	18 000
2. Caribbean	24 000
3. Latin America	66 000
4. Western and Central Europe	12 000
5. North Africa & Middle East	58 000
6. Sub-Saharan Africa	2.4 million
7. Eastern Europe & Central Asia	62 000
8. East Asia	41 000
9. South & South-East Asia	480 000
10. Oceania	3 600

TABLE 5: CHILDREN (<15 YEARS) ESTIMATED TO BE LIVING WITH HIV AS END OF 2005	
1. North America	9 000
2. Caribbean	17 000
3. Latin America	50 000
4. Western and Central Europe	5 300
5. North Africa & Middle East	37 000
6. Sub-Saharan Africa	2.1 million
7. Eastern Europe & Central Asia	7 800
8. East Asia	5 000
9. South & South-East Asia	130 000
10. Oceania	3 300

TABLE 6: ESTIMATED DEATHS OF CHILDREN (<15 YEARS) FROM AIDS-RELATED ILLNESSES DURING 2005	
1. North America	< 100
2. Caribbean	3 600
3. Latin America	3 200
4. Western and Central Europe	< 100
5. North Africa & Middle East	11 000
6. Sub-Saharan Africa	520 000
7. Eastern Europe & Central Asia	2 100
8. East Asia	1 300
9. South & South-East Asia	31 000
10. Oceania	700

TABLE 7: ESTIMATED NUMBER OF CHILDREN (<15 YEARS) NEWLY INFECTED WITH HIV DURING 2005	
1. North America	500
2. Caribbean	3 800
3. Latin America	7 700
4. Western and Central Europe	200
5. North Africa & Middle East	8 900
6. Sub-Saharan Africa	630 000
7. Eastern Europe & Central Asia	3 700
8. East Asia	2 300
9. South & South-East Asia	44 000
10. Oceania	1 100

The teaching profession has been severely affected:

- In Zambia, more teachers died of HIV/AIDS in 1996 than were produced by the country's colleges that year. And 1 300 teachers died in the first 10 months of 1998 compared with 680 teachers in 1996.
- In Kenya, teacher deaths rose from 450 in 1995 to 1 500 in 1999.
- HIV-positive teachers are estimated at over 30 percent in parts of Malawi and Uganda, 20 percent in Zambia, and 12 percent in South Africa. (HIV/AIDS: A Strategic Approach, 2001).

The Education Labour Relations Council, a statutory body which facilitates negotiations between Teacher Unions and the Department of Education in South Africa, commissioned the Human Sciences Research Council of South Africa (HSRC) to conduct a study on "*Survey of South African Public Educators on Impact of HIV/AIDS on educators, 2004"*. Educators indicated that:

- There was a shortage of educators
- The number of learners per class increased
- Their ability to teach effectively decreased
- They had less time for preparation and marking
- They had to teach subjects they were not trained in, on behalf of ill colleagues
- They felt depressed

Because of HIV/AIDS children's right to quality education was compromised due to:

- Educators having to deal with orphans who were mostly heading households.
- Children who became vulnerable due to their parents either working away from home or AIDS related diseases such as TB that require parents to be away in hospital.
- Children being expected to provide care to sick persons or take on additional responsibilities.

The impact of the HIV/AIDS is that the quality of education suffers because:

- A significant percentage of educators are infected and die prematurely.
- The death of colleagues, learners, family members and community members affects their ability to teach effectively.
- They find themselves with large class sizes, and therefore unable to attend to all the learners.
- Children affected and infected are not able to concentrate well to receive good quality education.

HIV/AIDS is not just numbers, staggering and frightening though these are. It is our lives.

Those who have died through AIDS were fathers, and mothers, and brothers and sisters, dear friends; they were doctors and nurses; primary school teachers, electrical engineers; community leaders; finance managers; entrepreneurs, researchers, and communal farmers trying to lift their families out of poverty (World Bank, 2000). They were our students in higher education institutions. They were our members of academic staff. They were our workers.

HIV/AIDS therefore goes beyond statistics. It is at the heart of our lives, touching things we touch and affecting people we love. As Mungai (2001) puts it "They (statistics) do not describe the processes of the lives, the illnesses and deaths of people tested. It is the lives of whole generations of AIDS orphans who will miss education, including the lives of those who end up in the streets, in prostitution and in deeper poverty unless they are cared for. It is the overwhelming problems experienced by relatives due to the sheer number of AIDS orphans under their care.

It is the agony of children who watch their lonely parents die in pain. In other families the parents are unable to earn a living yet in others the extended family has broken down.

It is the economic problem of orphans managing households as well as the nutritional problems involved and the efforts made by AIDS orphans to grow food. It is concerned with the poor health care that AIDS orphans get.

It is the sexuality, especially the process of adolescent development, which underlies sexual maturation, marriage ad family development. It is the patterns of sexual activities which lead to HIV infection. Of particular interest are the lives of commercial and forced sexual activities. (p. 261 – 62).

As long as there is no cure for HIV/AIDS, one of the most important lines of battle against the epidemic is effective HIV/AIDS education. Awareness has so far been created of the activities that increase risk and transmission. However, it is now necessary to be much more effective in promoting prevention of STDs and HIV/AIDS through a structured education which people can internalize. (Mungai, 2001, p. 239).

The challenge posed by the HIV/AIDS pandemic is threefold: stopping the further spread of the disease; providing care and support for those infected and affected, and offsetting the negative impacts of the disease on individuals, institutions, ad society's social systems.

Many Governments in Africa have developed and are developing responses to the pandemic. Michael Kelly in his paper, "*African Universities and HIV/AIDS"* identifies three reasons why any responsible academic should be centrally concerned about HIV/AIDS. Kelly argues that "First, AIDS has changed the world as we know it. Second, AIDS makes it imperative that a university takes the special steps needed to maintain itself as a functioning institution. Third, AIDS calls on a university to exercise certain responsibilities to the society within which it operates". (Kelly, 2000)

What have higher education institutions done in this respect? First we turn to a consideration of what the situation is with respect to HIV/AIDS in higher education institutions.

Higher Educatin Institutions and HIV/AIDS: Present Status

The dangers of HIV/AIDS to all peoples around the world, but particularly to people in Africa are now a matter of public record. So are the dangers posed to institutions such as Universities which are vulnerable to many adverse effects of HIV/AIDS. In recognition of this situation the Working Group on Higher Education (WGHE) of the Association for the Development of Education in Africa (ADEA) decided to undertake case studies on the way HIV/AIDS affects some individual universities in Africa, and to document the responses and coping mechanisms that these institutions had developed. The purpose of the studies was describe as well as to "generate understanding of the way that HIV/AIDS is affecting universities and to identify responses of staff, students, and management that might profitably be shared with sister institutions in similar circumstance." (Anarfi, J.H. 2000; Barnes, T. 2000; Magambu, J.K. 2000; Mwape, G. & Kathuria, R. 2000; Nzioka, C. 2000; Otaala, B. 2000; Seclonde, H. 2000).

The terms of reference were inter alia to respond to the following questions:

1. In what ways have the universities concerned been affected by HIV/AIDS?
2. How have the universities reacted to these impacts?
3. What steps are the universities taking to control and limit the further spread of the disease on their campuses?
4. What HIV/AIDS-related teaching, research, publication and advisory services have the universities undertaken?

5. How do the universities propose to anticipate and address the larger impact of HIV/AIDS on the national labour market for university graduates?

Out of the case studies Professor Michael Kelly of the University of Zambia made a synthesis entitled "*Challenging the Challenger: Understanding and Expanding the Response of Universities in Africa to HIV/AIDS.*" (Kelly, 2001)

The report paints a disquieting picture, as it indicates that many of the institutions studied remain in the dark concerning the HIV/AIDS situation on their own campuses: "*A thick cloak of ignorance surrounds the presence of the disease in the Universities. This cloak is amply lined with layers of secrecy, silence, denial, and fear of stigmatization and discrimination*".

In spite of difference in details, the studies show that HIV/AIDS is having a serious impact on the fiscal situation of the universities in much the same way as it does on other institutions. The disease increases operating costs, reduces productivity (especially through high absenteeism), diverts resources, and threatens sources of income. Although the case studies provide limited evidence in these areas (university record-keeping does not enable it), they make it clear that universities are experiencing all four effects.

Evidence from the case studies suggests that the university in Africa is a high risk institution for the transmission of HIV. "*Sugar-daddy" practices, sexual experimentation, prostitution on campus, unprotected casual sex, gender violence, multiple partners, and similar high-risk activities are all manifested to a greater or lesser degree."* Therefore, the report recommends, the entire university community – but in particular the university management – needs to face this threat squarely. "In the HIV/AIDS context of university life today the university culture is in danger of affirming risk more than safety. It Is in danger of affirming death more than life".

One unsettling finding that emerges from the report concerns the social life of students on campus and the extreme vulnerability of female students, workers, and those in precarious circumstances. Kelly says the case studies *"are shot through with concern about the subordinate status of female students and, in particular, their inability to negotiate for either no sex or safer sexual practices."* He speaks about *"consensual rape",* consents under duress to intercourse in order to preserve a relationship, avoid a beating, ensure financial support, or repay favours. The case studies suggest the prevailing climate on university campuses may encourage such violence and thereby facilitate the spread of HIV/AIDS.

In 2004, The Association of African Universities (AAU) commissioned a study entitled:

"*The response of universities to HIV/AIDS in the Global AIDS Initiative Countries of Africa-".*

The purpose of the study was:

- to assess African Universities' capacity to contribute to solutions not only through the teachers and other professionals they produce but also through their impact in policy and in the communities they serve.
- To examine how African universities in the target countries address HIV/AIDS.

The study covered 81 High Education Institutions in the Global AIDS initiative countries: Botswana, Cote d'Ivoire, Ethiopia, Kenyak Mozabique, Nambiia, Nigeria, Rwanda, South Africa, Tanzania and Zambia.

Results similar to Kelly's were obtained. And in 2005 UNESCO published a study entitled:

> *"Results from the Cross-Country Study of Higher Education Institutions' responses to HIV and AIDS".*

Overall the case studies demonstrate that there is little known in all the twelve institutions about the situation of HIV and AIDS. Information on staff and student morbidity and mortality is largely unavailable, and AIDS-related deaths are reported anecdotally. While small-scale knowledge, attitudes, and practices surveys have been undertaken on some campuses, no rigorous impact or risk assessments were available in any institution. As such, institutions are dealing with a problem whose magnitude and impact is unknown.

There are promising examples of research programmes contributing to national policies and programmes and a greater understanding of HIV and AIDS at multiple levels. Peer education programmes have expanded HIV preventive education and health promotion, and developed life skills and psychosocial competencies among members. Awareness raising campaigns appear to have contributed to increased dialogue and improved knowledge, although concomitant changes in behaviour are less certain.

The Situation in Secondary Level Education

In Namibia, the work of Zimba and Mostert (1993) stands out as a unique example of how their cognitive, attitudinal and behavioral risks among secondary school learners may promote HIV infection and promote the spread of AIDS. The authors sought to find out what the adolescents' understanding of sexual activity and modes of HIV infection as well as ways of preventing infection. 1 471 students from five of Namibia's 13 regions completed questionnaires and participated in focus group discussions.

Several risks were identified, for instance:

- 50 % of the students did not know the meaning of AIDS;
- 18 % thought there was a cure for AIDS;
- 42 % thought that some people were immune to HIV infection; and
- 46 % thought that HIV-infected persons did not look and feel healthy.

These results revealed the existence of misconceptions and a lack of accurate knowledge on the meaning and causes of HIV/AIDS; how infection occurs and a diminished perception of being at risk. In terms of behavioral misconceptions, a third of the sample feared getting infection from kissing, mosquito bites, public toilets, and swimming pools.

20 % of the sample took drugs, and 78 % took alcohol, thus increasing risks of HIV infection.

The authors made a number of recommendations:

1. Establishment of a school curriculum based on HIV/AIDS prevention programme for Namibian schools.
2. A systematic research project on secondary schools teachers' readiness to participate in the conception, design and running the HIV/AIDS prevention programme.
3. A survey to ascertain parents' fears, misconceptions and risks and to determine objections/support for introduction of HIV programmes.

Based on the clear findings that students expressed various risks, the authors recommend that once in place, the HIV/AIDS prevention programme should create opportunities for engaging the students into direct, active, sustained and focused risk reduction activities. This is based on the assumption, supported by this study's findings, that increasing HIV/AIDS knowledge per se would not take care of attitudinal and behavioral risks. (Zimba & Mostert (1993 – p. 64)

"Our results revealed that several potential HIV infection risks emanated from normal social-cognitive developmental demands for love, acceptance, peer conformity, conflict resolution, adolescent stress management and the quest for excitement and new experience. Given this, we recommend that efforts to reduce HIV infection risks among the students should be located in their "world". Media messages and HVI/AIDS prevention strategies meant for the general public would be less effective when used in programmes for the youth." (p. 64 – 65)

"Differences in responses to questions on sex meant that HIV infection risks were not always uniformly shared by boys and girls. Because of this, we recommend that school HIV/AIDS prevention efforts should partly aim at enhancing girls' self-concept and empowering them to resist seduction and sexual abuse. Boys should be helped to change their risky attitudes for the protection of others and themselves (p.65).

As sources of information, education, guidance and advice, parents in our study were not ranked highly. This can be explained by traditional beliefs which discourage parents from discussing sex with their children. Because of the seriousness of the HIV infection, we recommend that parental involvement in school HIV/AIDS prevention efforts be increased. Parents should be sufficiently educated about HIV/AIDS and asked to support and participate in prevention activities to protect their children from infection. (p. 65)

From the various activities described in the previous section, it would be helpful to provide examples of some **good practice** as well as indicating some constraints or barriers to change.

Examples of good Practice

From the Kelly report (2001) and the ACU workshop held in Lusaka (ACU, 2001) as well as some recent developments, it is possible to cite illustrative examples of **good practice** in HIV/AIDS policy development in universities and community engagement.

HIV/AIDS Policy Development
A number of Universities in South Africa have had HIV/AIDS policies for some time now (Chetty, 2000). More recently other universities in Africa have developed policies, including Kenyatta University, and the University of Namibia.

The University of Namibia (UNAM) has a Policy on HIV/AIDS. This Policy grew out of policy guidelines on HIV/AIDS originally drafted in 1997. The University of Namibia's policy on HIV/AIDS articulates with, and supports, the National Strategic Plan on HIV/AIDS Medium Term Plan II (1999 – 2004) and the 2001 Namibian HIV/AIDS Charter of Rights. The Policy is strongly shaped by normative considerations and the Human Rights provisions embodied in the Constitution of the Republic of Namibia.

The Policy has four principal constitutive components. These are:
- *The rights and responsibilities of staff and student,.*
- *The integration of HIV/AIDS in teaching, research and community service,*
- *Preventive care and support services, and*
- *Policy implementation, monitoring and review.*

At its last meeting in November 2002, the Senate of the University approved the HIV/AIDS Five Year Strategic Plan: 2003 – 2007, for implementation of its policy. Other universities which have not yet developed HIV/AIDS Policies were invited by the Working Group on Higher Education (WGHE) of the Association for the development of Education in Africa (ADEA) to bid for some modest funding to assist them develop their HIV/AIDS policies. To date four awards have been made to the Mombasa Polytechnic, University of Botswana, Highridge Teachers Training College, Nairobi, and Nkumba University, Entebbe, Uganda (Lamptey, 2003). On Nkumba University, William Saint had this to say:

> Prompted by Professor Kelly's report, "*Challenging the Challenger"*, stimulated by the example of the University of Namibia AIDS Policy, and financed by a small grant from the ADEA Working Group on Higher Education, the Nkumba University in Uganda has just completed the publication of its policy statement on HIV/AIDS. The policy was approved by Senate on December 13, 2002. (Saint, 2003 personal communication)

Community Engagement

Home-Based Care Programme

A lecturer at the University of Botswana set up a home-based care programme for HIV/AIDS infected and affected members of the community; and the programme proved so effective that the Government has taken it up as a model.

Youth Radio Station

The University of Namibia established a radio station in 2001 (under the auspices of UNESCO), which uses music, jingles, drama and talk shows as a means of mainstreaming HIV/AIDS issues among youth. It aims both to entertain and educate; and a survey revealed that it is the most popular radio programme for young people. 78 % of young people in the 16 – 24 age bracket and 98 % of the students on campus listen to it. Incidentally, it promotes and enhances the image of the University and provides a range of practical training, skills and experience that are of value to graduates wanting to work in the broadcasting and communications industries.

House to House Counselling

The University of Namibia has started a pilot project whereby school leavers in areas where prevalence is determined to be high are trained to equip them for house to house counseling. Their brief is to go from door to door collecting information about the incidence of STDs and HIV-related sickness and death, and to report back to the clinic, which then takes appropriate action to provide the necessary services.

My Future is My Choice is a University of Namibia initiative which aims to empower students in the 15 – 18 year old age bracket by giving them the information and skills that will enable them to make the personal choice to change their behaviour. It is firmly based on the concept of Child-to-Child transfer of knowledge (i.e., the older child passes information to the younger) – a system which is culturally acceptable and common in Africa; and the government has now adopted the programme for lower grade school children.

Introducing Certificate Courses and/or Modules

Kenyatta University is offering a wide variety of HIV/AIDS-related courses at the certificate, diploma (mainly in the holidays, for teachers) and post-graduate levels, and they are proving to be increasingly popular because of their reputation for helping graduates to secure really good jobs. What is particularly interesting is that full-time programmes are being offered in the evenings by demand and on a "paid for" basis – and it is not only working people from the community but also students who are opting to register for and pay for these programmes; such is their perceived value and relevance. The fee structure also means that the university can afford to pay for well-qualified and able teachers, thereby perpetuating the success of the programmes.

Training Community Leaders in HIV/AIDS

Kenyatta University is also involved through these programmes in spearheading the training of community leaders so that they are sufficiently informed about the issues and can play their part in minimizing the spread of the pandemic.

Involvement in Community Improvement Projects
Another aspect of Kenyatta's involvement with the community is the development of an outreach project called OKUO. This involves students and staff in various community projects such as cleaning the environment, advising on mother-to-child transmission, helping to plan home and family care (including advice on nutrition), providing counseling on HIV/AIDS and assisting with the care of orphans. (ACU, 2001. pp. 10 – 11)

The University of Namibia in collaboration with the University of Tampere, Finland, run a training workshop for Regional Governors, Senior Administrative Officers and Mayors and Town Clerks from all over Namibia, entitled "*The Role of Leaders in the Prevention of HIV/AIDS*". The workshop was designed to sensitize these leaders to various issues on HIV/AIDS and to assist the care of the infected and affected, and the mitigation of the pandemic on individuals and institutions.

The foregoing experiences provide a strong indication that gains and successes are being achieved in the fight against HIV/AIDS. It has become clear, however, that it is necessary to have a structured programme on HIV/AIDS education aimed at bringing about long-term behaviour change in sexual lifestyles. In order to achieve this goal, the HVI/AIDS programme would need to be integrated with both formal and continuing education, with adolescent development being the central topic, in order for it to be stable and sustainable (Mungai, 2001, p. 250).

The approach must be multi-sectoral and multi-disciplinary. And this must be reflected in all the activities, including the HIV/AIDS education programmes.

We turn to a brief consideration of barriers or constraints encountered by higher education institutions and schools.

Barriers or Constraints and Challenges
The ACU (2001) Lusaka report identifies the following as barriers to change:
- Lack of high level commitment
- Lack of necessary structures for implementation
- Lack of empirical evidence of the scope and scale of the problem
- Lack of resources (human and financial)
- Lack of buy-in from the campus community
- Limited access into the academic curriculum

Kelly (2001) indicates as a challenge the need for a comprehensive HIV Prevention Programme the first requirement of which is total management **commitment** which runs through and drives each of the following:

- HIV/AIDS policy and strategy development
- Developing culturally appropriate prevention messages
- Tackling socio-economic factors

- Establishing partnerships
- Sustaining awareness and education
- Challenging denial and stigma
- Situating prevention in a community context
- Linking care to prevention
- Rigorous scientific reflection

Additional challenges have come from the EFA goals (2000); the Millennium Development Goals (2001); and the UGASS Declaration of Commitment on HIV/AIDS as indicated in boxes **3 and 5**.

BOX 1: EFA GOALS (2000)
▪ expanding and improving comprehensive early childhood care and education, especially for the most vulnerable and disadvantaged children;
▪ ensuring that by 2015 all children, particularly girls, children in difficult circumstances and those belonging to ethnic minorities, have access to and complete free and compulsory primary education of good quality;
▪ ensuring that the learning needs of all young people and adults are met through equitable access to appropriate learning and life skills programmes;
▪ achieving a 50 percent improvement in levels of adult literacy by 2015, especially for women, and equitable access to basic and continuing education for all adults;
▪ eliminating gender disparities in primary and secondary education by 2005, and achieving gender equality in education by 2015, with a focus on ensuring girls' full and equal access to and achievement in basic education of good quality; and
▪ improving all aspects of the quality education and ensuring excellence of all so that recognized and measurable learning outcomes are achieved by all, especially in literacy, numeracy and essential life skills.

BOX 2: MILLENNIUM DEVELOPMENT GOALS (2001)

Agreed upon goals include:

Goal 2: To achieve universal primary education. Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling;

Goal 3: To promote gender equality and empower women. Eliminate gender disparity in primary and secondary education preferably by 2005 and in all levels of education no later than 2015;

Goal 6: To combat HIV/AIDS, malaria and other diseases. Have halted by 2015 and begun to reverse the spread of HIV/AIDS. Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases.

BOX 3: UNGASS DECLERATION OF COMMITMENT ON HIV/AIDS (2001)

Agreed upon targets include:

- reducing HIV infection among 15 to 24 year-olds by 25 percent in the most affected countries by 2005 and, globally by 2010;
- developing by 2003, and implementing by 2005, national strategies to provide supportive environment for orphans and children infected and affected by HIV/AIDS;
- ensuring that by 2005 at least 90 percent, and by 2010 at least 95 percent of young men and women aged 15 to 24 have access to the information, education, including peer education and youth-specific HIV education, and services necessary to develop the life skills required to reduce their vulnerability to HIV infection; and
- having in place strategies by 2003, to address vulnerability to HIV infection, including under-development, economic insecurity, poverty, lack of empowerment of women, lack of education, social exclusion, illiteracy, discrimination, lack of information and/or commodities for self-protection, and all types of sexual exploitation of women, girls and boys.

Given the above-named constraints/barriers and challenges, one can ask "where do we go from here"? What can higher education institutions do, to respond to the HIV/AIDS pandemic? We briefly deal with this question in the following paragraphs.

Where do we go Fom Here?

In order to respond successfully to challenges and risks implied above, and the vulnerability to which all of us are susceptible, the call is for commitment at personal, moral, political and social levels. Some points in this respect are quite clear for institutions of higher education.

1. Prevention has to be the main priority, especially in countries where the prevalence rates are higher. Prevention has to extend to care and to the mitigation of the impact of the pandemic on individuals and institutions.

   As Graca Machel Mandela puts it:

   > *There is a need to design and implement strategies that are as comprehensive as the virus itself. We must have prevention, and a continuum of care and treatment within one paradigm.*

2. Top-down commitment and support is essential: from the political, through the institutional, to the local level. In this regard the need for a paradigm shift in terms of instituting health promoting institutions, as described below is axiomatic.

Health Promoting Educational Institutions

The vision of health promoting educational institutions is derived from existing models of health promoting schools, with a specific emphasis on the practical need for HIV/AIDS to be viewed and addressed holistically in the region. In 1978 the Child-to-Child Programme based at the Institute of Education, University of London, supported the implementation of health-promoting schools. The World Health Organization (WHO) also notes that "although definitions vary, depending on need and circumstance, a Health Promoting School can be characterized as a school constantly strengthening its capacity as a healthy setting for living, learning and working".

Parson et al (1969) identify three benchmarks of a successful health promoting school. These are:

(i) an enabling environment (including the management, policies and relationships of the school to community);
(ii) the provision of a health enhancing physical and social environments in schools and through formal curricula; and
(iii) quantifying the product of health promotion in terms of knowledge, attitudes, behaviors, competencies, and values.

This last notion of 'health promotion' is intimately linked with the concept of "mainstreaming of HIV/AIDS into the curricula" in a university or school setting.

I have adopted the definition of "mainstreaming" as advanced by Michael Kelly (2005). Kelly (2005) defines mainstreaming HIV/AIDS as "ensuring that HIV/AIDS concerns become routine so that policies, programmes, and decisions are informed by, and take full account of, relevant HIV issues". As such mainstreaming seeks to ensure that staff and students routinely understand the relevance of HIV/AIDS of what they do as members of an institution and … to establish policies, plans, programmes and activities which effectively address the concerns arising from the epidemic." A report produced by HEARD on HIV/AIDS mainstreaming into government sectors defines mainstreaming as "the process of analyzing how HIV and AIDS impacts on all sectors now and in the future, both internally and externally, to determine how each sector should respond based on its comparative advantage" (HEARD, 2003). This applies to all educational institutions as part of the educational sectors of a country but also as human resources training centres. Mainstreaming can thus be identified as the dissemination of an issue into every operation of an institution, which finally coalesces in a paradigm shift.

Initiating and developing such a paradigm shift in relation to HIV/AIDS crisis is the most crucial aspect of the creation of a health promoting educational institution environment in many countries in Sub-Saharan Africa. This is because HIV/AIDS is a health crisis that already permeates campus life; it is a health crisis which impacts every discipline and which will impact the future work places of students from the present tertiary educational institutions, including universities. Most significantly, it is a health crisis that has or will have implications for most, if not all, of the tertiary educational institutions' community personally. Thus, in order to achieve health promotion competency, HIV/AIDS must become mainstreamed in the way that Kelly (2005) and HEARD define the process. The results of this revolutionary approach will have a significant, positive impact on the tertiary educational institutions' communities, and enable them to serve as models of HIV/AIDS mainstreaming for other institutions.

Partnership and Collaboration

The need for partnership and collaboration is axiomatic. The determinants of health lie outside the medical care system. Just as the underlying problems of poverty penetrate every pore of public health analysis the universities and other tertiary institutions as well as other educational institutions have to learn to work across departments, faculties and research interests - - sharing budgets and research funds, teaching programmes and being prepared to modify curricula to meet a common purpose. This also means offering skills and knowledge in non-academic prose to others, including politicians. Externally there is also need for partnership and collaboration with various institutions including:

Partnering to prevent youth infection

The World Bank is a member of the UN Interagency Working Group on schools and education, a partnership that facilitates countries development of strategic plans for HIV/AIDS prevention and impact management in education systems. How best can higher education institutions partner with it in matching teacher supply and demand and in providing quality skills-based prevention programmes and in enabling all children and youth to receive good quality education?

Collaboration with Commonwealth of Learning (COL)
The Commonwealth of Learning (COL) is already collaborating with UNESCO on a number areas, including distance education. It would be feasible to explore ways that it and UNESCO could support higher education institutions in the use of distance education to train rural communities as well as teachers on various aspects of HIV/AIDS.

Collaboration with UNESCO
Under the UNESCO/UNITWIN Network for Southern Africa, UNESCO "twins" three Universities in Southern Africa (Namibia, Eduardo Mondlane, University of Western Cape) with Universities in the north (Bochum, Lund, Utrecht). UNESCO Chairs have been created for Mathematics and Science Education, Human Rights and Democracy, and Environment. This arrangement has worked extremely well over a number of years and important documentation has been produced, capacity built through training and various programmes addressing these issued developed.

UNESCO could assist in the creation of chairs on HIV/AIDS in a number of institutions, particularly in those countries which have high prevalence rates. It could also assist in developing curricula for schools, tertiary institutions and colleges of education, on HIV/AIDS education, as well as assist in training of counseling for HIV/AIDS, since both the Guidance Unit in UNESCO Headquarters and the Regional Guidance and Training centre in Malawi fall under its remit. In this last regard an initiative has been taken by us in consultation with Professor Babatunde Ipaye (University of Ilorin) to develop modules for HIV/AIDS Counselling (Appendix I).

Collaboration with Forum for African Women Educators (FAWE)
The Forum for African Women Educators (FAWE) with Headquarters in Nairobi, Kenya, and with country chapters in many African countries has done extremely commendable work in promoting girls' education and promoting the notion that girls, given support and encouragement, have the potential to succeed in science and science-oriented subjects, including those that have been the preserve of the males, as well as anybody. FAWE has particularly been successful in their work through the Female Education in Mathematics and Science in Africa (FEMSA) Project which is linked to UNESCO's Special Project: "*Scientific, Technical and Vocational Education of Girls in Africa*". Launched in 1996, it covers activities in twelve African countries, including eight LDCs (Burkina Faso, Cameroon, Ghana, Kenya, Malawi, Mali, Mozambique, Senegal, Swaziland, United Republic of Tanzania, Uganda, Zambia). The overall objective of the project is to assist in improving girls participation in scientific, technical and vocational education (STVE), so as to give them the impetus necessary to launch into science careers. Specific objectives aim to include more girls in secondary school, notably by improving the quality and effectiveness of STVE, to make an impact on the attitudes and stereotypes which preventing girls from taking advantage of current opportunities in science and technology, and to promote a positive image of women in scientific and technical areas, as well as in social circles.

Higher education institutions could work collaboratively in the achievement of the various goals including the EFA goals (2000); the Millennium goals (2001) and the UNGASS Declaration of Commitment on HIV/AIDS (2001).

Collaboration with Women in Higher Education and Science
Phase I of the project "*Women in Higher Education and Science: African Universities Responding to HIV/AIDS*" was implemented between 2001 and 2004 and involved seven universities.

It started with a workshop in which 55 participants gathered at the meeting in Nairobi, Kenya, to discuss the extent and impacts of the HIV/AIDS crisis in East Africa and to review what responses had been undertaken by universities in the region, to formulate specific proposals to address areas where university action was most urgently needed.

During the workshop it emerged that only one (Kenyatta University) of the attending universities had a curriculum for undergraduate students in place for the teaching of HIV/AIDS course for Education students. It was also noted that universities have the potential and capability to contribute to the control of the spread of HIV/AIDS.

Five universities developed proposal for developing undergraduate curricular in HIV/AID. The participants underwent training on how to formulate a common course of HIV/AIDS and how to teach it. In the second year participants attended the Science Education for New Civic Engagement and Responsibilities (SENCER) Institute at Santa Clara University, California. The overall goal of their efforts was to help mainstream HIV/AIDS into the university programmes.

The core of these initiatives is to develop new models of education that connect basic science learning to complex public issues like HIV/AIDS that are appropriate to the conditions on African campuses. By emphasizing these connections in an interdisciplinary manner, students learn basic scientific knowledge (as it becomes more relevant) and engage more responsibly with the issues (as they learn the factual basis for addressing them).

Phase II of the project was implemented through a workshop in 2005, with the following goals:

1. confronting HIV/AIDS pandemic through integration of HIV and AIDS components in curriculum development and education in universities; and

2. improving science and health education in Africa universities

The purpose of the workshop was to infuse or integrate HIV/AIDS into selected university common courses. The three courses that were identified were Communication Skills, Development Studies and Entrepreneurial Skills. These are common undergraduate courses that are compulsory and offered in most Kenyan public and private universities. The expected outcome of the workshop was that the university common courses integrated with HIV and AIDS would be expanded to incorporate

HIV/AIDS. This is in line with Ministry of Education HIV/AIDS policy encouraging the mainstreaming HIV/AIDS into the curricular. With financial support this project can be replicated in other African countries outside Kenya.

Collaboration with the UN GIRLS' Education Initiative (UNGEI)
UNGEI is a movement of agencies, governments and civil societies committed to gender equality. It is also an active and growing partnership at regional and national levels. Its objective is to ensure girls as well as boys have opportunity to access and successfully complete a quality education.

In conjunction with the recent EFA High Level Meeting in Cairo (14 – 16 November 2006), UNGEI organized a technical meeting on the 12 November 2006. The starting point of the meeting was the findings of the Global Monitoring Report (GMR) 2007 focusing on Early Childhood Care and Education (ECCE) and the links to girls' education. The GMR clearly states that quality ECCE for girls and boys, in particular the most marginalized and disadvantaged, has a tremendous impact on the achievement of the EFA goals and contributes to the achievement of the MDGs. Findings included:

- Quality ECCE prepares a solid foundation for learning and makes both girls and boys ready to learn and attend school at the right age.

- Quality ECCE programmes have a positive impact on drop-out and repetition rates. The impact is greater for disadvantaged children.

- Quality ECCE programmes include parenting education and improve parents' and caregivers' knowledge and skills in caring for their children.

- ECCE increases girls' motivation, expectations and self-esteem – and these characteristics enable girls to better protect themselves against violence, HIV/AIDS and in emergencies.

- More girls can attend and complete school when they are relieved of child care responsibilities.

- ECCE can help change the roots of discrimination against girls by proving equal opportunities for boys and girls from an early age.

Collaboration with the Association of African Universities (AAU) and Association of Commonwealth Universities (ACU)
The working group on Higher Education (WGHE) of the Association for Development of Education in Africa (ADEA) has already taken initiatives supporting HIV/AIDS work in higher education institutions. It commissioned the study for instance, of seven universities referred to earlier. This role has been passed on to the AAU headquarters. It would be ideal to extend this work to other higher education institutions. The AAU has supported HIV/AIDS policy development in higher education institutions, as witness by the recent awards for this purpose. This commendable support should continue. In

addition support for the development of strategic plans to implement HIV/AIDS policies should be initiated, as should tracer studies of past students of tertiary institutions. The Association of Commonwealth University should work hard-in-glove with the AAU in these endeavours.

Collaboration with the New Partnership for African Development (NEPAD)
The New Partnership for Africa's Development (NEPAD) is a vision and strategic framework for Africa's renewal. The strategic framework document arises from a mandate given to the five initiating Heads of State (Algeria, Egypt, Nigeria, Senegal, South Africa) by the Organization of African Unity (OAU) to develop an integrated socio-economic development framework for Africa. The 37th Summit of the OAU in July 2001 formally adopted the strategic framework document. NEPAD is designed to address the current challenges facing the African continent. Issues such as the escalating poverty levels, underdevelopment and the continued marginalization of Africa needed a new radical intervention, spearheaded by African leaders, to develop a new Vision that would guarantee Africa's Renewal.

Primary Objectives include:

- To eradicate poverty
- To place African countries, both individually and collectively, on a path of sustainable growth and development;
- To halt the marginalization of Africa in the globalization process and enhance its full and beneficial integration into the global economy.
- To accelerate the empowerment of women.

Regional Workshops: Some of its activities and functions of NEPAD is to discuss strategic framework for Africa
Regional workshops to discuss the medium to long-term strategic framework for infrastructure development in Africa will be hosted by the Regional economic communities (RECs) and convened by African Development Bank (ADB) and NEPAD.

Because African economies considered individually are typically too small, **collaboration** and joint action at sub-regional levels are necessary for the development of regional infrastructure to allow for economies of scale through pooling and joint facilities, and to overcome the limitations of small markets and enhance competition. The goal of NEPAD is to develop infrastructure services that are adequate, efficient and of minimum cost, and can therefore support the development of trade and economic growth needed for achieving the NEPAD aim of reversing Africa's marginalization in the global economy.

E-schools launch in Egypt
More than **1 000** people attended the official launch of the NEPAD e-Schools demonstration project in Egypt in February 2007. The project involves 6 schools from **each** of the **16** participating countries in Africa. The project focuses on providing end-to-end Information Communication Technology (ICT) solutions that will connect schools across Africa to the NEPAD e-schools network and internet. It also includes the

provision of content, learning material, and the establishment of health points at the schools.

Egypt is the sixth country to launch the project after Uganda, Ghana, Lesotho, Kenya and Rwanda. This initiative is intended to graduate from the schools young people who are strong in body, mind, and character, who will be equipped with ICT skills to meet the challenges of the information society in a globalised world.

Role of ICT in development
Over 80 delegates recently attended a conference in South Africa themed *Achieving Best Value in Human Resources and Skills Management Using Information Communication and Technology*. Organized by NEPAD, the Commonwealth Secretariat and Africa Recruit the conference examined the business case for e-HR as well as a review of best practices, challenges, policies and case studies aimed at strengthening and developing productivity and employment in Africa.

Concluding Remarks
One of the most devastating criticisms of Universities and academics in Africa is that they do not play a role in addressing some of the most critical problems in Africa, and hence do not make a contribution to development efforts. The most critical problems in Africa include the HIV/AIDS pandemic. But some good progress has been made. Also at a meeting in Nairobi, the Association of African universities passed a declaration. In that declaration was an important resolution dealing with the issue of HIV/AIDS.

> "to a greater degree than ever before, African Universities must renew their commitment to helping Africa find effective solutions to its perennial problems of hunger, poverty and disease. They must, by their research and teaching, strengthen their contribution to improvements in food production and distribution, disease control and health service delivery, and the general wellbeing of their people. In particular, the HIV/AIDS crisis poses a serious threat to African societies within which Universities are situated. African Universities must be in the forefront of research, education and action in this area. We recognize that the solution to this problem might well reside in Africa."

The magnitude of this task is enormous, and, consequently, so is the responsibility taken by the University community through various present and future activities designed to stem and arrest the spread of HIV/AIDS. We believe that the message is not at all bleak, for the future does not have to be like the past. HIV spread can be prevented and we can deal with the consequences of AIDS. We believe that with strong and visible leadership from the University Administration there will be resonance from below. In the words of Human and Tafelberg (2000).

> Our key message is that, along with visible leadership from government and big business, the rest is up to each and everyone of us making a small contribution in our own way. The battle against HIV and AIDS will only be won by millions of initiatives at grassroots level. Some will be more effective than others, but every

> little bit will count. In the process, we have a good chance of creating a civil society – civil in the orthodox sense of building strong and sustainable institutions which are independent of the state; but civil too in the sense of instilling a genuinely caring ethic and feeling of fellowship among all the citizens who make up this remarkable continent - - Africa.

African universities (and other educational institutions) are faced with a dual challenge: on the one hand, the old problems of access and equity, funding, quality, etc., which are generally under control in most other parts of the world; on the other hand, the new demands of the knowledge society, namely curricular adjustments, linkage into industry, high-end research and innovation, as well as international networking for the purpose.

I would like to make a brief itemization on of some the suggestions on the way forward:

1. Investment and aid policy in relation to African HE needs to be adjusted away from what often appears to be an "either/or" approach, so that the education system is seen as such – a system: with the various parts interacting and reinforcing each other, and all contributing to the development process.
2. Africa's universities should be assisted to link more fully into the global knowledge networks - - this would involve, for instance, easier access for African researchers to global
   - Knowledge through the web - - one of the key action areas will be to tackle the limitations imposed on such access by inadequate bandwidth.
   - Greater access of African scholars to the laboratories and experimental sites of the best institutions in the world.
   - More North/South; South/South collaborative teaching and research projects involving African scholars, in true partnership mode.
3. Targeted support aimed at helping renew the African faculty through some of the measures listed above, but also fellowships, split-site graduate programmes and the greater involvement of the substantial numbers of scholars in the African Diaspora - - both in academia and in other spheres.
4. Facilitation of sub-regional and continent-wide interaction and collective work, and the provision of support, partnership and collaboration for the purpose.
5. Realistically, governments need to invest in issues related to health, food production, HIV/AIDS education and care, sanitation and clean water. They must also come to realize that technology is a resource that can be built so that African nations can assume control of their internal issues - - technology can indeed facilitate the ways in which action is taken with respect to each of these essential priorities. Africa's Internet infrastructure must be built and expanded in such a way as to facilitate online learning, improve the ability of students and scholars to conduct online scholarly searches, and expand educational opportunities for all learners beyond the confines of the lecture hall. In addition, scientific journals must become more widely available in Africa - - and African schools must be afforded a venue through which they can share their scholarship both with each other and the developed world. Computers and digital technology must no longer be viewed as a luxury; computers and digital technology are an essential component of and contributes to development.

6. Facilitation of African academic writing to epitomize how African writers continue to diversity from a knowledge consuming group to that of knowledge creators. Generally many African students are heavily dependent on Western research with little or no African studies to compare with.
7. There is need to establish clear principles of collaboration and partnership. Partnership should clearly state the purpose of collaboration, aim at building mutual trust and create an enabling environment for collaboration. This should be shared by all participating groups and should contain achievable goals and objectives. Collaborating partners should have the same vision. They should have a clearly agreed upon mission, with accompanying objectives and strategies. While the mission and goals of each of the collaborating partners will be different, their collaborative goals and interests should be shared.

African countries and their institutions have begun tackling the many problems of their University system, and there are many positive and encouraging signs. The rate of progress and the prospects for the renewal of the Universities in Africa will be much enhanced if Africa's friends took an informed interest in the process and followed through some of the commitments they have already made.

I am sure at this conference we wish to reaffirm the declaration of the African Universities quoted earlier. We are optimists by nature, and we believe in the three WWW's that we were introduced to in Nairobi some time ago, That is, We Will Win!, especially if we take to heart the challenges posed to us by Audience Africa (1995) indicated in **Appendix II**.

A favourite quote:

"In a time of drastic change it is the learners who survive; the "learned" find themselves fully equipped to live in a world that no longer exists"

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APPENDIX I
A MODULAR APPROACH TO THE TRAINING OF HIV/AIDS COUNSELORS IN AFRICA

Introduction

Module 1: An overview of counselling

1. Counseling as a helping profession
2. Counseling in Africa: Participants talk of the perceptions and place of counseling in their countries
3. Culture and Counseling
   - Socio-cultural premises of counseling
   - Culture as a facilitator in counseling
   - Inhibiting aspects of culture in counseling
   - Cultural variation in non-verbal communications and body language
   - Cultural silence on sex, and sexuality issues in Africa
4. Religion and Counseling: facilitating, inhibiting; meditative
5. Assessment/evaluation of counseling: Does counseling work?

Module 2: Introduction to health counseling

1. The concept of health and wellness as they relate to psychology and counseling
2. Meaning and purpose of health counseling
3. Enhancing and applying counseling skills to HIV/AIDS prevention work
4. Psychosomatic aspects of health

Module 3: HIV/AIDS: basic information for counselors

1. Basic introduction to the clinical manifestations of HIV infections and the AIDS disease. Methods of transmitting HIV.
2. Basic introduction to HIV antibody testing: concepts of sensitivity and specificity; types of tests available; concepts of sero-conversion and problems of false positive and false negative, etc., the crisis of the "worried well"
3. Transmission of HIV.
4. Prevention of HIV.
5. Pre-screening and post-screening counseling.
6. Mobilizing people for voluntary testing and counseling.
7. The social sequence of HIV.

Module 4: HIV/AIDS counseling

1. Theories and models in HIV counseling.
   - i) The Health Belief Model (HBM)
   - ii) The theory of reasoned action
   - iii) Social learning and cognitive theories
   - iv) The AIDS risk reduction model
   - v) Stages of change model
   - vi) Hierarchy of effects model
   - vii) Diffusion of innovations

viii) Social marketing
ix) Handling the case of the worried well
x) Hopelessness, helplessness and the existential self: the Biblical book of Job.

2. The psychology and culture of the major risk groups: adolescents; commercial sex workers; men who have sex with men; drug users and drug injectors; compulsive sex seekers; etc.
3. Patterns of communications with high-risk groups.
4. Reactions to HIV-positive results and counseling approaches In handling them.

Module 5: Systematic HIV-counseling

1. Meaning of systemic counseling in HIV/AIDS
2. Theory and practice of systemic counseling in HIV
3. Tasks in systemic counseling
4. Reframing: handling issues of spirituality and the client's belief system; helping to attain balance

Module 6: Psychological healing and the major counselling theories

1. Rational emotive theory
2. Personal construct theory
3. Reality therapy
4. Crisis theory and intervention
5. Logo therapy
6. Therapeutic treatment of existential neurosis
7. Problem solving therapy
8. Management of anxiety, depression, and stress related disorders

Module 7: Crisis counseling

1. Conceptual issues in crisis counseling
2. The philosophical vocabulary of the African in crisis situations and their application in HIV/AIDS counseling
3. The psychology of HIV/AIDS; crisis and crisis intervention; death; fatality and the African culture
4. Palliative counseling

Module 8: Home care and support networks

1. The concept of caring in the African culture
2. Support networks: purpose, functions and roles
3. Mobilizing/forming support networks

Module 9: Ancillary issues in HIV/AIDS counseling

1. Stigmatization and the counselor's role
2. Nutritional therapy in HIV/AIDS
3. Confidentiality and ethical issues in HIV counseling
4. The legal aspects of HIV/AIDS

Module 10: Practical work/project/field work

13. We are all in varying degrees responsible, and we must all make a firm and resolute commitment to reverse this trend, by breaking with the past and formulating a completely new endogenous development policy. We can do so provided that we share a number of convictions: the first is that, contrary to the general view, our continent is not poor. We all have to realize that, of all the continents, Africa has the greatest natural wealth, which means that with competent and serious men, capital and know-how, it could catch up with other parts of the world very quickly, as Latin America and Asia are now doing.

14. The second fact of which we must be convinced is that independence is not an end in itself but a means to the end of national liberation; in other words taking oneself in hand.

15. The third is that Africa will never be built by foreigners, whatever emotional, cultural and personal bonds they have formed with the continent, and whatever the terms of the moral contract that might lay the basis for a new type of partnership between our continent and the international community. Incidentally, the end purpose of assistance is to make it possible for assistance to be phased out.

16. The fourth is that only Africa can decide its destiny. Africans – and they above all – must take the initiative in solving their own problems. Africa is neither a 'lost continent' nor 'a continent in distress' inhabited by people incapable of raising themselves to the level of other peoples.

17. The fifth is that as long as Africans have no confidence in themselves, in their brothers and sisters, in their culture, in their abilities or in their values, they will never make full use of the resources of creativity and inventiveness that lie dormant within them.

18. The sixth is that the three decades of difficulties, mistakes, hesitant experimentation, set-backs and partial successes that have brought discredit on our continent will not have been in vain if we have the courage to carry out a critical assessment of the situation, examine our own consciences, recognize our inadequacies and weaknesses and draw, with humility, all the appropriate lessons from it with a view to a new start.

19. The seventh is that, notwithstanding the need for structural adjustment plans, they should rapidly give way to genuine development programmes based on growth, full employment and justice, devised and carried out by the citizens of the countries themselves for the benefit, in particular, of the most disadvantaged sections of society.

20. The eighth is that any centralization of power or seizure of power by a minority operating through a single party or a State-party is harmful. It is contrary to the process of development and represents a form of dictatorship. It must be opposed. Africa needs democracy because it is the missing link between development and peace, democracy being understood not as a model to be copied but as an objective to be attained.

21. The ninth is that as long as the idea of peace is mistreated in Africa, efforts to promote development will never live up to expectations. Armed conflicts, civil wars, border disputes, tribalism and ethnic rivalries, political disputes and the exploitation of religion for partisan ends make it only realistic to regard political instability and war not as epiphenomena but as a serious and ongoing trend. We can reverse this trend, which has gone on for 50 years, but we shall need an inflexible political will.

22. Finally, as compared with Europe, the Americans, and the countries of the Indian Ocean and the Pacific, which are forming economic blocs engaged in cut-throat competition, micro-States have no chance of becoming significant and credible forces unless they unite. With its present population of 640 million people, who will number more than 1.2 thousand million consumers in 23 year's time, we can be sure that Africa, with the wealth of its soil, its subsoil, its seas, its forests and its tourists and cultural potential, will never be marginalized if its people have the necessary negotiating skills to turn such undoubted benefits to commercial advantage. (Audience Africa, pp. 3 – 4).

Part 2: Invited Speakers' Papers

(In alphabetical order by first speaker's surname)

CUTTING EDGE SUSTAINABILITY – COLUMNS, PIPES & PASCUA

Philip Bangerter, Centre for Sustainable Resource Processing, Brisbane, Australia

Abstract: As engineering graduates emerge from their tertiary education, how well are they abreast of the Sustainability and Sustainable Development issues that confront our societies? If they are poorly equipped, where do we fall down? Is it lagging curriculum content at secondary and tertiary level or perhaps poor signals from industry? Is it climate-change science or environment or something else that is needed? This presentation will not only illustrate the issues facing employers, taking examples from the resources sector, but a model of sustainability will be proposed and the cutting edge research that is evolving in this sector will also be revealed.

GEOTHERMAL ENERGY IN AUSTRALIA: EMISSIONS FREE POWER 24 / 7

Graeme Beardsmore, Monash University, Victoria, Australia

Abstract: Geothermal energy is heat that exists naturally within the Earth. In many parts of the world geothermal energy is used as a direct source of hot water, or to produce steam to drive electricity turbines. It provides zero or very low emission energy twenty four hours and day. The geology of Australia is not conducive to “conventional” geothermal heat sources, but has proven to be the best place in the world to pursue so-called “hot dry rock” geothermal energy. This talk will give an introduction to geothermal energy and highlight the great contribution Australia is making to advance this promising clean power resource.

NOT ANOTHER INITIATIVE! EFFORTS TO BRING GREATER COHERENCE TO STEM EDUCATION, A UK PERSPECTIVE

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Science and science education are high on the agenda in the UK, as they are around the world. However the interest and good intentions of many organisations to try to do something about improving science education can be counterproductive to the extent that teachers and schools suffer from ‘initiative overload’, there is overlap and wasted time, effort and resources.

This presentation will outline some of the developments that are taking place in the UK to address the issues and create a more coherent approach to supporting teaching and learning of science in schools and other contexts.

SCIENCE EDUCATION AT THE FRONTIERS OF PHYSICS

Professor David Blair
University of Western Australia, Perth, Australia

Abstract: Einstein's 90 year old General Theory of Relativity is thought by many to be "much too advanced to teach at school". In fact the basic ideas are both conceptually simple and mind expanding in that they force you to think differently about your place in the universe. Combined with the exciting prospect of Gravitational wave Observatories soon being able to harness the new spectrum of gravitational waves provides a motivational force that demonstrates the relevance of physics today. This talk will introduce the ideas of gravitational waves and will explain how they may help to explain some of the greatest mysteries about the universe today. Related talks and an excursion will show how the above ideas have been put into practice at the Gravity Discovery Centre just north of Perth.

DEVELOPING PARTNERSHIPS FOR LEARNING SCIENCE

Professor Graham Durant, Director, Questacon - The National Science and Technology Centre, Canberra, Australia

Abstract: Schools alone cannot deliver the education that young people need to successfully operate in today’s rapidly changing world. The nature of education is changing and the role of schools and teachers will be forced to adapt to more flexible, open, learner-centred approaches. The development of learning partnerships with various agencies outside the classroom offers a useful approach to supporting teachers, students, schools and communities. This is particularly true in the field of science and technology where organisations that work in the free-choice learning arena such as science centres, museums and botanic gardens, and a significant number of industry partners and research agencies have expertise and resource materials available for use by schools and home-school tuition alike. Drawing on examples from a global network of science centres, the presenter will examine models of best practice and suggest ways that entire community resources can be brought to bear to improve learning outcomes for students.

NUCLEAR POWER AS A TIMELY TECHNOLOGY FOR WORLD NEEDS

Ian Hore-Lacy
Australian Uranium Association

Abstract: Electricity demand is rising quite rapidly, expected to almost double to 2030. Most demand is for continuous, reliable supply on a large scale (base-load). Nuclear power plays a major role in many countries. Renewables such as wind and solar are unable to meet this demand to any extent. Renewed interest in nuclear power arises from global warming and energy security concerns. Nuclear power is cost competitive in most parts of the world, and will become more so with costs on carbon (which would be required to make it competitive in Australia). External costs are very small, CO2 emissions from full life cycle are negligible. All wastes have been contained and managed almost uneventfully over 50 years. Life cycle energy balance is very favourable - inputs are typically less than 2% of output. Uranium is very abundant and will not be a constraint on nuclear power development in the foreseeable future. Safety has always been paramount in the west, and apart from the Chernobyl disaster there has never been a public safety problem in over 12,500 reactor-years of civil nuclear power operational experience. 415 of world's 440 power reactors are 2nd generation - reliable, robust and safe. First 3rd generation plants are now operating, in Japan. Later 3rd gen. plants now building 1-2 orders of magnitude safer then 2nd generation units. Nuclear weapons proliferation is a major world problem but has not arisen from nor (arguably) been exacerbated by civil nuclear power programs. Future: Hydrogen economy, high-temperature nuclear power is best prospect to make hydrogen on commercial scale.

COMPETENCES, FROM WITHIN AND WITHOUT: NEW CHALLENGES AND POSSIBILITIES FOR SCIENTIFIC LITERACY

Peter J Fensham, Monash University/QUT

Abstract: The Knowledge Society and the Changing World of Work are putting strong demands on schooling in many countries to shift its priorities from teaching established bodies of knowledge to equipping its young learners with a set of important competences. The implications that this challenge has for science education will be discussed, and related to the new directions for science curricula that are simulaneously emerging from within science education itself. A key question is: In what sense are these competences generic or domain specific?

- *As a chemistry teacher you have been assigned De Bono's Hats as a **Problem Solving** technique to use in your teaching next semester.*
- *The school is going to introduce three lessons a week this year on **THINKING.** As a science teacher are you interested in joining this new subject's teaching team?*
- *Being able to think of several ways to solve a problem is more important than knowing the right answer. Can you bring out this new emphasis about learning in your physics teaching?*
- *The goal of learning is to create something new. How can you incorporate this into your biology teaching this term?*
- *"**Inquiry**" is a much valued competence in the new World of Work. How could you incorporate the learning of this competence in your Science teaching?*
- *This semester Science and History have been allotted **Communication,** Mathematics and Geography have **Thinking**, etc. As the science teacher how would you take up this challenge?*
- *At your level of school it does not matter too much what science topics you teach, but make sure you teach the essential competences.*

Each of these has been an experience for a science teacher in the last three years. If, in your school, state or country, you have never been heard of such demands, it may not be long before you do, as the demands of the *Knowledge Society* and the *New World of Work* press their claims on the school curriculum more strongly.

Twenty three years ago, when the idea of **Science for All** was surfacing in a number of countries, the Canadian report, ***Science for all Canadians,*** listed four goals for school science.

1) *preparation for science-based careers*
2) *participation in socio-scientific decisions*
3) *preparation of all students for the world of work, and*
4) *the moral development of all students.*

In the twenty year interim almost no attention has been paid to Nos. 3 and 4, either by any of the new science curricula or by the research community for science education. No. 3 is now, I argue in this paper, pressing quite new and urgent demands on schooling and science educators needs to be part of the response. No. 4 points to social responsibility with respect to science and technology, that is now much more an issue in the general public arena than is within schooling.

If what you have read thus far seems unfamiliar in your school science context, it may be that the following will be a little more familiar.

- *The goal of the science curriculum is to develop scientific literacy, i.e. a set of scientific competences,*
- *Scientific literacy is for coping with S&T in the 21st Century Society*
- *There needs to be more stress on the Nature of Science.*
- *Students need a better understanding of scientific investigations.*
- *Scientific argumentation is an important new intention for school Science*
- *Students should gain the tools and confidence to engage in socio-scientific decision making*
- *Science teaching should engage students in ways that make clear their' opinions and ideas are important*
- *Science learning is not just about knowing correct answers; it is also about questions that do not have right answers or ones that have several right answers.*
- *Science education that does not generate interest in Science is a failure.*

If your science teaching measures up to all these criteria, you have only the first set of demands to worry about. But for some of you, I expect the second set of more familiar criteria are also quite a challenge to the way science education proceeds in your classrooms, schools and educational system more largely.

In this lecture I want to share with you the source of these two contemporary sets of demand on science teachers. The first set are ***Demands from WITHOUT***. That is, they do not arise from an analysis or evaluation of existing science education. The second set are ***Demands from WITHIN.*** That is, they do derive directly from the mounting evidence of the failure of so much present science education.

Interestingly, both sets have emerged from the same institutional source, the OECD in Paris, but from different section of this large organization, presumably working rather independently. While much in these sets of demands would seem to be contradictory there is one word that they share in common when referring to intended educational outcomes. This common word is "competence". I will try to enlarge in each case how it leads to this shared outcome for teaching and learning, and I shall also make a few suggestions about the initiatives that science education and science teachers could make, before they become victims of whichever of these sets is given priority.

The Knowledge Society

If science education has not taken seriously education its role in preparing students for the world of work, the OECD began to do so in the mid 1990s when it launched studies on how the world of work was changing (OECD, 1996a&b). At the same time a similar study was initiated in Britain by the Royal Society for the Arts, Industry and Commerce (Bayliss,1998). These studies found that the nature of work in developed countries is changing in three ways - *in kind*, *in the requirements for performance*, and *in the permanence of one's engagement.* These changes in the world of work and employment are driven by new forms of information transfer, ICT, (itself, interestingly, outcomes of science and mathematics we have ignored in our science education). The resulting new knowledge, enables innovation of new processes and products, and the globalization of their production. This new knowledge is increasingly the primary source of economic growth – *information is the currency of the economy.* Together these changes are known as the *Knowledge Society*.

In the manner that education has always been linked to the world of work and its knowledge demands, the next step from these recent studies of changing work was to explore the educational implications of this changing nature of society (see Gilbert, 2005).

The following comparisons indicate some of the differences between the educational implications of the *Knowledge Society* and those that exist in most, if not all, educational systems.

- "Knowledge" is to be a verb *rather* than a noun
- Knowledge is about acting and doing to produce new things *compared with* Knowledge made up of stored bits of established knowledge

Value is to be associated with:

- Knowing how to learn and Knowing how to keep learning *compared with* Knowing many bits of a subject's contents.
- Knowing how to learn with others *compared with* Individually accumulating knowledge.
- Seeing possibilities for solutions to problems *rather than* Knowing the right answer
- Acquiring important competences (skills) *rather than* storing Knowledge

For science educators and science teachers, this language of the *Knowledge Society* and what it means for education is almost entirely foreign. For us for so long, teaching science has been about our students acquiring more of that very rich corpus of scientific knowledge that we have, ourselves, earlier in our own education worked hard to acquire.

This new society has some other unusual features*.* *Change,* not stability, is now presented as its norm, and it follows that the education for the wellbeing of this type of society should have a dynamic character that equips students *to adapt to change, to generate new knowledge* and *continue to improve performance* (Fraser and Greenhalgh, 2001).

Lest I seem to be talking about abstract and academic analyses of modern or postmodern society, I can refer you to a string of active projects about these issues in the countries making up the Council of Europe, in Canada, the USA and Australia. In these projects there are constant references to the acronym ***DeSeCo*** which stands for ***Definition and Selection of Competence***, within which three broad types of competence are recognized – *communicative, analytical* and *persona* – as important.

The reports from these studies usually conclude with a longer or shorter list of competences to describe the learning outcomes that will be increasingly needed. It is clear that these lists are messages from employers and policy analysts that young people, regardless of their relative success in formal education, are emerging lacking knowledge and skills that are important for today's personal, social and economic life (OECD, 2000).

It is disturbing to note that while science and technology are often referred to as instrumental in bringing about these changing demands, competences in science and technology (other than IT skills) are only rarely mentioned.

Prominent in these lists of the new competences are ***Thinking, Communicating, Problem Solving, Knowing how to learn, Inquiring, Working with Others*** **and** ***Adapting to change***. The statements of Values and Purposes that accompany these lists commonly refer to *Connectedness, Resilience, Achievement, Creativity, Integrity, Responsibility,* and *Equity*.

Furthermore, there is such a dearth of connection between these competences and subject matter, that they seem to be essentially generic in character. Even problem solving is not elaborated in discipline specific terms, but in generic strategies of various types.

Science for All emerged in the 1980s as the slogan that signalled the recognition in UNESCO and many other countries that school science needed to be reconceptualised. It was no longer enough for Science in schooling to be aimed at the minority in need of Doug Roberts' *Vision I* of SL for their science-based careers, because the majority of students not so headed now had urgent societal needs to have access to the *Vision II* of SL. In one of the more perceptive national report on Science for All (in which both Doug Roberts and Graham Orpwood had more than a hand), four purposes for science education were set out.

The slogan, ***Science for All,*** had a challenging ring; but it was far from a definition of how science in schooling should now be conceived, and even further from what it should be like in practice.

The term, s*cientific literacy*, became popular in the 1990s as a new term for the intended reconceptualisation of school science. It had a more operational ring about than *Science for All*. It also seemed to link science education with the high status and priority in primary schooling that the basic literacies of *Language* and *Number* everywhere enjoyed.

Scientific literacy, however, did not have an obvious operational definition. Unlike language and number that have always been established priorities in the primary years of schooling, science had no such history of establishment in these years. Science had no obvious counterparts to the basics of reading, writing and operating numbers.

Scientific literacy was soon being associated in a number of countries with an amount of content for learning in school science that was patently absurd (e.g. AAAS, 1993), exceeding what had hitherto been the science content for elite groups of secondary students in academic streams that had chosen the sciences. By the later1990s and into the 2000s this impossible level of science education for all students has resulting in a serious decline of interest in science, in science-based careers, and in the learning of science as other than rote recall of dogmatic information. It is urgent that science education yet again be reconceptualised.

In this paper two quite separate initiatives of the OECD will be examined as pointers to a direction that science education must now consider, as it faces these failures of *scientific literacy* as its curriculum organiser.

Life in 21st Century

In 1998 the OECD set up the *Programme for International Student Assessment, PISA*, a project to provide information to its member countries on how well their 15 year olds were prepared for life in 21st Century society. This information was to be about the three domains, Reading, Mathematics and Science. The project had a six year cycle with testings in 2000, 2003 and 2006 when in turn each of these domains would be the major focus with the other two being minor foci. Expert groups were set in each domain to plan that part of the overall task.

The PISA project uses a language of literacies as its indicators of the students' preparedness. The Science Expert Groups have, for each of the three testings, taken a view of *scientific literacy* that enables it to be defined in terms of a number of scientific competences (skills) that are intimately connected to conceptual content. In this sense they strongly endorsed the argument by Driver and Millar (1987) against the separation that was common in school science curricula of conceptual content (for the secondary years) from processes (for the primary years) that had grown up in many countries following the major reforms of the 1960/70s.

For the PISA Science testing in 2000, when Science was a minor domain, these scientific competences were:

- *Recognising scientifically investigable questions*
- *Identifying evidence need in a scientific investigation*
- *Drawing or evaluating conclusions*
- *Communicating valid conclusions*
- *Demonstrating understanding of scientific concepts. (OECD, 1999)*

To ensure that all of these are active skills in the students, the tests take the form of a series of presented real world contexts involving science and technology, about each of which the students are asked a series of questions that reflect these competences. The use of these real world contexts that are novel for the students means that they are never simply recalling knowledge, but rather are having to apply their knowledge of science in the sense of a transfer of learning.

McGaw (2002) contrasted *PISA Science* with the other more familiar, and also concurrently occurring international project, *Trends in Mathematics and Science Study (TIMSS)*, by saying:

- TIMSS set out to measure *what students know*, while
- *PISA* is concerned with *what they can do with the knowledge they have.*

While the overall intention of PISA had been widely approved by the OECD countries, there was great scepticism that students anywhere would be able to answer the test questions, '*because in none of the participating countries were teaching such competencies being taught in school science".* In fact, the students' performances were better than this gloomy prediction, while still leaving much scope for further development.

There was also alarm that the test, with its usually long prose presentation of the S&T context, would turn into a reading test that would very much disadvantage boys compared with girls (as indeed the PISA Reading test showed was the situation in all participating countries). In fact in 26 of the 32 countries in 2000), there was no gender difference in performance and in the remaining six there were three that slightly favoured boys and three that favoured girls – remarkable finding to which I shall return later.

By 2006 when Science was the major domain in PISA these competences had been rethought and refined to be:

- *Identifying scientific issues*
- *Explaining scientific phenomena*
- *Using scientific evidence*
- *Willingness to engage with S&T issues* (OECD,2006)

It will be evident from both sets of competences that the PISA project has pushed the balance in science learning from *Knowledge of Science* to a combination of this with *Knowledge about Science*. In its attention to the latter, it has given considerable prominence to aspects of the *Nature of Science*, a current area of great interest among science education researchers who have seen this as a weakness in how national curricula were presenting their intentions for scientific literacy.

Discussion

So we have two developments (from the same OECD source) that are emphasising "competences" as the direction education and science education should move, and move rapidly. Both relate fundamentally to the way in which knowledge is constructed in education generally and in science in particular. In a number of national education systems these competences are currently being quite independently encouraged – one set widely generic and the other highly subject specific. It is not surprising that schools, teachers and subject curriculum developers are confused about responding.

In **Catching the Knowledge Wave?** Jane Gilbert (2005), one of the New Zealand group responsible for a response, sets out very clearly the contradictions between these two very different paradigms of knowledge and its learning. To bridge the gap she tries to make a case for competences and traditional learning by suggesting the new worker will need "*to put elements from one knowledge system together with elements from another, arranging them so that they work in new ways and do new things"* (p.156). Such an integrating and interdisciplinary intention is hard to comprehend, let alone to practice in schooling.

I would rather explore an alternative solution. The idea of generic competences clearly has an appeal, and it is to these we refer when we ask people in every day situations *to think outside he square, to communicate more clearly, to consider alternative ways of doing things*, and *to find out more about a topic*. Probably all our school systems have been remiss in giving enough weight to developing these general abilities in students, and new effort will be necessary to do so.

Teaching scientific competences as scientific literacy
This should not, however, be at the expense of the other sets of competences that are subject or domain specific. Hence, I propose as the next task for science education, in close conjunction with science teachers and students in real classrooms, is to explore scientific competences, such as those being used in PISA, that make sense at the various stages or levels, and to find what sorts of contexts, science content and pedagogies, will make them learnable by large numbers of students.

PISA Science has made a big contribution by defining, for one important level of schooling, some competences as elements of scientific literacy, and furthermore, it has shown that these can be validly and reliably be assessed. *PISA Science* is not, however, a curriculum and it is about 15 year olds, not younger or older students in school science. It is a piece of evaluative research that has defined desirable learning outcomes, and shown how to measure them authentically. These achievements are substantial, though limited as I have indicated. They are familiar as essential starting and end points for the design of curriculum.

One lead into the variety of scientific competences is to pursue Olson's ((1994) provocative claim that to understand a discipline means to be able to engage in its discourses. But what are the distinctive discourses of science?

Science education researchers have begun to answer with their work on *nature of science*, on *modelling* and on *argumentation in science*. Interestingly, the three PISA scientific competences above for 2006 map fairly well into these three issues of research.

Another Ohlsson (1995) listed a number of activities- *describing, explaining, predicting, arguing, critiquing, explicating* and *defining* -that each has a distinctive character and importance when used in the sciences. Marton, a psychologist, drew attention to *scientific intuition* as an important process in science (Marton, Fensham and Chaiklin, 1994). Intuition was recognized as important almost 50 years ago at the Woods Hole Conference that launched an historic burst of science curriculum activity in USA. But ever since we have singularly avoided it in school science, just as we have avoided *creativity*. (Bruner, 1967).

Repositioning school science education to development of scientific competences will not be easy for many science teachers, who have been required, so often, to simply be conduits for moving a store of scientific information from themselves or a text book to their students. This is why we must all press in our different situations for systematic and regular professional development to become a normal requirement for science teachers

Interest in Science and science education
I glossed over the fourth competence that was included in the 2006 PISA Science testing. The inclusion of *Willingness to engage with S&T issues* as a key competence was a direct response to the issue of decline in interest in Science and science education that has so apparent in many countries, particularly the more developed ones.

It is interesting that it has proved easier to include an interest in science as an expected outcome of school science in a multinational evaluation exercise than it has been to give such an affective outcome a real priority in designing the newest curricula for school science curriculum. Several of these developments have rejected revisions that would have led to this priority. It is true we do not know a magic recipes for recovering interest among our students and their teachers, but we do know some things which are likely to improve things. These include:

- teaching science as a sense of wonder and excitement about the natural world,
- teaching science in real world contexts that allow for students' ideas and values,
- teaching Science & Technology (in its sense as applications of science) rather than Science separated from the links these applications provide to personal and societal lives,
- more extended investigations into meaningful S&T problems, and
- teaching science as stories that include the human dramas of sciences' production, use, and effect on peoples lives.

Together these add up quite closely to what Glen Aikenhead (2006) has called humanistic science education. He recently published a book, **Science Education for Everyday Life: Evidence base practice**, in which he develops a case for such science teaching, and reports some very encouraging evidence of teachers and students responses when their science teaching moved in this direction. For the new approach of 21st Century Science Robin Millar (2006) has very recently also been able to report considerable success for a new curriculum at the penultimate levels of secondary schooling, that was based very much on the list above.

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THE FIVE MINDS FOR THE FUTURE

Professor Howard Gardner, Hobbs Professor of Cognition and Education, Harvard Graduate School of Education, USA

Abstract: In the future, schools should cultivate five kinds of minds: disciplined, synthesizing, creating, respectful and ethical. Howard Gardner describes each of these kinds of minds and indicates how best they can be nurtured.

At the start of the third millennium, we are well attuned to considerations of 'the future'. In conceptualizing the future, I refer to trends whose existence is widely acknowledged: the increasing power of science and technology, the interconnectedness of the world in economic, cultural, and social terms, and the incessant circulation and intermingling of human beings of diverse backgrounds and aspirations.

As one who has witnessed discussions of the future all over the world, I can attest that belief in the power of education—for good or for ill—is ubiquitous. We have little difficulty in seeing education as an enterprise—indeed, *the* enterprise—for shaping the mind of the future.

What kind of minds should we be cultivating for the future? Five types stand out to me as being particularly urgent at the present time. One by one, let me bring them onto center stage.

1. The Disciplined Mind

In English, the word 'discipline' has two distinct connotations. First, we speak of the mind as having mastered one or more disciplines—arts, crafts, professions, scholarly pursuits. By rough estimates, it takes approximately a decade for an individual to learn a discipline well enough so that he or she can be considered an expert or master. Perhaps at one time, an individual could rest on her laurels once such disciplinary mastery has been initially achieved. No longer! Disciplines themselves change, ambient conditions change, as do the demands on individuals who have achieved initial mastery. One must continue to educate oneself and others over succeeding decades.

Such hewing of expertise can only be done if an individual *possesses* discipline—in the second sense of the word. That is, one needs continually to practice in a disciplined way if one is to remain at the top of one's game.

We first acquire a 'disciplined mind' in school, though relatively few of us go on to become academic disciplinarians. The rest of us master disciplines that are not, strictly speaking, 'scholarly'; yet the need to master a 'way of thinking' applies to the entire range of workers—whether it be lawyers, engineers, crafts persons, or business professionals involved personnel, marketing, sales, or management. Such education may take in formal classes or on the job, explicitly or implicitly. In the end, a form of mastery will be achieved, one that must continue to be refined over the years.

Nowadays, the mastery of more than one discipline is at a premium. We value those who are interdisciplinary, multi-disciplinary, or trans-disciplinary. But these claims must be cashed in. We would not value a bilingual person unless he or she can speak more than one language. By the same token, the claim of pluri-disciplinarity (if you'll excuse the neologism) only makes sense if a person has genuinely mastered more than one discipline and can integrate them. For most of us, the attainment of multiple perspectives is a more reasonable goal.

2. The Synthesizing Mind

Nobel Laureate in Physics Murray Gell-Mann, an avowed multi-disciplinarian, has made an intriguing claim about our times. He asserts that, in the 21st century, the most valued mind will be the synthesizing mind: the mind that can survey a wide range of sources, decide what is important and worth paying attention to; and then put this information together in ways that make sense to oneself and, ultimately, to others as well.

Gell-Mann is on to something important. Information has never been in short supply. But with the advent of new technologies and media, most notably the Internet, vast, seemingly indigestible amounts of information now deluge us around the clock. Shrewd triage becomes an imperative. Those who can synthesize well for themselves will rise to the top of their pack; and those whose syntheses make sense to others will be invaluable teachers, communicators, and leaders.

Let's take an example from business. Suppose that you are an executive and your firm is considering the acquisition of a new company in an area that seems important, but about which you and your immediate associates know little. Your goal is to acquire enough information so that you and your Board can make a judicious decision, and you need to do so in the next two months. The place to begin is with any existing synthesis: fetch it, devour it, evaluate it. If none exists, you turn to the most knowledgeable individuals and ask them to provide the basic information requisite to synthesis. Given this initial input, you then decide what information seems adequate and where important additional data are required.

At the same time, you need to decide on the form and format of the ultimate synthesis: a written narrative, an oral presentation, a set of scenarios, a set of charts and graphs, perhaps a discussion of pros and cons leading to a final judgment. At last, the actual work of synthesis begins in earnest. New information must be acquired, probed, evaluated, followed up or sidelined. The new information needs to be fit, if possible, into the initial synthesis; and where fit is lacking, mutual adjustments must be made. Constant reflection is the order of the day.

At some point before the final synthesis is due, a proto-synthesis should be developed. This interim version needs to be tested with the most knowledgeable audience of associates, preferably an audience that is critical and constructive. To the extent that time and resources are available, more than one trial run is desirable. But ultimately there arrives a moment of truth, at which point the best possible synthesis must suffice.

What kind of mind is needed to guide the synthesis? Clearly, though he should have a home area of expertise, the synthesizer cannot conceivably be an expert of every relevant discipline. As compensation, the synthesizer must know enough about the requisite disciplines to be able to make judgments about whom and what to trust—or to identify individuals who can help make that determination. The synthesizer must also have a sense of the relevant forms and formats for the synthesis, being prepared to alter when possible, or advisable, but to make a final commitment as the deadline approaches.

The synthesizer must always keep her eyes on the big picture, while making sure that adequate details are secured and arranged in useful ways. This is a tall order, but it is quite possible that certain individuals are blessed with a 'searchlight intelligence'—the capacity to look widely and to monitor constantly, thus making sure that nothing vital is missing; and that they also have the capacity to value the complementary 'laser intelligence' that has fully mastered a specific discipline. Such individuals should be identified and cherished. It is crucial that we determine how to nurture synthesizing capacities more widely, since they are likely to remain at a premium in the coming era.

3. The Creating Mind

In our time, nearly every practice that is well understood will be automated. Mastery of existing disciplines will be necessary, but not sufficient. The creating mind forges new ground. In our society we have come to value those individuals who keep casting about for new ideas and practices, monitoring their successes, and so on. And we give special honor to those rare individuals whose innovations actually change the practices of their peers—in my trade, we call these individuals 'Big C' creators.

As a student of creativity, I had long assumed that creating was primarily a cognitive feat—having the requisite knowledge and the apposite cognitive processes. But I have come to believe that personality and temperament are equally, and perhaps even more important for the would-be creator. More than willing, the creator must be *eager* to take chances, to venture into the unknown, to fall flat on her face, and then, smiling, pick herself up and once more throw herself into the fray. Even when successful, the creator does not rest on her laurels. She is motivated again to venture into the unknown and to risk failure, buoyed by the hope that another breakthrough may be in the offing.

It is important to ascertain the relation among the three kinds of minds introduced thus far. Clearly, synthesizing is not possible without some mastery of constituent disciplines—and perhaps there is, or will be, a discipline of synthesizing, quite apart from such established disciplines as mathematics, mime, or management. I would suggest that creation is unlikely to emerge in the absence of some disciplinary mastery, and, perhaps, some capacity to synthesize as well.

4. The Respectful Mind

Almost from the start, infants are alert to other human beings. The attachment link between parent (typically mother) and child is predisposed to develop throughout the early months of life; and the nature and strength of that bond in turn determines much about the capacity of individuals to form relationships with others throughout life.

Of equal potency is the young human's capacity to distinguish among individuals, and among groups of individuals. We are wired to make such distinctions readily; indeed our survival depends upon our ability to distinguish among those who would help and nourish us, and those who might do us harm. But the messages in our particular environment determine how we will label particular individuals or groups. Our own experiences, and the attitudes displayed by the peers and elders to whom we are closest, determine whether we like, admire, or respect certain individuals and groups; or whether, on the contrary, we come to shun, fear, or even hate these individuals.

We live in an era when nearly every individual is likely to encounter thousands of individuals personally, and when billions of people have the option of traveling abroad or of encountering individuals from remote cultures through visual or digital media. A person possessed of a respectful mind welcomes this exposure to diverse persons and groups. A truly cosmopolitan individual gives others the benefit of doubt; displays initial trust; tries to form links; avoids prejudicial judgments.

The threats to respect are intolerance and prejudice, what in the worst case forms into individual, state, or stateless terrorism. A prejudiced person has preconceived ideas about individuals and groups, and resists bracketing those preconceptions. An intolerant person has a very low threshold for unfamiliarity; the default assumption is that 'strange is bad'. It is not easy to come to respect others whom you have feared, distrusted, or disliked. Yet, in an interconnected world, such a potential for growth, for freshly-forged or freshly-renewed respect, is crucial.

5. The Ethical Mind

An ethical stance is in no way antithetical to a respectful one, but it involves a much more sophisticated stance toward individuals and groups. A person possessed of an ethical mind is able to think of himself abstractly: he is able to ask, "What kind of a person do I want to be? What kind of a worker do I want to be? What kind of a citizen do I want to be?"

Going beyond the posing of such questions, the person is able to think about herself in a universalistic manner: "What would the world be like, if all persons behaved the way that I do, if all workers in my profession took the stance that I have, if all citizens in my region or my world carried out their roles in the way that I do?" Such conceptualization involves a recognition of rights and responsibilities attendant to each role. And crucially, the ethical individual behaves in accordance with the answers that she has forged, even when such behaviors clash with her own self interest.

My own insights into the ethical mind come from a dozen years of study of professionals who are seeking to do good work—work that is excellent, engaging, and ethical (see www.goodworkproject.org). Determining what is ethical is not always easy, and can prove especially challenging during times, like our own, when conditions are changing very quickly, and when market forces are powerful and unmitigated. Even when one has determined the proper course, it is not always easy to behave in an ethical manner; and that is particularly so when one is highly ambitious, when others appear to be cutting corners, when different interest groups demand contradictory things from workers, when the ethical course is less clear than one might like, and when such a course runs against one's immediate self interest.

It is so much easier, so much more natural, to develop an ethical mind when one inhabits an ethical environment. But such an environment is neither necessary nor sufficient. Crucial contributions are made by the atmosphere at one's first places of work: how do the adults in power behave, what are the beliefs and behaviors of one's peers, and, perhaps above all, what happens when there are clear ethical deviations, and—more happily if less frequently—when an individual or a group behaves in an ethically exemplary fashion? Education in ethics may not begin as early as education for respect; but neither 'curriculum' ever ends.

Given the high standards necessary for an ethical mind, examples of failures abound. It is not difficult to recognize behaviors that are strictly illegal—like theft or fraud—or behaviors that are obviously unethical—the journalist who publishes a story that he knows is not true, the geneticist who overlooks data that run counter to her hypothesis. In each case, the ethical mind must go through the exercise of identifying the kind of individual one wants to be. And when one's own words and behaviors run counter to that idealization, one must take corrective action. I would add that as one gets older, it does not suffice simply to keep one's own ethical house in order. One acquires a responsibility over the broader realm of which one is a member. And so, for example, an individual journalist or geneticist may behave in an ethical manner; but if her peers are failing to do so, the aging worker should assume responsibility for the health of the domain. I denote such individuals as 'trustees': veterans who are widely respected, deemed to be disinterested, and dedicated to the health of the domain. To quote the French playwright **Jean-Baptiste Molière**, "we are responsible not only for what we do but for what we don't do."

Tensions Between and Among These Minds

Of the five minds, the ones most likely to be confused with one another are the *respectful* mind and the *ethical* mind. In part, this is because of ordinary language: we consider respect and ethics to be virtues, and we assume that one cannot have one without the other. Moreover, very often they are correlated; persons who are ethical are also respectful, and vice versa.

However, as indicated, I see these as developmentally discrete accomplishments. One can be respectful from early childhood, even without having a deep understanding of the reasons for respect. In contrast, ethical conceptions and behaviors presuppose an abstract, self-conscious attitude: a capacity to step away from the details of daily life and to think of oneself as a worker or as a citizen.

Whistle blowers are a good example. Many individuals observe wrongdoing at high levels in their company and remain silent. They may want to keep their jobs, but they also want to respect their leaders. It takes both courage and a mental leap to think of oneself not as an acquaintance of one's supervisor, but rather as a member of an institution or profession, with certain obligations attendant thereto. The whistle blower assumes an ethical stance, at the cost of a respectful relation to his supervisor.

Sometimes, respect may trump ethics. Initially, I believed that the French government was correct in banning Muslim women from wearing scarves at school. By the same token, I defended the right of Danish newspapers to publish cartoons that poked fun at Islamic fundamentalism. In both cases, I was taking the *American Bill of Rights* at face value—no state religion, guaranteed freedom of expression. But I eventually came to the conclusion that this ethical stance needed to be weighed against the costs of disrespecting the sincere and strongly-held religious beliefs of others. The costs of honoring the Islamic preferences seem less than those of honoring an abstract principle. Of course, I make no claim that I did the right thing—only that the tension between respect and ethics can be resolved in contrasting ways.

In closing

There is no strict hierarchy among the minds, such that one should be cultivated before the others. Yet a certain rhythm does exist. One needs a certain amount of discipline – in both senses of the term—before one can undertake a reasonable synthesis; and if the synthesis involves more than one discipline, then each of the constituent disciplines needs to be cultivated. By the same token, any genuinely-creative activity presupposes a certain discipline mastery. And while prowess at synthesizing may be unnecessary, nearly all creative breakthroughs—whether in the arts, politics, scholarship or corporate life—are to some extent dependent on provisional syntheses. Still, too much discipline clashes with creativity; and those who excel at syntheses are less likely to affect the most radical creative breakthroughs.

In the end it is desirable for each person to have achieved aspects of all five minds for the future. Such a personal integration is most likely to occur if individuals are raised in environments where all five kinds of minds are exhibited and valued. So much the better, if there are role models—parents, teachers, masters, supervisors—who display aspects of discipline, synthesis, creation, respect, *and* ethics on a regular basis. In addition to embodying these kinds of minds, the best educators at school or work can provide support, advice, coaching which will help to inculcate discipline, encourage synthesis, prod creativity, foster respect, and encourage an ethical stance.

No one can compel the cultivation and integration of the five minds. The individual human being must come to believe that the minds are important, merit the investment of significant amounts of time and resources, and are worthy of continuing nurturance, even when external supports have faded. The individual must reflect on the role of each of these minds at work, in a favored avocation, at home, in the community, and in the wider world. The individual must be aware that sometimes these minds will find themselves in tension with one another, and that any resolution will be purchased at some cost. In the future, the form of mind that is likely to be at greatest premium is the synthesizing mind. And so it is perhaps fitting that the melding of the minds within an individual's skin is the ultimate challenge of personal synthesis.

THE WAY FORWARD – PARTNERSHIPS FOR PROMOTING SCIENTIFIC AND TECHNOLOGICAL LITERACY THROUGH AN APPRECIATION OF THE NATURE OF SCIENCE EDUCATION (NSE)

Jack Holbrook, ex-Secretary, ICASE, international consultant in science education and visiting professor in science education, University of Tartu, Estonia.

Abstract: ICASE (International Council of Association for Science Education) has a history of involvement in the promotion of scientific and technological literacy, starting from Project 2000+ - a project initiated in partnership with UNESCO in 1991. In 2001, ICASE was instrumental in providing a background document to a World Conference held in Goa, India in 2001 on the place of tolerance, peace, human rights and social issues within scientific literacy. In the first ICASE world conference, held in Penang, Malaysia in 2003, a Way Forward document promoting the need for partnerships to enhance the relevance of science education, initiated by ICASE, was endorsed by participants.

This paper describes and builds on these developments. It argues that student educational needs form the major thrust of education of which science education is a part and enhancing scientific literacy is more about educating citizens than promoting an understanding of science as a body of knowledge. From such a viewpoint, the nature of science education relates to relevant contexts to build an education for students which stress the nature of science, the development of personal skills and acquisition of social attributes to achieve a meaningful level of scientific literacy. The argument, however, goes further, recognising that the challenge is not so much in stipulating the ideal, or even in suggesting intentions of, science education, difficult though these might be, but very much in the manner in which science education needs to be implemented and experienced by students. These experiences relate to the vision placed on school science in promoting sustainable development which encompasses energy, food, health, work ethics as well as environmental concerns, and a recognition of, and decision making associated with, local, region and global issues on which science impact in an interdisciplinary manner alongside moral, ethical and social values, economic priorities and political considerations. All of the above is seen as leading towards the acquisition of a multi-functional scientific literacy, enabling students to be responsible citizens both within society and in their world of work. The paper argues that only through a partnership of stakeholders can the general public be persuaded that science education needs to be seen as a discipline separate from the sciences on which it depends. In this way science education can encompass more than the teaching of science as a body of knowledge and be viewed as an essential core educational component in the school.

PROGRESS IN SUSTAINABLE ENERGY EDUCATION

Philip Jennings, Physics and Energy Studies, Murdoch University, WA, Australia

Abstract: Energy conversion and use have become critical issues for our society. Current uses of fossil fuels are causing extensive environmental damage and it is generally recognised that alternative, sustainable sources are urgently required. Education has a vital role to play in the transition to a sustainable energy industry. A new generation of scientists, engineers and policy analysts is needed to research, develop and plan these new systems and this must all be done in the context of sustainability. Murdoch University has been teaching sustainable energy courses for more than a decade and these are now offered in undergraduate, postgraduate and continuing professional education formats. They are available on-campus and on-line throughout the world via the internet. There is a strong demand for these courses and the graduates have an attractive array of job opportunities in the rapidly developing sustainable energy industries. This presentation will cover the philosophy of sustainable energy education and the content and outcomes of these courses.

SUSTAINING RURAL AUSTRALIAN COMMUNITIES: WHAT SCIENCE? WHAT TEACHING?

Cliff Malcolm, Deakin University, Australia

Abstract: Rural communities are critical to Australia's environment and economy, and its character: stories of life in the bush sit alongside ANZAC in defining Australian identity. Even so, the bush is not 'mainstream Australia': rural communities have particular needs, cultures and issues, under pressure from globalisation, industry restructure, environmental degradation and drought. Schools have to think through their roles, balancing local and state demands, education for staying in the community or leaving it, serving the community or being served by it. Drawing on research in Victoria, this paper explores the nature of rural communities, relationships between schools and communities, and ways in which teachers define their roles and science teaching.

AUSTRALIAN SOCIETY: IMPEDIMENTS TO CHANGE OR LEADERS IN A SUSTAINABLE WATER FUTURE?

Blair E. Nancarrow, Director, Australian Research Centre for Water in Society, CSIRO Land and Water, Australia

Abstract: Australia is facing an uncertain future with the challenges associated with climate change added to climate variability. Where will our water come from, and will we have enough as populations increase? It seems that our very way of life is threatened, as well as the environment we all so enjoy. The Australian identity is inextricably linked to the great outdoors. While scientists, planners and engineers feel they know what needs to be done, and how to do it, they are finally realizing that unless they have the cooperation of the community, their solutions may come to nothing. "People are impediments to change" is what is generally said, and we set about to educate them so they will agree with us about what needs to be done. So what is going wrong? How much do we know about what the community wants for their future society? And do their goals match the goals of the scientists, planners and engineers? This paper explores some of these issues and the implications for communication and education.

EDUCATIONAL OPPORTUNITIES IN MEDICINE AND MEDICAL RESEARCH IN WESTERN AUSTRALIA

John Newnham
Professor of Obstetrics and Gynaecology (Maternal Fetal Medicine).
Head, School of Women's and Infants' Health, The University of Western Australia, Perth, Australia.

Abstract: This lecture will describe some of the recent changes in medical education at The University of Western Australia and the impact of large increases in the number of medical students. These changes have great relevance for students considering a career in medicine, for students already in training, and for recent graduates. The lecture will also outline some of the exciting changes that are occurring in medical research, with particular emphasis on strategies to prevent diseases as their origins.

ACTIVE ASSESSMENT: BETTER THINKING, BETTER LEARNING

Brenda Keogh, Millgate House, UK
Stuart Naylor, Millgate House, UK

Abstract: *Active Assessment* is used widely in the UK and elsewhere to link thinking, learning and assessment. Active Assessment gets students thinking and learning while assessment is happening. Research suggests that 'starting from where the learner is' makes teaching and learning more effective. But how do you make it happen in the classroom? How can you start from where the learner is when you have a whole class to teach? This workshop is about how to do it. If you are a secondary teacher, a primary teacher or a teacher educator then you can't afford to miss this.

PUPPETS
TALKING SCIENCE - ENGAGING SCIENCE

Brenda Keogh, Millgate House, UK
Stuart Naylor, Millgate House, UK

Abstract: Using puppets in science lessons engages children. They think more, talk more and enjoy science more. These are some of the findings from a two-year research project in the UK. The project explored the impact of puppets on children (mostly age 7-11) and their teachers. As well as having a positive impact on the children, using puppets also had a big impact on teachers' professional practice. The research is now being implemented in a major professional development project for teachers in the UK. In this session we will describe the main findings from our research, the issues which it raises and some of the implications for primary science.

ORPHANS AND OTHER VULNERABLE CHILDREN IN NAMIBIA – THEIR RIGHT TO EDUCATION AND HOLISTICSUPPORT AND DEVELOPMENT

Barnabas Otaala (Ed.D) Professor Emeritus, University of Namibia specialising in HIV/AIDS and Early Childhood development

Abstract: People everywhere, but particularly in developing countries, are struggling with similar daunting problems: hunger, homelessness, rapid population growth, unemployment, violent crime, poor health, the preventable deaths of millions of children, widespread environmental degradation, and education systems inadequate for countries' needs and people's aspirations. But the world is at the threshold of a new century, with all its promise and possibilities, with the cumulative experience of reform, and innovation. In the case of children, a number of international events affecting children have marked the past few years. In this paper, Professor Barnabas Otaala refers to a case study conducted in Windhoek, the capital city of Namibia. The study concerned the assessment of services provided to children affected and infected by HIV/AIDS, and the lessons that can be learned from it in relation to the UN Convention on the Rights of the Child (CRC).

Introduction and Background

People everywhere, but particularly in developing countries, are struggling with similar daunting problems: hunger, homelessness, rapid population growth, unemployment, violent crime, poor health, the preventable deaths of millions of children, widespread environmental degradation, and education systems inadequate for countries' needs and people's aspirations.

But the world is at the threshold of a new century, with all its promise and possibilities, with the cumulative experience of reform, and innovation. In the case of children, a number of international events affecting children have marked the past few years:

1. The Jomotien World Conference on Education for All, held in Thailand in March, 1990. One thousand five hundred delegates from hundreds of nations and organisations gathered to assess conditions and develop plans to improve education around the world. The World Conference generated an action plan and launched the Education for All movement to meet the basic learning needs of all children, youth and adults in all countries of the world;
2. The World summit for children in September 1990, which was attended by seventy Heads of State;
3. The Child-to-Child movement was started in 1978, shortly after the Alma Ata Conference which launched the world-wide commitment to spreading the concept of Primary Health Care (PHC), in preparation for the International Year of the Child (IYC) in 1979;
4. The emergence of the HIV/AIDS epidemic which has had a negative impact on development and particularly on children in Africa.

We expand some of these points before describing our exploratory studies on children's rights in Namibia and the services provided to children affected and infected by HIV/AIDS and making some recommendations on the need for education and provision of support for their holistic development.

1. Education for all (EFA): The Expanded Vision; And Millenium Development Goals

At the World Conference on Education for All (Jomtien, Thailand, March 1990), the international community reaffirmed its commitment to ensuring the right to education for every man, woman, and child. The conference also committed to ensuring that serving the basic learning needs of all implied more than just commitment to education as it now exists. What is needed is an "expanded vision" that surpasses present resource levels, institutional structures, curricula, and conventional delivery systems.

Commitment is embodied in the *World Declaration on Education for All,* and its accompanying *Framework for Action to Meet Basic Learning Needs,* which outlines a global strategy to be undertaken through the 1990s in line with the principles contained in the *World Declaration.* Subsequently, a secretariat was established based at UNESCO's headquarters in Paris. The objective was to promote cooperation in basic education and monitor progress toward the provision of basic education for all.

The World Declaration on Education for All, and the Framework to Meet Basic Learning needs was adopted and signed by 155 governments present at the conference. Through these two texts, the world community renewed its commitment to ensuring the Right to Education, and effectively broadened the scope of basic education to include early childhood development (ECD), primary education, non-formal education (including literacy) for youths and adults; and learning conveyed through the media and social action.

The conference also specified that follow-up action at the international level should serve national follow-up action and support it effectively. Such follow-up action should seek to maintain the spirit of cooperation amongst countries, multilateral and bilateral agencies, as well as NGOs (which had been the hallmark of the conference). The Mid-Decade Review of Progress towards June 1996 which was preceded by regional assessments of the state of basic education in Africa, Latin America, and Asia. In preparation for the Global end-of decade assessment, the Africa regional preparatory conference took place in December 1999 in South Africa.

The assessments are intended to help provide analyses of the state of basic education in both quantitative and qualitative terms covering the areas of **Early Childhood Care and Development** (including expansion of ECD programs, family and community involvement, attention to disadvantaged children, and ECD policy, regulations and management; **Primary Education** (including strategies for providing access to out-of-school children; parental attitudes; conditions of schools; quality of schooling; and direct, indirect and opportunity costs of schooling to families), **Learning Achievement and**

Outcomes (including strategies to measuring achievement outside the school system; quality of teaching-learning process), **Adult Literacy** (including types and range of literacy programs, mechanisms for monitoring women's literacy programs; policy, management and financing), **Training in Essential Skills** (including policy, the nature of skills programs; population/target groups served; and quality and effectiveness); and **Education for Better Living** (including types of electronic and print media used for education; social mobilization campaigns leading to awareness; policy, management and funding; and quality and effectiveness).

Early in the year 2000, a global summit, the World Education Forum, was held in Dakar, Senegal, from 26 – 28 April. The summit completed the global assessment. Representatives from all the regions of the world agreed upon priority policy and programme actions that target educational opportunities for those – young and old – who have been under-served or not reached at all during the 1990s. For those who have been reached within this decade, policy directions were set for ensuring quality lifelong education. All of these actins are now popularly referred to as the Education for All (EFA) goals (Box 1).

Box 1: EFA Goals as stated in the Dakar Framework for Action

Goal 1
Expand early childhood care and education. Expand and improve comprehensive childhood care and education, especially for the most vulnerable and disadvantaged children.

Goal 2
Free and compulsory education of good quality. Ensure that by 2015 all children, particularly girls, children in difficult circumstances and those belonging to ethnic minorities, have access to and are able to complete primary education that is free, compulsory and of good quality.

Goal 3
Promote the acquisitions of life skills by adolescents and youth. Ensure that the learning needs of all young people and adults are met through equitable access to appropriate learning and life skills programme.

Goal 4
Expand adult literacy. Achieve a 50% improvement in levels of adult literacy by 2015, especially for women, and equitable access to basic and continuing education for all adults.

Goal 5
Eliminate gender disparities in primary and secondary education by 2005, and achieve gender equality in education by 2015, with a focus on ensuring girls' full and equal access to and achievement in basic education of good quality.

Goal 6
Enhance educational quality. Improve all aspects of the quality of education and ensure excellence so that recognized and measurable learning outcomes are achieved by all, especially in literacy, numeracy and essential life skills.

The EFA goals were supplemented and complemented by the Millennium Development Goals (Box 2)

Box 2: The Millennium Development Goals

The Millenium Development Goals are a set of development targets internationally agreed upon by the member states of the United Nations. They commit governments to reduce poverty by 2015 and to accelerate the pace of economic, social and human development.

Goal 1: Eradicate extreme poverty and hunger

- Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day.
- Halve, between 1990 and 2015, the proportion of people who suffer from hunger.

Goal 2: Achieve universal primary education

- Ensure, that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary education.

Goal 3: Promote gender equality and empower women

- Eliminate gender disparity in primary and secondary education, preferably by 2005 and to all levels of education no later than 2015.

Goal 4: Reduce child mortality

- Reduce by two thirds, between 1990 and 2015, the under five mortality rate.

Goal 5: Improve maternal health

- Reduce by three quarters, between 1990 and 2015, the maternal mortality ratio.

Goal 6: Combat HIV/AIDS, malaria and other diseases

- Have halted by 2015, and begun to reverse the spread of HIV/AIDS.
- Have halted by 2015, and begun to reverse the incidence of malaria and other major diseases.

Goal 7: Ensure environmental sustainability

- Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources.
- Halve, by 2015, the proportion of people without sustainable access to safe drinking water.
- By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers.

Goal 8: Develop a global partnership for development

- Develop further an open, rule-based, predictable, non-discriminatory trading and financial system. (Includes a commitment to good governance, development, and poverty reduction – both nationally and internationally).
- Address the Special Needs of the Least Developed Countries (Includes: tariff

and quota free access for least developed countries' exports; enhanced programme of debt relief for HIPC and cancellation of official bilateral debt; and more generous ODA for countries committed to poverty reduction).

- Address the special needs of landlocked countries and small island developing states (Through the Programme of Action for Sustainable Development of Small Island Developing States and the outcome of the twenty-second special session of the General Assembly).
- Deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long term.
- In cooperation with developing countries, develop and implement strategies for decent and productive work for youth.
- In cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries.
- In cooperation with the private sector, make available the benefits of new technologies, especially information and communication.

2. The UN Convention on the Rights of the Child

The UN Convention on the Rights of the Child (CRC) recognizes that the particular status of children engenders specific forms of vulnerability, and particular interests and entitlements. It sets out the inherent rights and entitlements needed to guarantee a child's right to survival, development and an adequate standard of living. These rights encompass entitlements to basic standards in health, education, food, shelter, welfare and protection from exploitation and violence.

Securing the right to adequate healthcare is paramount to ensuring the survival and development of children. Every year, more than 10 million children die before the age of five. Nearly half of these deaths occur within the first month of life.

Child survival figures reveal stark inequalities. The poorest 20% of the world's children are ten times more likely to die before the age of 14 than the wealthiest 20%. In sub-Saharan Africa, 172 out of every 1000 children do not survive to their fifth birthday. This compares with six out of every 1000 children in industrialised countries. The factors affecting children's health include access to quality healthcare, nutrition, household income, parental (particularly maternal) education and access to safe water and sanitation.

The CRC places a responsibility on states to ensure that adequate measures are taken to combat disease and malnutrition, through the application of readily available technology, including ensuring that children receive adequate nutritious foods and clean drinking water and the highest attainable standard of healthcare.

Education is vital to both a child's physical and intellectual development. It enables a child to develop skills and knowledge, which will improve their livelihood and earning potential during later stages of their lives. Education also contributes significantly to improvements in health. One study in Africa found that a 10% increase in female education led to a 10% decline in child mortality. The CRC entitles all children to access to free primary education. It also outlines the responsibility of states to ensure the provision of secondary, higher and vocational education. The quality of education provided should allow the child to develop its personality, talents, and mental and physical abilities to their fullest potential.

A child's ability to survive and develop can be hampered or scarred due to violence and exploitation, both inside and outside the family. These include hidden, hazardous and unregulated forms of labour, sexual abuse and exploitation, and the direct and indirect consequences of conflict. The CRC outlines the responsibility of the state to protect children from abuse, neglect, violence, exploitative labour and conflict.

Finally, the CRC places the responsibility on the family to secure, within their abilities and financial capabilities, the conditions of living necessary for the child's development. The state is given the responsibility to assist parents in this task.

The CRC provides inspiration and a framework for the development of child poverty eradication policies. These need to be developed in the context of national circumstances, and shaped to address the specific needs of children in each case – but within the overarching framework of the recognition of the universality of the rights of the child.

3. Child-to-Child Approaches

Child-to-Child started as an international programme designed to teach and encourage older children, especially school children, to concern themselves with the health and general development of their younger brothers and sisters and of younger children in their own communities. The programme has grown from a few health messages to be spread by children into a world-wide movement in which children are considered as responsible citizens who, like their parents and other community members, can actively participate in the community and in the developmental affairs of the community.

The approach emphasizes that children need to be accepted as partners to promote and implement the idea of health and well-being of each other, of families, and of communities. In so accepting them, you help them to develop, and the approach enhances their own worth both in their own eyes, and in those of adults. Hence there is a strong link with the idea of children's rights. You respect partners and you work with them.

The parallel between Child-to-Child and the **Convention on the Rights of the Child** may not be immediately obvious, but the philosophy and work of Child-to-Child is in fact a practical expression of the **Convention's** many provisions which seek to make children **subjects** rather than objects of efforts to ensure their survival, protection and development. Articles 5 and 14 of the Convention speak of the evolving capacities of children; Article 12 refers to children's right to express views freely in all matters which affect them; Article 24 obligates governments to "ensure that all segments of society, in particular parents and children, are informed, have access to education, and are supported in the use of basic knowledge of child health and nutrition, the advantages of breastfeeding, hygiene, and environmental sanitation, and prevention of accidents". These extracts from the **Convention** read like guidelines for a Child-to-Child project.

In Namibia Child-to-Child was formerly introduced towards the end of the first year of independence (Mostert and Zimba, 1990), at a major workshop held in Windhoek.

4. Scope of HIV/AIDS and Orphans in Africa

In Africa there are an alarmingly high numbers of children homeless and living on the street. The plight of these children has been a matter of great concern to UNESCO which focuses in part on combating the exclusion of children from any given society. The street children crisis has been deepened by the HIV/AIDS pandemic, which is a formidable challenge and obstacle, not only to the economies of several countries, but also to families and communities in the South African Development Community (SADC) region.

GLOBAL HIV EPIDEMIC o Since its first documented appearance 20 years ago, HIV has infected more than 60 million people worldwide. o Globally, there are an estimated 40 million people living with HIV. o About one-third of those currently living with HIV/AIDS are between 15 – 24 years.
REGIONAL HIV EPIDEMIC o Sub-Saharan Africa is the region most severely affected by HIV/AIDS: - 3.4 million new infections in 2001 - 28.1 million people are living with HIV/AIDS regionally o HIV prevalence rates have risen to alarming level in Southern Africa o Recent antenatal clinic data show that several parts of Southern Africa have prevalence rates among pregnant women exceeding 30%.

Source: AIDS Epidemic Update: UNAIDS/WHO, December, 2001

Sub-Saharan Africa is said to be amongst the most severely affected regions by the HIV/AIDS pandemic. This has contributed to an increase in the number of children living on the street, children living in families with inadequate care and support, and children resorting to high-risk behaviour for their own survival and that of their siblings, such as commercial sex and child labour. As a result, more and more children in the sub-region are being affected by and becoming infected with, HIV/AIDS. This threatens both their health and social acceptability. The chances of these children entering and remaining in school to attain a basic education are thus severely reduced.

In the hardest hit countries, HIV/AIDS has wiped out four decades of development progress. In 2001, 580,000 children under the age of 15 died from HIV/AIDS. A further 2.7 million children under the age of 15 are now living with the virus. Coping with HIV/AIDS is hardest for the poor. Unless HIV/AIDS is rapidly addressed, it will perpetuate the intergenerational transmission of poverty and prevent the attainment of the Millennium Development Goals.

	Total Children living with HIV/AIDS	Children who have lost one or both parents to HIV/AIDS	Estimated AIDS Deaths
Botswana	10 000	66 000	24 000
Lesotho	8 200	35 000	16 000
Malawi	40 000	390 000	70 000
Namibia	6 600	67 000	18 000
Swaziland	3 800	12 000	7 100
Zambia	40 000	650 000	99 000
Zimbabwe	56 000	900 000	160 000

Source: Report on the Global AIDS epidemic: UNAIDS/WHO, June 2000

Children are affected by HIV/AIDS in numerous ways. They can be directly infected through their mothers in the womb, at birth, or through breastfeeding. They can also contract HIV/AIDS as a result of unsafe or unwanted sex with an infected partner, or by sharing needles with someone who is infected with the virus. Even if they are not directly infected, children and young people are afflicted by HIV/AIDS as it impacts upon their families and communities.

HIV/AIDS has a profound effect on responsibilities in the home. As parents become ill, children struggle to take over adult responsibilities for housework or family care. They may miss school as a result. Some children are left as orphans, sometimes with responsibilities for their siblings. Alternatively their kin, and grandparents in particular, may take them in, but often in difficult circumstances. The loss of care and security experienced by children in HIV/AIDS afflicted families is accompanied by feelings of sadness, loneliness, and falling self-esteem.

HIV/AIDS can also have a drastic effect on the family's income. Those affected are eventually unable to work, and face increasing health care costs. The search for a cure and funeral expenses can also place a heavy burden on family funds. There may be no money available to pay for food for children's school fees. Children in child-headed households are particularly vulnerable – with average monthly incomes in Zimbabwe, for example, of only $8 compared to $21 amongst non-orphaned neighbours.

Children and their families might receive some assistance from the community. Neighbours and women's groups may give children support in carrying out household tasks and may also help out with food on a short-term basis. Hospitals and NGOs might also offer homecare, free medication and material support to the family. Support with emotional needs may be sought from wider kin and neighbours in the first instance. The capability of the community to assist, however, will often depend on the extent of the epidemic. The provision of health and education services may suffer as nurses and teachers fall victim to HIV/AIDS. Teacher deaths due to AIDS in Zambia in 1998, for example, were equivalent to two-thirds of the number of newly qualified teachers.

One insidious effect of the HIV/AIDS is the unholy trinity of "shame, discrimination, stigmatisation" an elaboration of which we now turn.

Challenge of "Shame, Discrimination, Stigma" (SDS)
In Namibia's Constitution discrimination on the grounds of colour, religion, sex, place and origin and state of health are prohibited. Many officials preach against discrimination and stigma. Yet, on a daily basis, there are several reports in school, in communities, and in places of work, where people are being discriminated and stigmatized on the basis of their being affected and infected with HIV/AIDS. AIDS orphans, particularly, have borne the brunt of this "shame, discrimination and stigma" (SDS). Yet in traditional African customs and practices, orphans and other vulnerable children used to be well taken care of, and grew up in a spirit of acceptance.

The most effective health interventions are worthless if they are not used. What is it about our cultures that compels us to overlook a major barrier to improved healthcare: the entwined issues of stigma, discrimination, and shame (hereafter, SDS)?

SDS is such a powerful force that, if there is a chance their conditions would be revealed, people would rather suffer and die, and have their children suffer and die, rather than access treatment that could improve their quality of life and save their lives. Currently, those with any number of illnesses are stigmatised and rejected, as are family members if those illnesses are made public. People also hide their medical conditions because they fear, oftentimes justifiably, that they will lose friends, jobs, housing, educational and other opportunities, if their conditions are publicly known. The many conditions affected by SDS include forms of cancer, Hansen's Disease, mental illness, mental retardation, tuberculosis, domestic violence, substance abuse and dependence, sexual dysfunction, and sexually transmitted diseases, now most notably HIV disease.

Repeatedly and loudly and for decades, experts at the international level and service providers at local levels have described the powerful forces of SDS. No less a personage than the late Jonathan Mann, then Director of the WHO Global Programme on AIDS, warned the world about SDS in regards to HIV. In 1987, speaking informally to the UN General Assembly, he "identified three phases of the HIV/AIDS epidemic: the epidemic of HIV, the epidemic of AIDS, and the epidemic of Stigma, discrimination and denial". He noted that the third phase is 'as central to the global AIDS challenge as the disease itself' (cited in Parker et al, 2002).

"Each year, more and more people die from the (HIV) disease and it is the stigma and misinformation around HIV that is killing people," Juan Manuel Suarez de Toro, President of the International Federation of Red Cross and Red Crescent Societies, said in a recent World Red Cross Day message. "people place themselves at high risk from infection or refuse to access treatment rather than face the consequences of social stigma, such as losing their homes, businesses and even their families," he said (Olafsdottir, 2003).

Given this background we briefly turn to the situation on the ground in Namibia in terms of the preliminary studies dealing with children's rights; and services provided to children infected and affected by HIV/AIDS.

5. Children's right

In a 1995 study Zimba and Otaala, among other things, examined Nama childrearing practices associated with selected articles of the Convention on the Rights of the Child, and tried to draw up programmatic implications of these practices.

We observed, firstly that there seemed to be conceptions of children's rights that were consistent with universal understanding. Children's rights to education and good health were, for example, valued by Nama parents in ways similar to those expressed by concerned parents all over the world. However, the Nama families faced considerable hardships in providing for their children's education and medical care. Unemployment, lack of stable incomes and lack of affordable medical schemes were used to explain the hardships. Income generation activities and general community development initiatives appear to present possible solutions to the problems.

Secondly, there appeared to exist conceptions of children's rights that were inconsistent with current global formulations. Nama parent's conceptions of corporal punishment present a good example here. From a non-Nama perspective, it would seem that the endorsement of the use of corporal punishment in the home and at school violates children's freedom from physical and emotional abuse. According to the Nama, this interpretation would be inappropriate. To them, corporal punishment is one of the tools available to parents for socializing children into honest, well-behaved, self-disciplined, obedient and reflective individuals. In addition, it helps to produce out of children persons who fear and respect authority. To the Nama, this is important for the maintenance of regulated and ordered social relationships. Our judgement is that this concept conceptualization should be taken into account when championing the cause against child abuse. Obviously, most Nama parents do not perceive any abuse when corporal punishment is intended to create out of children responsible human beings with some realistic understanding of social and emotional connotations of right, wrong, unfair, fair and just actions.

Thirdly, our data revealed contextualized conceptions of children's rights. These were displayed when the consideration of the freedom to make their own choices and decisions regarding entertainment, spending money, friends, schools and churches to attend did not only implicate the social–cognitive developmental needs and welfare of the children but in addition involved matters of safety, security, protection from harm, custom, tradition and social relations with peers and adults. For example, whereas more than half of the respondents thought that adolescents were old enough to exercise the freedom of choosing their own friends, more than a third of them considered this to be in error because to protect them from alcohol and drug abuse, forming anti-social behaviour, bad influence and the misuse of sex, the youth required advice, counselling and guidance from their parents and other adult family members. It appears from this understanding that according to the Nama the exercise of children's rights to free choice and decision making should take into account their **contextualized best interests**. These interests should reflect Nama custom, tradition and contemporary social-cultural, social-economic and community development realities. (Zimba and Otaala, 1995, pp. VIII – IX).

Services Available for Children Affected and Infected by HIV/AIDS
Our preliminary study revealed that a range of services and programs were available in the Windhoek region. In the study we gathered information about the child and caregivers and the setting; about programmes and services which directly affect the setting, caregiver and the child; about the larger context including community attitudes, policy directions and strategies which influence service planning and delivery.

Program available

The programs currently operating in the study region included:

Survival programs
- Needs assessment by community volunteers (followed by distribution of goods and services to identified needy families and/or community groups);
- Safe homes: OVCs can live here temporarily. Officially registered safe homes receive N$10 per day per child. Monitoring is informal (i.e. neighbours may report incidences. There is no formal process for de-registration);
- Home based visiting;
- Soup kitchens: lunches for school children;
- Emergency and temporary accommodation for children;
- Special 'Fete' days when families can receive donated goods (3 times per year);
- Fostering of babies when they have nowhere else to go.

Health programs
- Vouchers for purchasing anti-retroviral and other medications;
- Health services;
- Support with maintaining medication schedules;
- Nutrition programs;
- Exercise and massages;
- Accessibility and support for HIV/AIDS testing, including counselling, and other support services for those found to be HIV positive;
- Dissemination of documents to access health and medical services.
-

Programs aimed at well-being, psychosocial development, family and community connections
- Home based visits;
- Counselling for 0-18 year old OVCs including a weekly support group (NOTE: Children aged 0-8 years do not access support groups. Instead they attend the mother support group with their mothers.);
- Support groups for infected adults and caregivers;
- Support for residential (relative) care in the community;
- Opportunity to meet and interact with others in an informal way;
- Promotion of adoption for orphans;
- Counselling for pregnant women.

Formal education and training programs

- Training for community volunteers;
- Training for home based visitors;
- Day-care preschool program, providing food and medicine;
- Camps for older children;
- After school tutoring;
- Training for caregivers (including workshops on *Building Resilience In Children Affected By HIV/AIDS; Home Based Family Care In Namibia; How To Start A Support Group);*
- School fee vouchers;
- Provision of school uniforms

Freedom of expression, choice and movement

- Income generating projects for infected mothers (Young children often accompany the mothers, but no activities are organised for the children);
- Bursaries for exceptional children to attend secondary school;
- Raising awareness about HIV/AIDS including advocacy for acceptance of HIV positive children and their mothers.
- Children in residential settings who had access to day programs such as school lunch program and day care program, which serves meals were not experiencing these deficiencies.

How children access services and programs

Information about services available to OVCs is disseminated through community agents such as Churches, schools and NGOs, government departments, support groups, community volunteers, door-to-door visits, and general public awareness (radio, posters, brochures) and by word of mouth.

In one case the centre became known when it set up in a community and was able to take in children who appeared at the door. Now it is full and provides services according to priority criteria determined by the organisation: Many children who would benefit remain unable to access this service. The centre is currently looking for ways to expand its delivery to accommodate the numbers presenting themselves.

The belief that there may be many OVCs who are not known, not registered or not accessing services was reported by all respondents.

One of the small organisations reported that they are aware of the needs of the 0-8 yeas old population in their own (small) geographical location.

We think we know about them all…went door to door in this area – had community meeting

Director of small organisation

Monitoring and quality of service provision and delivery
No formal monitoring of quality of service provision was identified during this study. Organisations reported that informal monitoring took place and/or that remarks by neighbours would sometimes alert them to distressful situations for their children. Researchers used observations and interview data to assess the extent to which services were meeting established criteria for effective early childhood programs (see Box 2 above) These are described as follows:

1) <u>Programs are community driven and highly participatory</u>

Organisations and centres appeared to be community driven: That is, they were based on needs identified in and from the community, were situated where needs were prevalent and were run by or included staff and volunteers from the community and from the client population.

In Centre B the impetus and management of the service had emanated from a source outside the community (an international organisation). Management and staff did not include community representatives.

2) <u>Programs emphasise a wide diversity of areas concerning children's health and well-being</u>

Centre a was a small organisation which ran multi service programs including home based visiting, support groups for mothers, income generation (in planning stages) and links with several other organisations. Children in the centre interacted in their community but were branded as being 'from the AIDS house'. It was reported that some neighbourhood children has been told not to play with the centre children because of this stigma. A four-year-old had been barred from the local kindergarten because of his HIV positive status.

Centre B focussed primarily on providing an 'educational' program for 3-6 year olds. This was supplemented by serving nutritious meals, organising for health checks, occasional visits by doctors, and distribution of prescribed medicines for the children. This organisation did not focus on family support or related services nor was it linked to schools or other community services at the time of the study.

Centre C was based within the community. Children attended community schools. There appeared to be linkages with other social service providers. Volunteers from NGOs came on an adhoc basis to interact with children. A large organisation had an association with this centre, including referrals and placement of children. Monitoring was not observed but a representative from the large organisation reported that they would respond if complaints were made. (The centre reported having more than the allotted capacity of children, because the children had no-where else to go.) School aged children at this centre appeared to mingle with non-OVCs in the community.

Centre D had contacts with schools, training programs and health services. The Centre contained homes within a large compound, behind a security gate. Children did not mingle with non-OVCs in the neighbourhood.

Centre E is a decentralised large organisation which runs many programs. Children in residential homes associated with Centre E were integrated in their neighbourhoods and communities and were accessing health and nutrition programs through the large organisation.

3) Programs emphasis strategic communications for awareness rising

The large organisations were highly committed to this activity. Numerous brochures and posters were produced and disseminated widely. Workshops and training packages were developed for diverse participants. Books were published and distributed through a variety of outlets. Income generation projects served double purposes of raising awareness and raising funds (for example the production of beaded AIDS brooches and story books for children).

Centre A played and active role in raising awareness about the needs of infected and affected individuals and children. Radio and print media were used to promote positive messages about these issues. Community meetings were held to discuss the importance of not rejecting HIV positive people and families. Centre B reported on their success with *'flag days'* whereby people celebrate the anniversary of the day they become aware of their HIV positive status and vow to live positively with the disease. They also engage in small scale awareness raising:

We…sensitised people in the area. We had community meetings. We even went from door-to-door. That's why we never have a burglary, because (everyone) knows we are the "AIDS-house". Blankets can be outside for a week. (Director, small organisation)

Centre B, Centre C, Centre D and the residential houses did not appear to engage in awareness raising activities. Centre E is very active and has a strong infrastructure which supports awareness raising about all facets of HIV/AIDS.

4) Programs have links to community programs including schools

One large organisation reported having exceptionally close relations with health and educational agents and was thus able to provide services for its registered clients in an effective and efficient manner. All organisations expressed a desire to increase inter-agency linkages and to develop vehicles for information-sharing and referrals, but time and coordination needed for this was not deemed to be a priority in light of service-oriented needs.

One safe house identified links with schools. All safe houses reported linkages with health and social service providers.

Many caregivers in residential houses were receiving assistance from Centre E. However, many caregivers reported feeling unconnected. Some were in conflict with community services such as municipalities and schools who were making funding claims upon them. Many respondents in residential houses reported that they could not access adequate health services and/or did not appear to know where to seek assistance for the children in their care.

The school is always threatening with letters to pay the school fees otherwise the children will be out of school. The municipality is also threatening with the payment of the house, water and electricity. (Caregiver in residential house (rh))

Need school fees and schoolbooks because they are threatening from the school (Caregiver in rh)

She is not well informed … she does not know where to seek help, who to talk to and how to find solutions to her problems. (RA comments on caregiver in rh)

5) Programs provide training opportunities for sustainability
The stability of infrastructure to ensure sustainability of current levels of service delivery and to facilitate the development of new programs as needs emerge was not evident in all situations.

At one Centre, a sustainable infrastructure was in place. This service had been operating for several decades. The infrastructure would protect service continuity beyond the presence of anyone individual such as the Head/Director.

An another Centre, the commitment of one individual was the driving force behind service development and delivery. The absence of this individual could result in program closure.

The majority of caregivers in residential houses (all but 2) reported having no backup should they become ill or unable to care for the child (ren) in their care. This was a source of grave concern to may caregivers.

As long as I am alive everything will go well, but what will happen to them if I pass away one day?

Elderly caregivers in rh

Training
One large organisation reported a training (and advancement) program for their staff. Most respondents in this study were not engaging in professional development activities. Caregivers in safe houses were aware that organisations were offering workshops/training in relevant topics, but only one respondent reported having attended any such program. In one safe house, turnover of caregivers was rapid. Caregivers seemed to have no experience or preferred background for the position. Training did not seem to be accessible due to lack of awareness, lack of time and/or lack of interest/commitment by some workers at this safehouse.

What Children and Caregivers Say
J came when he was only 1 year old. He lost his mom during childbirth. He was brought by the social workers and we've heard nothing about his relatives since.

(Caregiver is sh re child aged 4)

F came from hospital. He was 5 months. He was born in Katima. His mother was positive. He came as Baby F; no mother's name, nothing. No details of family. Only this year did we find out his surname. *(*Caregivers is sh re child aged 2½.)

Narratives by children often revealed a sense of confusion and/or rejection:
They put my father in a big hole and now I live here. (Child in sh)

Do you now who brought you here? *No.* (Child in sh, aged 6)

He changed houses in the compound a short while ago. It seems as if he does not remember anything before that. (RA about child aged 5)

He says he is 3 years, his friend says he is 5. The caregiver says he is 5. (RA)

I believe he is not well informed about himself. He does not know his own age.
(RA re child in sh)

Some children obviously believed that something wrong with them had resulted in their current predicament and/or they held other simplistic views about their situation:
My mother is in Owamboland. She doesn't want me to live there. (Why not?)
I don't know. (Child in sh)

My mother does not want me anymore. (Child in sh)

Why are you here? *I am sick.* (Child in sh, aged 5)

Other children had a grasp of their situation:
My mother and father died because they have AIDS. (Child in sh)

"Aunty" brought me with my mother and my sister. Where are they now?
They are in Rehoboth. (Child in sh)

I want to become a soldier…because a soldier took Jesus and put him on the cross.

I want to become a policeman and shoot the children (sic) and drive away.

I want to work with shovels and cleaning the house when people die.
I will clean the yard, shovelling.

(Children)

A number of children have visions of material wealth for themselves.

I want to work and earn a lot of money to be rich and buy a lot of things and many things to eat … buy a lot of furniture and a big house.

I want to buy clothes.
I want to work for company and buy myself a big house and a lot of FOOD.
I want to buy a house and stay with my children.
I want a BMW…a big one!

(Children)

Positive Experiences of Children
While many deprivations were noted, nearly all caregivers believed that the children were currently in the best situation possible under the circumstances.

A number of encouraging statements were made about children by caregivers in all situations:

When they came here they seemed to have no hope – you did not believe that they would wake up in the morning – but now most of them are well – they are fine. They put a smile on my face.

I thought we were going to bury M (child age 6 months) but there she is – I think that her mother's death gave her motivations!

We cannot replace family but we give them love and care.

At least they are healthy under this difficult situation. And they have a room.

The children come from difficult circumstances. Now they have their own bed. They sit at the table with a Mummy. They have shelter.

The children they have a place to sleep and eat, they have a home.

Some of these children have nothing, nobody…They are better off here.

I think they get everything….I take them to the swimming pool. We buy toys.

Stigma and Discrimination
Despite existing laws and regulations, children and caregivers in this study were subject to stigma and discrimination in several ways.

Caregivers reported that relatives had deserted/neglected children who were known or suspected to be HIV positive. Some children were 'blamed' for a parental death. In at least one case, a child was barred from kindergarten because his HIV positive status was known.

Everybody was blaming my baby for my sickness. They did not want to touch him because he was positive. They really don't like him and I was thinking of giving him up for adoption. (Caregiver in rh)

When I started getting sick and weak my mom suggested that they (father's family) may look after the child for a while but they didn't want to. It hurt me. (Caregiver in rh)

Some of their mothers passed away, and their fathers are not interested in them anymore. (Caregiver in sh)

We don't tell the other children that he has HIV. But we told the others that when he is bleeding; don't touch it as he has a disease in his blood. (Caregiver in sh)

The other boys on the street won't play with S. (because of his HIV+ status)… He goes out anyway and starts kicking the ball…He has taught me so much about courage. (Caregiver in sh)

…some were never visited by any parent or relative. Do you want us to send these children to die of hunger? To be told they are HIV positive and rejected? (Caregiver in sh)

I cannot play with other children because my blood is bad. (Child who is HIV positive)

Large organisations and at least one small organisation were active in raising awareness to counter stigma and discrimination:

We advocate. When the need arises I take up issues. We also do radio stations programs. Like now, I am going to UNAM for a call-in program. We try our best to be a mouthpiece for our children. (Caregiver in sh)

However there was no evidence in the study region of a centralised plan for a public awareness campaign to counter stigma and discrimination:

A second form of stigma was reported by caregivers in a non-community based setting. They stated that children did not like to be branded as 'orphans'.

They don't want to be told that they are in an orphanage…
When the children complete matric they feel insecure. Because they do not know what the future looks like. Where they should go. (Caregiver in sh)

Recommendations from our Survey
Psychological assessments, therapies and memory making
There is need to:

1. Develop procedures for assessing the state of health and well-being of OVCs and their caregivers.

2. Make available counselling services, support groups and therapy for post-traumatic stress disorder for children and caregivers who will benefit from these services.
3. Develop record keeping procedures that will ensure children (and caregivers) have information about their backgrounds, including information about their parents and relatives.

Programs

There is need to:

4. Review and enhance services and programs which are specifically targeted at children aged 0-8 yeas of age.
5. Develop and make widely available day programs for young children. These should include an early care and development focus along with the provision of nutritious meals and health services such as health checks and distribution of medicines.
   (a) Day programs should include opportunities for providing information and support to caregivers of young children through group meetings, workshops, home visiting and similar programs.
6. Increase programs which support educational and health services to older children including school lunch and after school tutoring programs, school fee vouchers, school uniforms, and donations of clothes, blankets and other goods.
7. Provide incentives for volunteer programs. Volunteers can be trained and supported to assist with child related activities and provide respite to caregivers. Activities could include excursions, outings, facilitating involvement in sports and other community oriented activities.

Caregiver support

Training, workshops and support groups for caregivers

There is need to:

8. Provide information about and access to resources for all types of caregivers which address ways to stimulate cognitive, emotional and psychosocial development in young children.
   (a) Facilitate the development of support groups for caregivers.

There is need to:

9. Provide training and support for caregivers who wish to develop or enhance income generation projects.

Infrastructure and backup

There is need to:

10. Provide a system of 'backup' or emergency care for caregivers in residential settings and safe houses who become ill or are unable to care for the child(ren) in their care for other reasons.
11. Develop an infrastructure for the recruitment, selection, training and support to caregivers in safe houses.

Leadership

There is need to:

12. Find ways to develop and reward advocates who take on leadership positions in safe houses and other situations which support young OVCs.

Community and organisation support

There is need to:

13. Provide incentives for enhanced community involvement to address the needs of OVCs, including those who are infected or affected by HIV/AIDS.

Coordination, linkages and support for organisations and service providers

There is need to:

14. Provide incentives or other means for allowing time and resources which will facilitate collaboration, networking and linkages amongst organisations, centres, and other service providers who target similar populations of children and families.

Policy development and funding issues

Equity issues

There is need to:

15. Establish a centralized database and to review service delivery which is available to all regions.

Standards and monitoring

There is need to:

16. Develop a system for identification and monitoring of OVCs, including those aged 0-8 years including information on accessible and needed services for each child.
    (a) Establish a process for updating data on individual children
    (b) Establish a system for collaboration with all relevant agencies to ensure that data is comprehensive and that duplication does not occur.
17. Develop standards, monitoring processes and code of conduct for caregivers in safe houses.
    There is need to:
    (a) Establish standards for working hours, duties and salaries.
    (b) Monitor the number of children and age/sex combinations to ensure healthy relationships can be established in the home.

Funding

There is need to:

18. Investigate current funding policies from the Ministry and to monitor current use of this funding source.
19. Review criteria and assess procedures for support to organisations and caregivers from the Ministry and other donors;
    (a) Investigate the potential for increased support from government sources and other agencies for identified needs of the target population.

20. Coordinate funding and other support from Ministries and other reliable, long-term sources as a means to increase access to existing sources, reduce duplication of funding and identify targets for new or redirected funds.
21. Investigate the potential for accessing corporate sponsorship;
    (a) Provide assistance to organisations to learn about diverse fund raising techniques.

Sustaining existing programs and developing new programs
There is need to:

22. Develop an infrastructure (collaborative network amongst policy decision makers and service providers) which will allow for consistent assessment of service delivery and of changing needs, and
    (a) Make use of the infrastructure to plan and develop new programs as needs emerge.
23. Provide seed grants and/or other supports to facilitate the development and implementation of sustainable income generation projects for caregivers.
24. Enhance and develop new programs aimed at recruiting foster families, reunifying families and relatives with children and, where appropriate, adoption of children.

Reducing stigma and discrimination
There is need to:

25. Provide incentives for programs of public education awareness raising aimed at decreasing discrimination for children and adults who are HIV+.
26. Review and ensure compliance with anti discrimination laws and policies for children and adults who are known to be HIV+.
27. Find ways to further integrate children in non-community based settings to counter branding as orphans, and other sources of stigma.

Data gathering and research directions
There is need to:

28. Assess the situation of young OVCs and their caregivers through studies which include qualitative data, as well as quantitative measures, including descriptions of the experiences of caregivers and narratives which incorporate children's perspectives

Zimba, R.F. (2003) *Community Support for the Education of Orphans and Other Vulnerable Children.*

<u>Orphan-hood and vulnerability</u>
"an OVC in Namibia is child under the age of 10 whose mother, father or both parents or primary caregiver has died, and/or is in need of care and protection".

<u>Need of orphans in Namibian Schools:</u>

1. <u>Basic Needs</u>

These include toiletries, bedding, plates, cups, cutlery, clothes, shoes, school supplies, pocket money, uniforms, school fees, as well as "the school development fund".

2. Safety and Security Needs
   It was reported that stealing, fighting, quarrelling, use of insults, drunkenness and bullying were common in hostels. Also sexual relationships.
3. Need for protection against neglect, abuse and the risk of HIV infection
   Although programmes were provided to fulfil this need; the community activities, including drunkenness and sex undermined those programmes.
4. Need for protection against discrimination and stigmatization
   In some communities San children were discriminated against.
5. Need for psychosocial support
   Several OVCs were depressed, anxious and worried, and needed support.

Strategies on community support
Need for

1. mobilization of resources
2. involvement in activities organized in support of OVCs
3. raising awareness about the needs of OVCs
4. building capacity to be used in support of OVCs

5. Concluding Remarks

Given what has been said above about the challenges that face us, someone might easily conclude that we have ended with a "paralysis of analysis". I should therefore hasten to echo James Thurber's words; "let us not look back in anger or forward in fear; but around in awareness". In concluding, I want to draw our attention to two key areas, attention to children, and attention to the critical role of education, to which we must pay attention.

Let us remind ourselves of the UNICEF position paper for the World Conference on Human Rights, held in Vienna in June 1993:

> "The best interest of the child are universal. They include the right to survival, to healthy development and protection from abuse. These rights are agreed. They are international standards. But what value do they have in a world which turns its back on hunger and want, on torture, rape, and exploitation of children?
>
> Children's lives cannot be put on hold while adult society mulls over its obligations towards them. Public commitments have been made. Treaties have been written and ratified. The time to act is now!"

Also, as I have had occasion to say many time before, in different for a, the survival and protection of children is the responsibility of all of us, individually and collectively, including us the participants at this very important conference, because as Leon Chestang (1974) has aptly observed:

"And so I ask, who, if not us, will nurture our children?

Who, if not us, will protect them?
And who, if not us, will assure them of their birthright? Who?"

On education one can say that it holds the key to development, to receptiveness to others, to population control and to the preservation of the environment. Education is what will enable us in Africa especially, to move from a culture of war, which unhappily we know too well, to a culture of peace, whose benefits we are only just beginning to sense. We are prepared to deal with the threats of the past but we are still helpless when confronting the threats of today and tomorrow.

There should be a consensus that time has come to move from discussion to decision, and from decision to implementation. Further delay in tackling the education crisis particularly in teacher education as it exists in each country or region and globally will have a very high cost in both financial and human resource terms.

Dean Acheson, one of the great and witty Secretaries of state in the USA tells about a bright young diplomat who came to him once and outlined a brilliant strategy. The young man ended his presentation by saying, "And with the help of God, we shall carry this through." To this the Secretary responded: "Unfortunately, young man, God doesn't work for the State Department!"

God may not work for African children either: I would hope and pray, however, that **HE** has a watchful eye on their healthy growth and development, under the Convention the Rights of Children, and other provisions, meant to protect our most precious resource, and the future of humanity.

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APPENDIX 1

Table 1.1: Adult HIV/AIDS Rate by Country in Africa (2000)

RANK	COUNTRY	ADULT HIV/AIDS RATE (%)
1.	Botswana	35.80
2.	Swaziland	25.25
3.	Zimbabwe	25.6
4.	Lesotho	23.57
5.	Zambia	19.95
6.	South Africa	19.94
7.	Namibia	19.54
8.	Malawi	15.96
9.	Kenya	13.95
10.	Central African Republic	13.84
11.	Mozambique	13.22
12.	Djibouti	11.75
13.	Burundi	11.32
14.	Rwanda	11.21
15.	Ivory Coast	10.76
16.	Ethiopia	10.63
17.	Uganda	8.30
18.	Tanzania	8.09
19.	Cameroon	7.73
20.	Burkina Faso	6.44
21.	Republic of Congo	6.43
22.	Togo	5.98
23.	Democratic Republic of Congo	5.07
24.	Nigeria	5.06
25.	Gabon	4.16
26.	Ghana	3.60
27.	Sierra Leone	2.99
28.	Eritrea	2.87
29.	Liberia	2.80
30.	Angola	2.78
31.	Chad	2.69
32.	Guina-Bissau	2.50
33.	Benin	2.45
34.	Mali	2.03
35.	The Gambia	1.95
36.	Senegal	1.77
37.	Guinea	1.54
38.	Niger	1.35
39.	Mauritania	0.52
40.	Equatorial Guinea	0.51
41.	Madagascar	0.15
42.	Comoros	0.12
43.	Mauritius	0.08
44.	Somalia	NA

Year 2000 estimate. See UNAIDS, 2000

Namibia was Africa's seventh worst affected country in Africa, while its ranking also coincided with the world's seventh worst affected country. Subsequent to the publication of the UNAIDS report, the 2000 seroprevalence data indicated that Namibia's seroprevalance rate was actually 22.3% which would place it as fourth most affected.

LEARNING FOR SUSTAINABILITY: CHALLENGES FOR SCIENTIFIC AND EDUCATIONAL INSTITUTIONS

Prof. Paul J Perkins AM, Fenner School of Environment and Society, Australian National University, Canberra, Australia

Abstract: Learning for sustainability offers a transformative whole of system approach to addressing our most pressing issues, including climate change, water and social cohesion. Delivered alongside regulation, policy and economic incentives, the development of new awareness, skills, values and emerging complex systems science concepts will grow capacity to respond to the challenges of sustainability and bring about productive adaptation and lasting change. Nationally, the Australian Government is in the final stages of developing a National Action Plan for Education for Sustainable Development (NAP ESD). Building on the activities of the first plan and under the banner of the UN Decade for Education for Sustainable Development, it will explicitly acknowledge the interconnected nature of the social, economic and environmental dimensions of sustainability and the need for new partnering - risk sharing models as we evolve new ways of learning, living and working. Learning for sustainability offers profound opportunities for innovation across all sectors, not least for our science and educational institutions to contribute to the achievement of a more sustainable Australia.

BUGS, TREES AND MINERALS - HOW MICROORGANISMS AND AUSTRALIAN NATIVE PLANTS ARE HELPING TO DISCOVER NEW MINERAL DEPOSITS

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Abstact: The CRC for Landscape Environments and Mineral Exploration prides itself on its tertiary and postgraduate education and training program. This presentation will highlight the critical contribution that postgraduate students have made in; our understanding of the role played by soil bacteria in moving gold around the landscape through the application of modern molecular biology techniques, and how trees and native Australian grasses can help mineral explorers detect mineral deposits buried deep within the landscape. The increasing recognition of the role biology plays in the formation of mineral deposits is changing the way mineral explorers view geological systems.

WONDERFUL SCIENCE

Joan Solomon
Plymouth University, UK

Abstract: This programme is for **primary pupils** learning about science in the natural world. It brings a treasury of new emotions and uses of senses – touch, vision, hearing, sight and taste – as well as other **secret ones**.Wonder stretches open the eyes and mouths. Breathing out becomes an audible "Wow!" as we watch the huge arch of a rainbow, coloured drops in the dew on grass, or the brilliant stripe of colours as cut glass catches the sunlight. Our wonderful experiments let the children "feel" the force of magnets, and the stretching of an invisible skin around drops of liquid. Other experiments depend on sensory experiences:- "touch" in the cuddling of comfort-blankets, or feeling the heart-beat of a chick, just hatched out. Plants move slowly towards the light and, deep in the soil, "feel" gravity. Some make tiny amounts of honey we can taste. Stars move grandly round the night sky, and under our clothes we feel the movements of food and muscles. Story and dance add to the richness of learning.

THE PUBLIC AND ITS SCIENCE

Joan Solomon
Plymouth University, UK

Abstract: People from an English Market Town often said that science was too difficult for them, and turned their irritation and memories of earlier testing on the questioner. Now they sound a little more confident, quite ready to disagree with the interviewer. This carried them away from "expert knowledge", towards "knowledge in the community". **"Do you have any interests in science?"** Some continued to protest no interest. We suggested gardening, astronomy or wild life, to recapture people's **"**personal views". A minority had enjoyed science at school, or at home. Others were unsure how it fitted in with their other beliefs – political, religious, or medical. Science knowledge was often needed for local action with neighbours or family. One continual topic was the ever present pressure of **time -** strongest in interviews carried out inside the supermarket - producing busy hostility:- **"I have shopping to do!"** The image of a **"stream of consciousness"**, with present feelings as a metaphor for time pressure, took up the idea of scientific education for the development of imagination.

USE OF AQUIFERS TO STORE AND REUSE RECYCLED WATERS USING MANAGED AQUIFER RECHARGE

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Abstract: Managed Aquifer Recharge (MAR) is a group of methods where water is added to groundwater in a controlled managed way with the intent to recover this recharged water at a later date. MAR is particularly useful for assisting with the recycling of water as the groundwater systems provide an economically viable storage option as well as assisting in the water treatment processes. There is extensive research currently being undertaken on improving the MAR process; on the recycled water quality improvements that occur within the aquifer; and how these quality changes can be predicted by computer modelling. This presentation will give details on what is MAR and how is it used with recycled water, on the research associated with changes in recycled water quality during MAR, and what the future holds for MAR.

AFTER THE HICCUP…REVISITING AND REFOCUSING THE YEAR 11 AND 12 CURRICULUM REFORM

David Wood, CEO, Curriculum Council of Western Australia

Abstract: Western Australia is implementing an outcomes and standards education approach through a major K-12 curriculum reform. The reform has focused recently on Years 11 and 12. The presentation will be based on revisiting and refocusing the Year 11 and 12 curriculum reform by briefly outlining:

- the background to the reform,
- the proposed curriculum model and inherent issues,
- why the changes were needed,
- a clearer view of the future.

David will present from an 'old science teacher' perspective who has maintained close links with the discipline while being a school principal and now CEO of the Curriculum Council.

TEACHERS EXPERIENCING ANTARCTICA (TEA)

Tony Worby, Antarctic Climate and Ecosystems Cooperative Research Centre and Australian Antarctic Division

Abstract: Two Tasmanian teachers will participate in a 6 week voyage to Antarctica in September – October 2007 aboard Australia's icebreaking research vessel "Aurora Australis". The voyage is named the "Sea Ice Physics and Ecosystem eXperiment (SIPEX)" and represents a multidisciplinary study of the frozen ocean around Antarctica. This research is a major contribution to the International Polar Year and the teachers onboard the ship will form an integral part of the education and outreach program that aims to encourage a new generation of polar researchers. The objective of the program is to engage teachers in the science activities onboard the ship and for them to provide daily updates on their activities via a dedicated voyage website. This talk will present some background information on the role of the polar regions in the climate system, recent observed changes and activities aboard the SIPEX voyage, focusing particularly on the "Teachers Experiencing the Antarctic" program.

Part 3: Reviewed Synopses

(In alphabetical order by first author's surname)

MAKING PEACE THROUGH THE INTEGRATED SCIENCE CURRICULUM: A CASE STUDY OF THE NIGERIAN JUNIOR SECONDARY SCHOOL

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Abstract: This study examined the extent to which the integrated science curriculum of the junior secondary school (JSS) can be used in the training of the mind for the emotions of peace as well as its implementation and facilities available for teaching. The curriculum content was analyzed using nine questions and a questionnaire was administered on science teachers. Data was analysed using descriptive statistics. Some factors were identified that will make the curriculum integrated for making peace. The implications of these findings are discussed in relation to the review of the philosophy, objectives and content of the JSS curriculum.

Introduction

According to Lasonen (2004), the term peace implies an absence of conflict and quarrel, the enjoyment of security, well being and harmony and not just the absence of war or armed conflict. Peace can be by various activities one of which is by creating a culture of peace in our values, attitudes, traditions, and behaviour. All our institutions and practices should be arranged to maximize the life chances of all and education can achieve this purpose.

Education is the most effective means that a society possesses for confronting the challenges of the future. An integrated science curriculum can build a culture of peace if it includes the teaching of the ethics of science and engineering which is the need for scientists to be aware of and take responsibilities for the consequences of their scientific exploits (Aladejana and Aladejana, 2003). According to Article 9 of the Declaration of the United Nations (2000), education plays significant roles in promoting and ensuring peace. Specifically, it recommends ensuring that children benefit from education on values, attitudes and modes of behaviour that will enable them to resolve any dispute peacefully. It also encourages the revision of educational curricula.

There is therefore the need to incorporate peace education into the school curriculum. A way to make peace can be by using science to address the personal, environmental and global benefits that can train the mind in the emotions of peace and as a tool to address the causes and impact of violence and conflicts. According to the Declaration on Science and the Use of Scientific Knowledge adopted by the World Conference of Science (1999), science should promote intellectual and moral solidarity of mankind, which is the basis of a culture of peace. Integrated science, a compulsory subject by all junior school students in Nigeria can be explored for this purpose.

Theory

The study is underpinned by the theoretical framework of integrated curriculum which links subject areas and provides meaningful learning experiences that develop skills and knowledge while leading to an understanding of conceptual relationships. In integrative curriculum, the planned learning experiences not only provide learners with a unified view of commonly held knowledge but also motivate and develop learners' power to perceive new relationships and thus to create new models, systems and structures (Lake, 1997, Palmer, 1991).

Objectives

This paper will therefore examine the Nigeria JSS Integrated Science curriculum to:

1. determine the extent to which it can be used to train the mind in the emotions of peace and as a tool to address the causes and impact of violence and conflicts.
2. identify specific topics that can be used as means and tools for achieving peace
3. examine the implementation of and the facilities available for teaching integrated science

Significance

The study will highlight the place of science for life. It will look at one of the proper roles of scientific knowledge. Although science has been known for breakthroughs and discoveries in areas such as electricity, medicine and transportation, the study will help to identify that methods and content of science can also be used to engender peace. Specifically, teachers and curriculum planners will be able to identify that the integrated science curriculum of the Nigerian JSS can be used to cultivate a culture of peace. Also, the need for activities that can build peace into the youths to be integrated into the science curriculum will be clearly visible to teachers. This is quite significant as it is the children, the youth and women that are at the receiving end when there is war or conflict.

Design and Procedure

The paper is a descriptive study using primary and secondary data. The analysis of the Nigerian JSS integrated science curriculum content for factors that can in any way engender peace, was carried out using nine self-designed questions. The questions were designed based on reviewed literature and previous works of the researcher. The questions were validated by assessment by a science educator, a curriculum expert and a researcher in peace studies. The philosophy and objectives of the curriculum were assessed to determine if they address the issues relating to a culture of peace. Also a questionnaire was administered on 613 purposively selected secondary school science teachers to gather data on the implementation and widespread use of the curriculum across the country and their responses to the research questions. Also the implementation of the curriculum in terms of examinations was assessed. The results were analyzed using descriptive statistics.

Findings

The results are based on the research questions.

Question 1: Does the curriculum provide answers to some of the issues that are potential causes of conflict and violence?

The curriculum was found to address some of these issues. Such topics include:

Causes, Symptoms and Prevention of diseases many diseases

The curriculum has dealt extensively with these diseases, their causes and prevention. Many diseases like small pox are by traditional belief attributed to deities, while some are believed to be inflicted on one by supernatural powers. This has constantly led to great family and local community conflicts.

Sex Determination

The curriculum describes adequately that having all-female children is not the problem of the woman but purely a chance event and basically depending on which of the man's sperm fertilizes the egg. In the Nigerian society, a family is not successful unless there is a male child who is believed will be the one to carry on the family name and who will hold the home in future. When a woman now has all-female children, the fault is put solely on her and this is a great source of conflict in the home.

Inheritance of Characters (Dominant and recessive traits).

The fact that some characters can be manifested in an offspring even when it is not visible in the parents is a topic in the curriculum. Conflicts often arise when some men doubt the paternity of their children based on their physical appearance e.g. when parents who are non-albino give birth to an albino child.

Question 2. Does the implementation of the curriculum encourage nation wide cooperation among all the students?

The same curriculum is found to be used throughout all the private and public JSS in the 36 states of the country. The same examination conducted by the National Examination Council (NECO) is taken by all these schools at end of the 3-year course. Marking of the scripts is done by exchange of scripts amongst teachers in the different states. Along with this examination, each of the states conducts JSS examinations for its own students. This makes it imperative for students in different schools and even different ethnic groups to cooperate in the areas of quite competitions, science week activities, field trips, science exhibitions, and studying together.

Question 3: Can the use of the curriculum help to remove disparity between the privileged and unprivileged?

Since the curriculum is used by all JSS schools in Nigeria, all the privileged highbrow private school students as well as unprivileged public school students share the same information and use even the same textbooks. The result is that the children of low socio-economic status are not at a disadvantage in terms of what is being learnt. Children of the privileged and unprivileged can attain the same feats and go into the same future careers. This removal of disparity is essential for all children to feel at home with each other, as they will have common grounds for discussion and interaction and consequently, less room for friction.

It is found that what differs amongst these schools are the facilities available to teach the content. Most public schools have inadequate funding, large class size, no laboratory, no equipment and chemicals.

Question 4: Is the use of dialogue/discussion method recommended?

The curriculum recommends the use of discussions as one of the methods of teaching for topics like process of weaning, food crops, gravity, machines and controlling the environment. With the students able to discuss and listen to the views of others and arriving at a consensus, they can learn the use of dialogue in resolving issues.

Question 5: Are there topics related to environmental considerations in the curriculum?

The curriculum is based on the thematic approach. Six themes are adopted, one of which is 'controlling the environment'. In the three books of the JSS, topics to be learnt under this theme include environmental sanitation (refuse and sewage), disease vectors, preventive medicine, maintaining balance in the environment, wild life conservation, pollution and the deterioration of the environment due to human activities.

Question 6: Will learning the curriculum content raise the scientific level of all learners?

The study has shown that 87.08% of the curriculum content provides the learner with the required scientific knowledge. These topics span through the disciplines of physics, chemistry, biology, and the social sciences. There is adequate scope and depth. Students will have the required basic knowledge from learning these topics to be scientifically literate. They will be able to use simple appliances in the home as these are well stipulated in the content. Such knowledge will prevent an individual from conflicts even within himself/herself and be able to live better quality life. This is important as the peace that one enjoys within determines largely how much peace one enjoys with others.

Question 7: Are there topics highlighting the roles of the scientist, ethics of science and engineering?
The JSS curriculum does not contain any topic on the ethics of science and engineering. It must be recognized that scientists have social responsibilities for the information they have and the results of their researches. The government and the general public must be aware of precautions to be taken. When students have this awareness at this level, many future possible conflicts are averted.

Question 8: Can the instructional methods recommended in the curriculum train the mind of the students for intelligent inquiry?
Many of the topics in the curriculum can train the mind for intelligent enquiry. Such topics have activities that require the students to count, observe, perform, examine and compare. Activities of this nature can train the mind. When an individual has the scientific mind, rumours, false accusations, superstitions and many other ills, which often cause conflicts will no longer be a source of conflict and peace will reign.

Question 9: Is the curriculum suitable for the local culture?

Most of the examples used in the curriculum are of local origin, which the students are quite familiar with. The JSS curriculum has many of such examples: use of yam for the test for starch, examples of food in a balanced diet, plants and animals used in the food chain and pollutants. This makes the curriculum to be real to the students and they can identify with the content. They do not see it as foreign or that their background is inferior to that of others. When feelings of inferiority and non-belongingness exist, then conflicts can thrive easily.

Discussion

The implications of these findings are discussed in relation to the review of the philosophy, objectives and content of the JSS integrated science curriculum.

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Integrated and Subject-Specific Science Education in Swedish Compulsory School: Differences in Students' Activities

Maria Åström, Mid Sweden University and Linköping University, Sweden

Abstract: This seminar concerns the student activities in Swedish classrooms that both work integrated and subject-specific. Students have answered seventeen questions of how often they have themes in lessons, and if they use different books in the lessons. The students answer on this question is cross-correlated to seventeen questions of the activities that occur in their science classroom. There are statistical significant differences at all questions but two. The results are discussed.

Objectives

The research question for this paper is what student activities are occurring in science education in Swedish compulsory school. The study is done with quantitative method, with a cross-correlation between students' answer on in what amount they work with themes compared to seventeen questions of what student activities their science education contains.

Significance

Since there are two types of science education in this school form, integrated science (nature-oriented) or subject-specific science (biology, chemistry and physics) that both have the same national curriculum it is interesting to find if there are differences between the two types of organising the science curriculum. In Sweden there has been a discussion of how to teach and grade students in science in compulsory school since the early 1980ies when the regulation gave opportunity to grade students in science (NO) or biology, chemistry and physics. About twenty percent of the schools work integrated, about half of the schools work subject-specific and the rest work both integrated and subject-specific (Andersson, 1994; Åström, 2007). Recent studies show no difference in scientific literacy as assessed by the PISA 2003 in Sweden (Åström, 2006). If there is no difference between the overall student results in scientific literacy, why is there a husk debate dealing with either working integrated or subject-specific? This study spreads some light on the question of what student activities are done in each organisation of the science curriculum and if there are differences between what is done in schools with much integration (thematic work) and these with little integration (subject specific teaching).

Theory

The major idea behind the different sorts of education rises from the early 1970ies. Bernstein wrote about two forms of curriculum, integrated and collected (Bernstein, 1975). *[…] frame refers to the degree of control teacher and pupil possess over the selection, organization, pacing and timing of the knowledge transmitted and received in the pedagogical relationship'* (p. 89 emphasis in original). He finds that integrated curriculum has more diffuse boundaries than collected curriculum. It can be interpreted from Bernstein that the integrated code is a means whereby teachers can enter into social relationships with teachers from other departments since they need to co-operate to accomplish the educational task (Brown, 1977). Therefore co-operation between teachers is anticipated in integrated science classes. Hirst and Peters wrote about integrated and traditional curriculum (Hirst & Peters, 1970). They describe traditional, tough-minded teaching that stresses the importance of knowledge with a clear division of subjects, numerous examinations, formal class instruction and the maintenance of discipline through punishment. They contrast this to a tender-minded teaching where children learn to learn in a curriculum that reflects children's interests and needs in a combination of group projects and individual activity. Bennett tried to find differences in student results between progressive teaching and traditional teaching (Bennett, 1976). The progressive teaching style had as its first criteria integrated subject matter and the traditional teaching style had as its first criteria separate subject matter. Bennett's description of student activities in integrated classes stresses the active student, students' activity in planning, discovery techniques, intrinsic motivation and co-operative group work by students. The discussion of two kinds of approaches to curriculum has long time roots in earlier traditions of schooling, but those writers made early attempts to find what could characterise the benefits of each school organisation. Attempts to find differences between the two school organisations in Sweden in the light of scientific concepts have given results that there are no differences between the overall student results on questions of scientific concepts between the different groups having integrated or subject-specific science (Andersson, 1994). With the new concept of scientific literacy as measured by PISA (OECD, 1999, 2006), that gives different results compared to for example TIMSS between gender groups (Fensham, 2005) it is interesting to explore what is assessed by PISA in regard of what students activities that are done in science classrooms in Sweden according to student questionnaire answers.

Design and procedure

This study consists of a statistical analysis of twenty questions asked to 1225 students that were testing a survey in Sweden. The sample consists of fifteen year olds in Sweden and most of them attend the last year in compulsory school. The sample of students came from the whole country but the sample is not a representative selection from the whole population. Students were asked three questions 1) to what extent they were having themes in science education where all three science subject were represented, 2) if they had themes with both science and social sciences represented and 3) if they used books in both biology, chemistry and physics at the same lesson. The student answers on those three questions are cross-correlated to seventeen questions of the activities that occur in their science classroom. The questions about activities occurring in the classroom deal with students' discussion and opinions in subjects, how the laboratory work is done and every-day life experiences brought to the science classroom. The seventeen questions in this study were, due to rotated test design, answered by 472 to 508 students. The students answered the questions on a four grade Likert scale from occurring 'always in lesson' to 'never in lesson'. The questions were cross-correlated and tested with chi-2 test and Spearman correlation. This gave correlations at five and ten percent level of the three 'thematic questions' to the seventeen lesson questions at thirty-five alternatives. Since there seemed unlikely from an examination of the cross-tables that so many of the correlations were 'true' correlations the four grade Likert scales were dichotomised and new cross-tables with chi-2 test and Spearman correlation were calculated. This gave table 1 with fourteen correlations at five or ten percent level. The results are discussed below.

Findings

When correlating the above questions with the questions about the activities in the classroom the following is found. Table 1 is describing the correlation between the items that show correlation between the questions about student activities and the questions about themes and text books.

The results from Table 1 are interpreted in the following way when reading the first row in the table: 'Students that use books in biology, chemistry and physics at the same lesson at few lessons' also have 'few lessons where students have discussions about the topic' (tested at five percent significance level). Similar conclusions are drawn from the other cells in the table.

Two of the seventeen questions correlate to all three of the thematic and textbook questions; 'Students are asked to apply a science topic to everyday problems' and 'Students are asked to do an investigation to test out their own ideas'. A third question correlates to two of the three questions about themes and textbooks, 'The teacher uses examples of technological applications to show how science is relevant to society'. The first question about student activity might be expected as correlated to thematic work since one of the components in the Swedish debate about integration concerns every-day life according to (Riis, 1985). The second question about student activity might also be expected since students own investigations is a part of integrated science as Bennett predicted and the third question about technology applications is also a part of the integration discussion in Sweden.

The correlations between the question about themes with both science and social sciences and the student activity questions are somewhat difficult to judge, since there are only seventeen per cent of the students that answer that they have themes combined like that in some or all lessons. The conclusion is that it is not a common way of working to involve themes with both sciences and social sciences. However the students that have themes with both science and social science give answers correlated as found in table 1. There are five of the seventeen questions that have not been found correlating to a significant degree to the three questions about themes and textbooks. Those questions are 'There is a class debate or discussion', 'Students spend time in the laboratory doing practical experiments', 'Experiments are done by the teacher as demonstrations', 'Students do experiment by following the instructions of the teacher' and 'The teacher uses science to help students understand the world outside school'. Those activities are expected to be occurring in all science classrooms with or without integrated science.

Some additional statistics have been done, trying to reduce data with cluster analysis and factor analysis that will be discussed at the presentation. This data reduction shows some groups of questions that are not expected, but this might depend on the research settings.

Some differences between gender groups in what the students' answers of what they do in science classrooms are discussed at the presentation.

Table 1

Item	themes in science education	themes with both science and social sciences	uses books in both biology, chemistry and physics
Students have discussions about the topic			**
The lessons involve students' opinions about the topic		**	
Students are given opportunities to explain their ideas	**		
Students are required to design how a science question could be investigated in the laboratory		**	
Students are allowed to design their own experiments			**
Students are asked to apply a science topic to everyday problems	**	*	**
The teacher clearly explains the relevance of science concepts to our lives		**	
Students are asked to do an investigation to test out their own ideas	**	**	**
The teacher uses examples of technological applications to show how science is relevant to society		**	**

**= at five per cent level
*= at ten per cent level

The conclusion from this investigation of correlation of students answer is that there are some differences between what is done in classrooms with many thematic (integrated) lessons and classrooms with few thematic lessons. The focus of what occurs in the integrated organisation is that students are asked to work with every-day problems, investigate their test their own ideas and have examples of technology applications. The patterns are although not that strong as was expected from literature studies and theories of integrated versus 'traditional' teaching. Especially Bennett's model of active student, students' activity in planning, discovery techniques, intrinsic motivation and co-operative group work by students is not met at the extent as was supposed.

The sample is however not representative for the whole country, since the schools were not picked at random, so the results are only an indication of what is done in some Swedish schools. More data is required to get an accurate view of the situation in the whole country.

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Building a Scanning Tunnelling Microscope: A Continuing Project in an Engineering Physics Program

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Abstract: This poster presentation is describing a project of advanced physics at University level that is used to get the physics content connected in a meaningful way for students at undergraduate level in engineering physics. The presentation focus on teachers and students experiences of the project.

Objectives

The objectives of this poster presentation is describing a project of advanced physics at University level that is used to get the physics content connected in a meaningful way for students at undergraduate level in engineering physics. The presentation focus on teachers and students experiences of the project.

Significance

To obtain a more engineering approach to education in an engineering physics program, which started 2005 at Mid Sweden University, an advanced student-building project was implemented. The project is intended to be the connecting comprehensive thread trough the first three years of studies. The project is to design, build, and use a scanning tunnelling microscope (STM). An STM roughly consists of three parts: a mechanical scanning head, an analogue electronic part and a computer measurement equipment. The unique feature of the STM is its atomic resolution (Binning & Rohrer, 1986).

Theory

A common idea amongst people is that science, and especially physics is fragmented and much learning need to proceed before advanced physics can be obtained (Roth, 1997). This project is an attempt to start early in the undergraduate education, already in the first year, to learning by doing an advanced physical device by oneself from start to finish. The project is open and students have much scope for own ideas, since it is a participatory project (Berthelsen, Illeris, & Poulsen, 1981; Illeris, 1979). Since the students are studying physics, the project should render in a technical device that is possible to use in other physical classes during the education. The project differs from thematic studies in that the students work is rendering in a physical product (Ransedokken, 1997).

Design and procedure

In an introductory course, during the first 8 weeks of the first semester, the students built the mechanical parts of the STM and used it for imaging of gold surfaces. The electronics and software for the measurement equipment was designed and built earlier by two teachers. The student time allocated for the building of the STM-head was 80 hours. The sixteen students that started the program were divided into six groups with 2-3 students in each. The examination consisted of an oral presentation in Swedish and a written report in English. In the next course in mechanics they measured the resonance frequency of their mechanical STM-head using Fourier transform techniques.

Later the scanning tunnelling microscope is intended to be used in courses such as: modern physics (to study quantum tunnelling), in electronics (to replace the analogue electronics built by the teachers), programming (to replace the teachers software), in experimental physics (to study computer aided electrical measurements), in solid state physics (to used the STM for imaging of atoms on graphite and studies of charge density waves), in quantum mechanics (for studies of quantized conductance).

Findings

The students' expectation of the project in the beginning of the first course is rather high. They are enthusiastic and have some experiences from upper secondary school of working in project. The results from the first introductory courses show highly enthusiastic and creative students. Four of the groups managed to get images of gold surfaces. Most groups experienced a lack of time at the end of the course, and we will next year include more parts on project planning and also make restrictions of the design framework.

In conclusion, we have implemented a project around a scanning tunnelling microscope connecting several courses in a new engineering physics program. The first semester courses showed highly enthusiastic students. Minor changes, such as on project planning, will be made next year for the introductory course.

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Shifting from Being Clean to Being Stewards: An Examination of the Effect of Significant Activities on Understanding of Sustainability

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Abstract: This presentation is about research into the development of 11-12 year old students' understandings of the concept of sustainability during their engagement in an environmental education programme. An interpretive-qualitative mode of inquiry was used to investigate this development. The activities that had a significant effect on the development of their understandings were fieldwork, role play and reflective discussion. The strategies used for collecting and analysing the students' understanding were interviews and document analysis. This presentation is suitable for primary and middle school teachers.

Objectives

Sustainability is one of four key concepts identified for inclusion in environmental education programes in the framework *Guidelines for Environmental Education in New Zealand Schools* (Ministry of Education, 1999). Of the four key concepts, sustainability can be regarded as the most important because understanding about environmental issues or expressing feelings of concern about environmental problems does not engage the learner in active participation (Bolstad, 2003). Students need to be able to integrate their understandings, feelings of concern and skills in order to take appropriate action to solve environmental problems and work towards achieving sustainability. The aim of this research was to explore whether students aged between 11-12 years of age could develop an understanding of the concept of sustainability and use their understanding to take action to solve an environmental problem.

Significance

Sustainability, or sustainable development (Parliamentary Commissioner for the Environment (PCE), 2002), can be regarded as an integral part of an environmental education programme for the following reasons. First because New Zealand is a signatory of Agenda 21, a "global action plan for achieving sustainable development" (Gough, 1997, p. 2) and New Zealanders have made a commitment to implement its recommendations, an understanding of the concept is needed. Second, an understanding of sustainability is required because it is embedded in many recent statutes that affect the everyday lives of many New Zealanders, for example, the Resource Management Act 1991 (PCE, 2002). Third, New Zealanders need an understanding of this concept because there has been a move away from centralised decision making to communities and individuals making decisions about managing their environment (Ministry for the Environment, 1995). This decentralisation has occurred because individuals and communities have a vested interest in managing their environment well because they have to live with the long term consequences of their environmental decisions.

There appears to be a lack of research about how to facilitate the development of students' understanding of sustainability. Two international reviews of environmental education literature highlight the lack of research into the outcomes of environmental education learning (Hart & Nolan, 1999; Rickinson, 2001). Even the term sustainable development is not familiar to 53% of New Zealand students aged between sixteen and seventeen years of age (Keown, 2002).

A further problem is to define sustainability. Although it is a familiar term (Elshof, 2003), agreeing on a definition is problematic because of the myriad of ways that it is interpreted as well as it being a complex concept (Gough, 1997).

Theory

Two learning theories have been suggested as best suiting environmental education programmes – experiential learning theory and a social constructivist-linked view of learning. Both theories underpinned the environmental education programme that was taught.

Experiential learning theory was used because it is holistic, engaging all of the human faculties, namely head, heart and hands (Barker & Rogers, 2004). This theory also accounts for the way that the students were able to reflect upon their experiences and come to the realisation that there was an environmental problem. Therefore, through the engagement of their faculties and reflections upon their experiences, the students were able to take informed action.

A social constructivist-linked view of learning was used because it enabled the students to construct new knowledge based on their existing ideas and their experiences through discussions with both the teacher and their peers as well as through reflection (Jordan, Porath & Bickerton, 2003). This process gave the students an opportunity for deeper learning to take place. It also enabled the students to utilize their new knowledge when deciding on a plan of action. Therefore, the programme included the identification of prior knowledge, opportunities for group work and discussion, class discussion, personal reflection on learning and fieldwork in the environment.

Underpinning the programme was a definition of sustainability. It is the definition most commonly used by educators (Yencken, 2000) and states:

"Humanity has the ability to make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs." (World Commission on Environment and Development, 1987, p. 8)

Because of the complex nature of sustainability, this definition was contextualised to reflect the students' context and their particular environmental and social concerns (Summers & Kruger, 2003). The contextualised definition contained two ideas:

1. This idea is related to the idea of sustainable development and is an environment component of sustainability. It is the idea that people need to think about their environment and the way it is used so that its quality is either maintained or improved;

2. The second idea is that of intergenerational equity, to ensure that future generations inherit an Earth that is at least, or if not more, as diverse and productive as the one that the current generation enjoys. This idea relates to the social component of sustainability representing the way that people interact with their environment.

Design and procedure

The research used an interpretive-qualitative mode of inquiry with a case study approach. 22 students aged between 11-12 years engaged in an environmental education programme. There was an even gender mix and a range of academic abilities. However, the range was skewed in that approximately 74% had a reading age above their chronological age according to school data. These students attended an intermediate school in a high socio-economic district that was close to a local freshwater lake that was the context for the programme.

Four sets of data were collected during the course of the programme. Data about the students' initial understandings of sustainability were gathered at the beginning of the programme in the form of individual semi-structured interviews. About two-thirds of the way through the programme the students completed an individual written task to gauge the development of their understanding of sustainability. This task was referred to as the first understanding probe. In this task the students had to think of a way that the lake could be used in the future and then justify such use in terms of their understanding of sustainability.

Near to the conclusion of the programme the students completed another written task, referred to as the second understanding probe. On this occasion the students firstly participated in a group role play activity. Each group had a scenario card and had to try to "sell" their use of the lake as the best way of caring for the lake. After a discussion about the scenarios, the students chose a scenario, stated reasons for their choice and then justified their choice using their understanding of sustainability.

At the end of the programme the students were again interviewed individually about their understanding of sustainability.

The environmental education programme was planned in collaboration with the classroom teacher. It was integrated and included activities from all curriculum documents, from science to health and the arts. The programme was set in the real-life context of the local lake with which the students were familiar. The programme also incorporated the three key dimensions of environmental education, namely education *in, about* and *for* the environment (Ministry of Education, 1999). The inclusion of all three key dimensions results in a balanced programme with a holistic nature (Barker & Rogers, 2004), which can assist in the development of understanding of the concept of sustainability.

The two ideas from the contextualised definition were used to categorise the students' responses into levels of complexity of understanding. The first category was entitled *No*

Idea and included all ideas that had no relationship to sustainability. The second category, *Environmental Ideas*, included all ideas about caring for the environment. The third category was called *Future/Choices Ideas* and incorporated ideas about intergenerational equity. It is important to note that these two categories were of equal complexity as they represent the two parts of the definition. The final category was called *Complex Ideas*. In order to be placed in this category, the students had to express an understanding that integrated both the environmental and the social component of the concept of sustainability.

Findings

Table 1 below illustrates the development of the students' understandings during the programme and shows how the students' ideas about sustainability developed in complexity. This development is shown by the way that at the end of the programme, all but one of the students were able to express their understandings about sustainability in terms of either environmental or social ideas. However, these findings also show how difficult it is for students of this age to develop a complex understanding of sustainability. This finding is shown by the way that only two students were able to express an understanding that integrated both the environmental and social ideas.

Despite this difficulty, the students were able to express ideas of stewardship. For example, one student said that sustainability meant "… keep something good … so that the people after you will benefit from it as well …" (Student S11). This idea of being stewards was also shown in the environmental action undertaken. Examples of

Table 1

Table showing analysis of understandings developed

Date Data Collected	27/04	09/06	05/08	23/08
Data Type	Initial Interview	Understanding Probe 1	Understanding Probe 2	Post-teaching Interview
No Idea Category	19	7	2	1
Environmental Ideas Category	3	13	7	3
Future/Choices Ideas Category	0	2	13	16
Complex Ideas Category	0	0	0	2

actions taken included writing letters to the newspapers; making a presentation to other students at the school and the Board of Trustees; reporting to the local council and a national waterways group as well as making a submission to the local council about their management plan for the lake. These actions show that students can develop an understanding of sustainability and then use it to take appropriate action.

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DEVELOPING ARGUMENTATION IN GRADE 10 BIOLOGY LESSONS IN SOUTH AFRICA: IMPLICATIONS FOR TEACHERS' PROFESSIONAL DEVELOPMENT

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Abstract: Two types of argumentation lessons, one dealing with a socio-scientific topic and another with a pure scientific topic in two grade 10 biology classes in a Cape Town school are compared. Pupils' dialogue was rated for levels in sophistication of argument. Higher levels were found in the scientific topic. Beliefs and attitudes are displayed in the more socio-scientific lesson compared to drawing on facts and evidence in the more scientific lesson. We identify critical incidences - key moments in teaching either supporting or hindering successful argumentation. Implications for the development of a CPD programme are discussed.

Objectives

The South African Department of Education (DoE, 2004), like many other curriculum developing agencies, recognizes that a school science curriculum involves 'critical inquiry, reflection, and the understanding of [science] concepts and processes, and their application in society' (p46). In biology (or life sciences as it is known in South Africa), for example, learners in grade 10-12 (typically ages 14-16) are required to, 'understand the nature of science and the influence of ethics and biases in the life sciences' (DoE, 2004 p.28). These requirements can be seen as quite radical in science education, that is, a move from a content oriented curriculum towards a focus on scientific literacy and 'ideas about science' (Goodrum, Rennie and Hackling, 2001). One major area of critical thinking is considered to be the ability to formulate an argument, using evidence to support a claim and, even stronger, to dislodge counter claims. Argumentation (the process of arguing) is a crucial component of critical thinking, because it requires learners to engage with data and evidence, to make claims based on these and to weigh the extent to which others' claims can be substantiated (Erduran, Osborne and Simon, 2004). This paper explores teacher actions and classroom discourse within groups of students engaging with two types of argumentation lessons, one dealing with a socio-scientific topic and the other dealing with a pure scientific topic. The outcomes have informed the design of programmes of continuous professional development (CPD) in teaching critical thinking in South Africa.

Significance

Kuhn (1993) reckons that the ability of critical inquiry forms the basis of scientific knowledge, and especially building up new scientific knowledge using evidence. Dealing with evidence in a critical way should therefore be central in the teaching of school science. Several types of argumentation tasks can be distinguished. These may include tasks requiring to defend a given position, or to present the opposite position of a given argument. Glassner, Weinstock and Neuman (2005) report on the way students argue in providing evidence-based proof for different types of claims, or alternatively suggesting a plausible explanation for these claims. The authors differentiate between causal claims (e.g. the use of mobile phones during driving causes car accidents); deontic claims (e.g. we must limit the building of one-storey houses to reduce environmental damage); and existential claims (e.g. the Earth is getting warmer). Brem and Rips (2000) differentiate argumentation tasks according to the amount of evidence students need to generate by themselves or can select from. The more evidence is provided explicitly, the more likely a claim will be supported by evidence and thus constitutes a higher-level argument.

Theory

Several schemes have been proposed for the analysis of argument discourse. Toulmin (1958) developed a typology of argument structure in normal discourse and suggested a progression for the different argument structures. Walton (1996) suggested a classification of arguments in scientific reasoning. He particularly focussed on the role allocated to expert opinion within the argument. Jimenez-Alexandre and Pereiro-Munoz (2002) summarise Walton's scheme in two key questions, i.e. 'who has the status of an expert in the argument?' and 'how consistent is the position of the expert with those of other experts and with evidence?' The role of the expert is pertinent for argumentation in the Southern African cultural context as the local worldviews (Jegede and Aikenhead, 1999; George, 1999) attach considerable weight to the authority proposing a claim. More recently research has been reported on the teaching of argumentation (Newton, Driver and Osborne, 1999) as part of supporting understanding in the major area of ideas about evidence (Osborne et al. 2004a). The same authors developed and tested sets of pre-written lessons materials fostering argumentation for the national curriculum in England together with professional development materials for training of teachers. Their work provided one of the lessons taught (Euglena) and a scheme of levels by which outcomes of argumentation can be assessed.

Design and procedure

Two different types of argumentation lesson were taught in the same school by different teachers. Mr Van Rhyn taught a lesson of his own design requiring discussion of a socio-scientific topic, organ trafficking. Mr Jacobs taught a lesson requiring the class to consider evidence for different taxonomic classifications of the microorganism, Euglena. This lesson therefore required argumentation of a different type – about the scientific concepts involved. Both lessons were videotaped and the recordings analysed at three stages. In stage one the content and progress of each lesson was tracked against a framework for constructivist teaching (Scott, 1987). At the second stage the outcomes of class and group dialogue were analysed and ascribed levels of argumentation according to the scheme devised by Osborne (Osborne, Erduran and Simon, 2004). Osborne's scheme ascribes highest levels of argumentation (at level 3 and above) to arguments that contain rebuttals of claims, warrants and/or backings. In the third stage of analysis recordings were analysed independently by four researchers and then compared for consensus to identify 'critical incidents', that is teacher behaviours and significant shifts in patterns of dialogue (see also Simon, Erduran and Osborne, 2006) that might explain levels of argumentation.

Findings

Levels of argumentation were found to be substantially different for each lesson. In the Organ Trafficking lesson rebuttals hardly occurred, limiting the overall outcome to level 2 on Osborne's scale. In the main part of this lesson learners were required, in their groups, to list the pros and cons of organ trafficking rather than to argue about a specific claim or to take up a particular position thereby limiting opportunities for more developed argumentation at levels 3 and above. In the Euglena lesson examples of arguments containing rebuttals were more frequent. The overall level of argumentation was judged to be at least at level 3 and in many cases closer to level 4 on Osborne's scale.

Eight critical incidents (four in each lesson) were identified and agreed on as being key moments and actions underpinning or hindering successful argumentation. On the success side each teacher spent time explaining the purposes and scope of the argumentation required and laid down clear rules for group discussion such as allocation of roles and time frames for the completion of tasks. Although rebuttals were hardly evident in the Organ Trafficking lesson, there was one moment when the Mr Van Rhyn prompted a student to engage by taking up a particular moral position. This tactic has been termed 'playing devil's advocate' (Simon et al, 2006) and it achieved some success in this lesson as can be seen below (T = teacher; L1 = learner 1):

T We now get into a moral issue about this (organ trafficking) … I think … it's a personal thing that we probably have to sit down and personally make this … how you feel morally about your own moral values and how you've been brought up will decide eventually what decision (about whether or not to donate a kidney) you will take.

L1 If they (medics) say your son needs a transplant .. OK … and you are a suitable donor … and it's (having organs removed/having an operation) is against your religion you are .. you are .. going to think of your son first even though your religion says … you are going to help your son. The first thing you think about is about helping your son rather than .. OK, your religion says he must die. This is what I think.

On the more problematic side, both teachers tended to constrain opportunities for arguments to develop just at the points where learners seemed to be most engaged and prepared to contribute warranted claims or rebuttals. There were two reasons for this. One is a fault of the design of the task – not allowing enough freedom or providing a structure to allow for different claims to be made. The other is not providing enough time for challenges to claims and warrants (rebuttals) to develop.

Apart from the intrinsic design features of learning activities or the micro-decisions taken by the teacher at the time there is another important factor affecting the different outcomes of argumentation in these two lesson types. There seems to be a crucial difference between arguments drawing on scientific evidence and centred around a set of causal claims, and those centred around an existential claim drawing on moral stances and beliefs (Glassner, Weinstock and Neuman.,2005). Both have significance for the development of our programme of curriculum development and CPD for teachers in South Africa and for science teaching more generally. In the Organ Trafficking lesson a crucial limiting factor in the teaching design was the remit given to each group as the basis for group discussion. Instead of a request to develop different claims each either in support of or against the trafficking of organs, learners in each group were required to list a series of claims both for and against and then to submit these to the whole class. The style and presentation of the activity limited the opportunities for each group to reason using warranted claims. This is probably one of the reasons why a more heated exchange occurred when groups were finally asked to reach a decision (described as critical incident OT3 in our full paper). A more successful approach here might have been to allow time for a relatively free discussion about an open question, e.g. 'Should organ trafficking be allowed?' and then to follow this with a more closed discussion task focussed around a number of different reasoned claims both in support and against trafficking. Such two-part tasks have been documented as being successful in other contexts for argument in Biology such as genetics (see for example, Jimenez-Aleixandre, Rodriguez and Duschl, 2000). We are promoting this approach in our training workshops.

The different features and outcomes from these two lessons produce something of a dilemma for us as educators/trainers if we want to promote the worth of both types of argument as part of the new science curriculum and our training programme. Unless we are careful, we could promote the view that if teachers want to achieve high levels of argumentation in their lessons they should stick to structured activities based on clear relationships between evidence to argue about competing claims rather than to engage in more messy and complex debates about ethical, moral or socio-economic concerns. We feel that to do so would be dishonest and counter-productive, not least because it is against the spirit and specific intentions with which the curriculum in South Africa was written.

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DEVELOPING AN ONLINE PORTAL TO SUPPORT SCIENCE AND TECHNOLOGY EDUCATION IN NEW ZEALAND

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Abstract: The New Zealand Biotechnology Learning Hub (www.biotechlearn.org.nz) and New Zealand Science Learning Hub (*www.sciencelearn.org.nz*) are online portals that have been developed to make contemporary science and technology research more accessible to school students and teachers. Rich in multimedia resources, such as video clips and interactive activities, the portals provide a glimpse into a world that can otherwise be difficult for teachers and students to access. The strength of the project is its research base, including interviews with the industry sector and classroom-based case studies. Classroom trials and teacher and student development teams inform the ongoing development of both portals.

Objectives

Both the New Zealand Biotechnology Learning Hub and the New Zealand Science Learning Hub[7] have been developed with Government funding to make contemporary science and technology research more accessible to school students and teachers. Specific aims include: Raising awareness of how science and technology concepts included in the school curriculum relate to the modern world; demonstrating effective strategies to transform research organisations' science stories into classroom experiences; and developing an on-line digital framework to promote communication between the research and development sector and schools.

The development of both portals is based on an extensive research project which included focus group discussions with industry and classroom-based case studies.

Significance

Relevant, authentic contexts enhance students' interest and engagement in science and technology learning and can foster curiosity and inquiry as a learning approach and as a learning outcome. They also provide a stimulus for dialogue, with a concomitant development and use of the language of science and/or technology (Lemke, 2001; Roth, 2005).

In order to introduce such authentic contexts, a range of approaches have been used to create links between research organisations and the classroom. These include providing classroom activities that illustrate laboratory processes (e.g., Sweeney, 1998); inviting teachers into biotechnology laboratories and enabling them to translate the "real process" into a form that

[7] The Science Learning Hub will be launched in June 2007. The Biotechnology Learning Hub has been available online since March 2005.

they can carry out with students (e.g., Cullis, Sogor & Lachvayder, 1998); running programmes for school students in a university, science centre or R&D company (e.g., Joliffe, 2003; Thomas *et al*., 2002); and mentoring select groups of students (e.g., Chowning, 2002). Unfortunately, these initiatives tend to be costly and time-intensive, both to set-up and to run, and require both teachers and the research community to develop and sustain an on-going relationship.

Information and communication technologies provide alternative avenues by which teachers and students can access contemporary research (e.g., Linn, Clark, & Slotta, 2002). However, few online resources specifically link industry stories with science and technology pedagogies, and school storerooms filled with unused (and unusable) resource material developed or sponsored by industries and government organisations indicate the need for resources that have been developed with teacher input.

Theory

When presented in ways that are accessible and meaningful, ICT-based teaching and learning materials provide opportunities for the multi-sensory experiences. Such multimodal opportunities for meaning making and communication are of increasing interest to education researchers, and studies of ICT use in science teaching and learning are just beginning to explicate the affordances of simulations, animations, and other visual tools in bridging experience and abstraction and supporting the explanation and understanding of science concepts (Webb, 2005). In particular, research has indicated that effective teaching using multimedia resources is characterised by the use of meaningful content presented in life-like situations or realistic problem solving environments (Sherwood, 2002) where learning is enhanced through informed conversation (Huffman, Goldberg, & Michlin, 2003).

This is consistent with a socio-cultural view of learning (Wertsch, 1991) and focuses attention on the environment created by the teacher. For example, while a student may access information through the Internet, it is in a classroom/community that the ideas gleaned have the chance to be challenged, tested, played out, and discussed (Dalton and Tharp, 2002; Hart, 2001). Despite this, the majority of studies addressing the implications of ICT in the classroom neglect the impact that interaction with the teacher and peers have (Becta, 2003). To be effective and useful, ICT-based resources therefore need to be based on sound research of teaching, learning, and teacher pedagogical content knowledge (Dickson & Irving, 2002; Churach & Fisher, 2001).

Design and procedure

In order to identify specific needs of New Zealand's education and industry sectors, an initial research project was carried out to inform the development of the Biotechnology Learning Hub, and subsequently the Science Learning Hub. This research included focus groups with industry representatives, and six classroom-based trials.

Focus group interviews were conducted with representatives from six government-funded institutes, five universities, and 11 private biotechnology companies. Four main themes were addressed in the discussions: how to engage and nurture student curiosity and interest; how to develop and foster scientific and technological literacy for responsible citizenship; existing initiatives between the industry sector and schools; and how an on-line framework can be used to support science and technology education (Eames, Harlow, & Coll, 2004).

The purpose of the classroom-based case studies was to explore ways in which teachers can transform scientific and technological knowledge into appropriate teaching and learning experiences. The research, which included teacher workshops and collaborative development of classroom materials, was conducted at four schools with six experienced teachers and students in Years 5 – 9 (i.e., 9 – 14 year olds). Data collected included field notes from lesson observations, teacher planning documents, samples of student work, and semi-structured interviews with the teachers and a sample of students (Moreland, France, Cowie, & Milne 2004).

Findings

Classroom case studies

The classroom trials suggest that access to relevant resource material, as well as the opportunity to learn from experts, was viewed by teachers as being important for enhancing the quality of the learning programme. As has already been indicated, this can be problematic and there is a need for alternative forms of access. Additional findings included the following: the underpinning science and technology concepts need to be identified and understood by teachers so that they can become an integral part of the learning programme; understanding the *nature* of science and technology, and the implications of this for a teaching / learning programme is important; science and/or technology problems need to be embedded in real-life contexts in order for students to engage with the complexities inherent in science and/or technology concepts and processes; hands-on activities provide motivation and authenticity for students, but pose challenges for teachers and schools; and the industry sector can provide additional resources that allow for the enrichment of classroom activities (for example, providing authentic data for analysis).

Focus group interviews with industry

The industry sector participants were very much in favour of science and technology education for scientifically and technologically literate citizenship, as well as for promoting science and/or technology as a career option. Several were involved in school-industry partnerships, but all agreed that it was difficult for an organisation to build relationships with more than a few schools at a time. Many also commented that such relationships were not 'core business' and that there was pressure 'from the top' to limit such activities.

There was general support for an interactive website that would support education in schools. In particular, such a website could: present science and technology as a 'fun' endeavour; demonstrate how science and technology affects the lives of everyone in the community; provide a point of networking between the biotechnology sector and teachers, students and the wider community; provide a forum for the critical analysis of, for example, media reports about science and/or technology issues; and provide feedback for schools and the biotechnology sector by showing 'what works.'

Conclusions

The findings from both the classroom trials and the industry interviews were used to inform the development of the Biotechnology Learning Hub, and later the Science Learning Hub. Key features of these online resources are that: both the education and science/technology communities have had considerable input in the development of content; there is access to experts in a format that can be sustained by the science and technology sectors; the content is rich in multimedia, reflecting the needs of modern learners; information is layered to accommodate different educational needs, levels and interests; and content is regularly updated in response to the needs of both the education and science/technology communities. Reactions from key stakeholders (teachers and industry) have been extremely encouraging, and classroom trials continue to inform ongoing development of content and portal functionality.

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THE SCIENCE-RELATED EPISTEMOLOGICAL BELIEFS OF UPPER SECONDARY STUDENTS IN SINGAPORE: A PILOT STUDY

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Abstract: The results of a pilot study that focused on the science-related epistemological beliefs (SEBs) of upper secondary students (N=147) in Singapore are presented. The study used the Science-related Epistemological Beliefs Questionnaire (SEBQ), which was developed by adapting items from earlier studies and also by adding items from the literature relating to the nature and philosophy of science. The psychometric properties of SEBQ are also presented. Five dimensions of SEBs were found using exploratory factor analysis, but only one dimension significantly correlated with the science achievement of students. Significant gender difference was found in relation to two out of five dimensions.

Objectives

Epistemological beliefs (EBs) can be defined as an individual's beliefs about the nature of knowledge and the process of knowing (Hofer, 2000). EBs have received burgeoning attention from educational researchers since the groundbreaking work of William Perry Jr. in 1968. The increased focus on the topic stems from research findings indicating that these beliefs are related with students' learning.

Although there is an increasing interest in EBs construct, studies focusing on it are scant. Most of these studies are set in the Western context and are focused on general- rather than domain-specific beliefs. The existing instruments were largely developed and validated in the foregoing context. Very few studies (e.g. Mori, 1999; Chan & Elliot, 2002) featured samples from other cultures, specifically from Asia. Studies (Mori, 1999; Lee, 1995) that partly involved members of Asian diaspora communities in the United States suggest the limited applicability of existing instruments for Asian samples (e.g. Korean and Japanese), possibly due to cultural differences (Chan & Elliot, 2002).

In light of the paucity of studies pertaining to EBs in the Asian context and considering the view that EBs are more domain-specific than domain-general (see review of Hofer & Pintrich, 1997), the present study was conceptualized. The study aims to determine the structure as well as explore the nature of the science-related epistemological beliefs (SEBs) of upper secondary students in Singapore, an Asian country with a predominantly Chinese population. An additional goal of this study is to investigate the association between SEBs and science academic performance, and between SEBs and gender. To achieve the goals of the study, an instrument for measuring SEBs was crafted by adapting items from previously developed instruments on general EBs and adding new items that can capture the distinctiveness of the structure of knowledge and justification of knowing in the field of science.

Significance

Beginning with Ryan (1984), the effect of EBs in the learning process has been investigated to a significant extent. Students who have more sophisticated EBs are more likely to engage in self-regulated learning (Hofer, 1999; Paulsen & Feldman, 1999), be intrinsically motivated to learn (Hofer, 1999), and have high grades (Hofer, 1999; Schommer, 1993) than those with less sophisticated beliefs. Students' beliefs about the changing nature of science tend to affect their ability to integrate their understanding of a topic (Songer & Linn, 1991). It can be surmised from the results of these studies that consideration of EBs is important in fostering science learning.

The findings of this study provide novel empirical information regarding the nature of the SEBs of Asian students, in particular Singapore secondary students. No study has been reported in the literature regarding the EBs of students in Singapore. This information can be used by concerned teachers to determine specific areas that need more attention in developing more sophisticated beliefs, which may accordingly help in the promotion of better learning, particularly in science. Researchers can also use this information as a reference when looking at cultural differences in relation to EBs, as well as in validating the proposed dimensions of EBs.

Theory

The multidimensional model of EBs has gained popularity since the landmark work of Schommer in 1989. This model considers EBs as a system of more or less independent dimensions that may develop in different patterns (Hofer, 2000; Schommer, 1990, 1992). Schommer (1989; 1990) hypothesized that EBs comprise five dimensions: source, structure, and certainty of knowledge; and control and speed of acquiring knowledge. After developing an instrument that measures general EBs (also called as Epistemological Beliefs Questionnaire or EBQ) and using it on a sample of Western university students, she empirically established all of her hypothesized dimensions, except the first one.

The results of replication studies using EBQ showed deviations from Schommer's five-dimensional model. Schommer's own replication research using secondary students (Schommer, 1993) and a different group of university students (Schommer, Crouse & Rhodes, 1992), still in a Western setting, indicated that some dimensions of EBs tend to merge. Along with the merging of some dimensions, Qian and Alvermann (1995) extracted fewer than the five hypothesized dimensions. An Asian-based replication study done by Chan and Elliot (2002), who translated the original EBQ into Chinese and for use by pre-service teachers in Hong Kong, found only three out of the five hypothesized dimensions.

Trying to focus more on the philosophical roots of EBs, Hofer and Pintrich (1997) proposed the exclusion of control and speed of acquiring learning from Schommer's (1989) original dimensions of EBs, noting that these dimensions are more associated with intelligence and learning than EBs. They instead proposed a four-dimensional model of EBs. They took the first three of Schommer's dimensions— certainty, simplicity, and source of knowledge—and added a new dimension— justification of knowing. The empirical existence of justification of knowing (Hofer, 2000; Stathodolou & Vosniadou, 2006) and source of knowledge (Chan & Elliot, 2002; Hofer, 2000; Mori, 1999; Stathodolou & Vosniadou, 2006) was established by researchers, along with another new dimension— attainability of truth (Hofer, 2000; Mori, 1999; Stathodolou & Vosniadou, 2006).

In the present study, the four dimensions of EBs postulated by Hofer and Pintrich (1997) were used as a framework for exploring the science-related epistemological beliefs (SEBs) of upper secondary students noting the consistency of this framework with the philosophical description of epistemology.

Design and Procedure

The pilot study used a convenience sample of 147 upper secondary students from three government schools in Singapore. About 68% of the participants were female. They completed the Science-related Epistemological Beliefs Questionnaire (SEBQ) in 20 minutes. They were informed that their responses will not affect their grades.

The SEBQ includes items adapted from those used by earlier researchers (Hofer; 2000; Qian & Alvermann, 1995; Schommer, 1989; Stathopoulou & Vosniadou, 2006) and new items from the literature based on the philosophy and nature of science. Each of the items in the adapted instrument was rephrased to suit language ability of the target population in the study and was also made specific to science. Three senior lecturers in science education from the National Institute of Education in Singapore validated the contents of the instrument. The final instrument comprised 42 items using a five-point Likert response scale ranging from "Strongly Disagree" to "Strongly Agree". The readability level of the instrument was found suitable for the target sample.

Findings

After conducting exploratory factor analyses with varimax rotation on the students' responses to each item of SEBQ, a five factor solution was considered most parsimonious. The five-factor solution explained 39.4% of the total variance.

The description of the five factors or dimensions extracted, the number of items comprising each factor, and Cronbach alpha reliabilities are given below:

1. Simple Knowledge-"Science knowledge is Simple and unambiguous rather than complex and confusing" (7 items, a =.73)
2. Attainable Truth- "Scientific truth about everything is attainable by experts", (6 items, a= .72)
3. Source of Knowledge -"Science knowledge is handed down from authorities rather than obtained by reason". (4 items, a =.60)
4. Justification of Knowledge- "Scientific knowledge should be questioned and verified using varied sources"(5 items, a =.66)

5. Confidence in Authority- "Science knowledge presented by authorities is true" (4 items, a =.48)

It should be noted that a new dimension emerged from the analysis—Confidence in Authority. This dimension appears to be a variant of Source of Knowledge. The stability of this dimension needs further investigation.

Item–total correlations ranged from .22 to .63, suggesting that the items in each factor are discriminating well between those who scored high and those who scored low. The correlations between items were small to moderate (from .12 to .46). The reliabilities of the dimensions, albeit not very high, were acceptable for group comparisons.

More of the students tend to believe in attainability of absolute truth in science and support the view that knowledge is handed from authority to the knower. The majority of the students tend to view knowledge as complex and prefer questioning and verification ideas presented to them. Students gave inconsistent responses to items in Confidence in Authority dimension. For example, more students are inclined to question the information in science textbooks but also endorsed the idea that everything presented in textbooks is true. Significant gender difference was found only in relation to the dimensions, simplicity of knowledge ($F(1,131)=4.60$, $p=.03$) and confidence in authority ($F(1,131)=9.13$, $p=.003$): Boys are more inclined to believe in simplicity of knowledge than girls, while girls tend to believe more in the information presented by authorities than boys.

It was found that only Confidence in Authority significantly correlated with the science grade of students ($r= -.23$, $p<.05$), specially of girls. The modest negative correlation detected indicates that the greater the students' confidence in the veracity of knowledge presented in sources, such as textbooks, the lower is the students' science grade. Perhaps those who put a lot of trust in the information from such sources of knowledge no longer question this information and are less likely to engage in critical thinking. It makes more sense if the result for Justification of Knowledge is considered. Although its positive correlation with science grade is not significant, the value is comparable with that between Confidence in Authority and science grade. The more the students question ideas from sources, the higher is their grade, which seems to be the opposite of the result in relation to Confidence in Authority.

The five-factor solution obtained in this pilot study upholds the multidimensionality of EBs. Although one new dimension was extracted, the strong similarity of the dimensions found in this study with those of earlier studies suggests the construct validity of the SEBQ.

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THE AG.CMP METHOD
A FIVE PILLAR APPROACH TO BASIC SCIENCE LEARNING

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Abstract: This presentation is aimed at sharing the major findings of the Nigeria-UNESCO Science and Technology Education Project, and in particular, the paradigm shift from Active to Effective learning. The AG.CMP method refers to the five pillars of effective learning, which are: **A**ctive, **G**ender Sensitive, **C**onsistent, **M**eaningful and **P**roductive. The achievements and lessons learnt from the Nigerian Initiative will highlight the core issues pertaining to the qualitative transformation and regulation of the teaching/learning process not only in Basic Education but as well in the other levels of the Education System.

Objectives

The transformation of African societies into emerging knowledge societies is a major challenge facing the continent. In a globalizing world, the need to survive, participate and compete is felt at all levels. The key issue relates to promoting quality human resources with a solid scientific and technological background. Therefore, Science and Technology Education becomes the backbone of the combined processes of transformation and regulation of emerging societies. Especially at basic education level, it appears that proceeding to qualitative changes from the bottom will ensure the sustainability of the overall societal development. The largest African country with regards to population size has embarked on the development of Science and Technology Education to significantly contribute to Nigeria Economic Empowerment and Development Strategy for Sustainable Economic Growth and Human Development.

A low level of interest in Science and Technology Subjects has been assessed among Youth. The records on examination are showing declining performances, leading to a central question: How effective is the teaching and learning of science and technology in primary & secondary schools, Colleges of Education and at Tertiary level? In particular, how to improve basic science and technology learning? What kind of transformation should be considered to make significant difference in learning achievements? How to generate meaningful acquisitions with equity and consistency?

Significance

Referring to the Teaching/Learning process, the issue of understanding is essential especially in science and technology education. However, the practice observed in most schools is lecture based teaching/learning process. Memorizing the lessons written or read by the teacher is a daily mode of knowledge acquisition in many schools over the continent. The lack of Teaching/Learning materials and the low level of qualification of most teachers remain the major constraints. As a result, learning by heart is not helping. The issue of learning to learn (Faure & al, 1972) should be further investigated in the light of the achievements. It has been assessed that students are learning a lot, but not understanding most of what they have learnt. The lack of proper understanding in the learning process led to inadequate competences of local expertise. Subsequently, the high dependency from abroad is perpetuated. More and more, the focus should be on learning to understand. It is through the understanding that learners are motivated to learn more and to perform better.

There are many factors contributing to the understanding: the teaching method, the teaching/learning materials, the participation of learners and local communities, and the interaction with the environment. In Basic Science learning, the availability and proper use of teaching aids and instruments will enhance the understanding and meaningfulness of the learning process. From a teacher centered process, there should be a focus on a learner centered process. The major objective of the teacher relates to this key question: Are learners achieving in relation to the curriculum? Teaching strategies ought to be organized around this core preoccupation. (Naidoo & Savage, 1998). The significance of the research undertaken through an operational activity in Science and Technology Education pertains to the possibility of immediate use of the findings in improving basic science and technology learning and enhancing learning achievements. Moreover, the findings are not restricted to Science subjects; they also impact on the other subjects of the Basic Education Curriculum.

Theory

Active pedagogy methods represent an important trend in the promotion of learners' participation. The approach is based on the fact that the more you participate, the more you learn. The theory emphasizes ways of organizing the classroom, asking questions and giving time to thinking and answering. Active pedagogy is a significant progress made with regards to the lecture based pedagogy. In every session, the role of the teacher will ensure maximum participation. (Ornstein, (ed), 1994) The practice has shown that in many cases, the active participation is taking place without relevance of the learning contents; subsequently, learning achievements are limited. Moreover, in Science and Technology Education sessions, Active learning was not including systematically the equitable participation of both girls and boys. Activities were often dominated by boys. Therefore, the issue of gender sensitivity stands as a factor to consider in addition to the active nature of the learning process. (ECLAC, 1992)

Considering the employability of the graduates of the education system, though having undergone active learning, the competences acquired are questionable. The issue of inadequacy with the needs of the development sectors is being addressed not only in the curriculum reform, but also in reviewing the teaching/learning methods. (De Feiter & al., 1995). There is need to determine the basic foundations of effective learning as compared to active learning. Indeed, a learning process can be active without being effective. Hence, the focus should be on the effectiveness of the learning process.
In addition to the active and gender sensitive nature of the learning process, three other characteristics are considered: consistency, meaningfulness and productivity. The learning process should relate to the curriculum, to the challenges facing the community, the society and the World. It should lead to concrete products as outputs of the each learning session.

Design and Procedure

The pilot phase of the improvement of Science and Technology Education targeted 370 primary schools with an average of 10 schools per State in Nigeria. Each participating school nominated two mathematic teachers and two integrated science teachers to participate in the capacity building activities. Every school has been supplied with two Primary Mathematics kits and two Primary science kits. Globally, 740 Primary Mathematics kits were distributed and 740 teachers trained on the use of the Mathematics kits. The same number of Primary Science Kits was made available and equivalent number of science teachers trained on the use of relevant kits. However, beside the use of kits which is important, it has been decided to enhance the pedagogical competences of teachers. Already, 1480 primary mathematics and science teachers have been trained on Effective Learning Techniques.

The zonal workshops according to the six geopolitical zones officially determined by the country were organized focusing the five-pillar approach to Effective Learning: Active, Gender sensitive, Consistent, Meaningful and Productive. The AG.CMP Method was applied for the first time to improve Basic Science and Technology Education in Nigeria. The achievements of the teachers during workshops were assessed and also a first assessment exercise was conducted in the six geopolitical zones with interviews of learners, teachers, Head teachers and Education Administrators. The schools were distributed both in rural and urban areas. Female teachers' participation was also factored in, taking into consideration Gender inequality among Science and Technology Teaching Staff. It is worth noting that the Science Teachers Association of Nigeria and the Mathematics Association of Nigeria organized the workshops on the use of the kits, conducted by Kit Suppliers.

Findings

Most of the 1480 teachers of the pilot phase were teaching with no appropriate teaching learning aid. Chalk, Blackboard and Ruler were the most common tools used. At least 4/5 teachers were lecturing. A restricted minority was trying active methods and using their resourcefulness.

The availability and use of both types of kits impacted on the teaching/learning process and especially in the new distribution of roles within the classroom. The time of talking has been reversed between Teachers and Learners. Instead of teachers doing all the talking, it has been witnessed that the learners do now more of the talking. The teacher has become a guide, a coordinator. There is a shift in the profile of the teacher from Teacher-lecturer to Teacher facilitator.

Prior to the intervention, more than half of the pupils found mathematics boring, especially girls. The assessment revealed that the introduction of the kits and particularly the games in learning mathematics, made this subject friendly to the learner. Pupils confirmed that the Mathematics subject is now a lot of fun to them. The teachers emphasized that they are no more working with only abstract things and concepts.

Children can touch concrete objects, manipulate, measure, calculate, evaluate; the teaching is more effective and efficient.

Among the findings, few teachers were able, prior to the Initiative, to relate the learning to the basic science curriculum. Most Teachers heard about the curriculum, but had never read it. Moreover, the link between the learning contents and development challenges at local, state and federal levels were not considered. In addition to the lack of consistency and meaningfulness, productive activity was restricted or not addressed at all. Now, the 1480 targeted teachers are more confident with regards to achieving the objectives of the curriculum.

As concerns the understanding of basic principles of science, Pupils demonstrated their learning achievements, when they were asked what to do when their mother's frying pan containing oil is burning: are you pouring water in it to stop the fire? Almost all pupils answered 'no'; and added we cover the frying pan to stop burning, because air supports burning. This appropriate reaction expressed the meaningfulness of the learning process to their daily life. The knowledge acquisition could save lives as well as the entire household in handling the case referred to.

Pupils are more confident in their knowledge acquisition with the AG.CMP Method. As an illustration, some pupils are saying that before, they did not know that water boils at 100 º C. But now they know that water boils at 100 º C. 'We have tested it!' Having the possibility to test provides a unique opportunity of enhancing the learning achievements in Basic Science and Technology Education.

As a result, 59 200 primary school pupils involved in the pilot phase are gradually changing their profile from passive and active pupils to that of Achieving Learners. This change in profile is laying the foundation for the promotion of educated nation builders, proactive and creative, culturally rooted and committed to universally shared values. Indeed, culture goes along with effective learning. In the process of basic science and technology learning, reference is made to Science as a tool for improving the quality of life and building sustainable livelihoods. Moreover, the development process is based on the combination of Education and Culture.

An overall outcome and contribution of the Science and Technology Education Project is the paradigm shift from Active to Effective learning using the AG.CMP Method. The paradigm shift is affecting not only Science and Technology Education, but also relates to all subjects taught at Basic Education level.

The Five-Pillar approach is being promoted by 71 Colleges of Education, Polytechnics, and 20 Universities participating actually in the project. Significant impact has been witnessed both on learners and teachers. The excitement has been so important that some Basic Education Authorities decided to train, on their own, more teachers on Effective Learning Techniques and buy micro mathematics kits and micro science kits for all local schools.

Scaling up the achievements is an overwhelming duty which will target 50% of all remaining schools in the country at basic and secondary education levels. It means that 50% of schools in each of the 774 Local Government Areas will be reached. More than 14 million children are directly concerned within the next three years. The findings and achievements could be shared among countries experiencing similar realities, particularly in Africa and other developing countries.

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TECHNOLOGY AND TEACHERS IN RURAL SCHOOLS: CREATING FUTURE ADVANTAGE

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Abstract: While there seem to be compelling arguments for the incorporation of computers and their applications into curricula, the reality is far from ideal. Problems are particularly evident for teachers and students in rural areas. This paper reports on a project situated in regional and rural areas of Victoria (Australia) in which a group of 16 primary and secondary teachers participated in an intensive program of professional development designed to assist them in embedding ICT into their classroom. The project provides some insight into the availability and use of current technological resources in the rural schools and examines the impact of an intensive professional development program of instruction on the implementation of ICT into the curriculum.

Objectives

This paper reports on a project situated in regional areas of Victoria in which a group of 16 primary and secondary teachers participated in an intensive program of professional development designed to assist them in embedding ICT into their classroom. The project provides some insight into the availability and use of current technological resources in the rural schools and examines the impact of an intensive professional development program of instruction on the implementation of ICT into the curriculum

Theory

It is now widely recognised that a computer-mediated curriculum can support student learning by providing a medium that is constructive, active and engaging (Severinsen, 2004, Huffaker, 2003). Used as tool, it is effective at situating the learner at the centre of learning, in control of his/her learning. “Technology is a potentially powerful learning tool in the rural and urban setting if used effectively. It is the use of this tool and understanding how to use the tool that is important.” (Gregor, 2005). Research indicates that the benefits of computer mediated learning can be the key ideas of active learning, metacognition and transfer of learning from one situation to another (Huffaker, 2003). Students spend much of their own time investigating on the internet and the use of computers in schools as a curriculum tool is highly supported. (Levin & Arafeh, 2003). While there seem to be compelling arguments for the incorporation of computers and their applications into curricula (Harrison, Comber, Fisher, Haw, Lewin, Lunzer, McFarlane, Mavers, Scrimshaw, Somekh, & Watling, 2002), the reality is far from ideal. The problem is particularly compelling for teachers and students in rural areas. Australia has many rural and remote areas, as does the USA, Canada and many countries, and there is increasing concern about disadvantage associated with this. This project has explored a model that has the potential to address rural issues in the teaching and learning of ICT.

Significance

This project is significant in three ways:

- providing data on the technological resources that are available in the schools,
- in identifying how these resources are used by teachers
- examining the effectiveness of professional development for changing teaching practice in using ICT.

An Australian national survey conducted in 2005 of 2940 teachers, 928 parents and students found significant disadvantage for rural schools and students in a number of different areas. In particular, there was a high turnover of teaching staff as well as huge difficulty in finding staff to fill positions, particularly in mathematics, science and ICT. Teachers in regional and rural schools indicated a high unmet demand for professional development in all areas. In addition, teachers, parents and students reported inequities in terms of the availability and quality of on-line access, access to technical assistance and support services, and resource provision (Lyons, Cooksey, Panizzon, Parnell & Pegg, 2006).

Research has shown that for schools to integrate ICT into their curricula, a number of factors need to be in place (Ping, Swe, Hew, Wong & Shantri, 2003). These include the school's and teacher's integration strategies, the support from school leadership, professional development for the staff, and resources. This paper will deal with issues and possible solutions to the problems of the integration of ICT, in relation particularly to rural schools.

Design and Procedure

In response to the problems flagged by the Australian research into rural and regional disadvantage, the Association of Independent Schools of Victoria (AISV) designed and implemented a professional development and school support initiative. The project involved 12 schools diverse in their size, religious affiliations and location. There were : 5 small school (<100 students), 4 medium schools (100-300 students)and 3 large schools (>600 students). The schools were divided into three dispersed hubs across Victoria (Australia). Collaborating with the rural schools AISV provided an intensive training program on ICT at each hub for teachers (termed ICT coordinators) chosen from within individual schools, some resource support for those in need, and follow-up mentoring. The model involved progressive training for teachers at school – a "train-the-trainer" model.

Initially, the research project was developed to investigate the integration of ICT into numeracy and literacy, however, evolved further as teachers incorporated ICT in all discipline areas, including science. This paper will focus particularly on examples in science.

The research questions addressed by this paper include:

- What are the particular circumstances in these rural schools and communities that affect the use of ICT in teaching and learning?
- How successful is the intervention in achieving a positive change in:
    - Teacher classroom practice and understanding of the potential role of ICT to support learning and effective pedagogies relating to this?

  - Teacher and student attitudes to the use of ICT in teaching and learning?
- What aspects of the professional learning model embedded in the intervention have been successful in improving teaching and learning?

This research project investigated three hubs of schools located across the state as both the schools and teachers attempted to integrate learning technologies as a normal part of classroom practice in mathematics, literacy and science. In total, 12 schools were studied, with a mixture of both primary school levels (grades preparatory to year six) and secondary (grades seven to twelve). School principals, coordinators, classroom teachers and students were initially surveyed to provide a baseline of competencies, interest and daily use in Information and Communications Technology (ICT).

After the initial visits and coordinator consultations, coordinators attended the training period of five days, 8 hours each day. These workshops were evaluated and coordinators provided feedback on the usefulness of the program for their professional competencies. The paper will present some brief case descriptions to illustrate the variety of beginning competence levels, and outcomes for coordinators during the workshops, and examine the effectiveness of different aspects of the training model. After a period of 4-5 months, schools were visited by a mentor, and also the evaluation team member, to discuss progress and provide advice. At this time, interviews were held with the coordinators, participating teachers and students involved in the teacher's classroom where the integration of ICT was occurring. The final part of the project was a further survey response by all participants and a showcase event in which teachers displayed student work and described innovations they had made in their teaching.

Findings

It was clear that there was a huge difference across all sectors and in particular, the coordinators varied greatly in their skills and abilities. These surveys, and initial visits to the sites involving teacher interviews, highlighted the diversity of circumstances experienced by the schools, not only in terms of ICT availability and use, and teacher experience, but also in more general issues of cultures of curriculum planning and integration, size, communication, and pedagogical presumptions. The successful uptake of ICT in classrooms depends on a complex of such environmental factors.

It was found, for instance, that some coordinators used the computers mainly as a word processing machines and little else, while others were already attempting to incorporate electronic learning into their curriculum delivery. Back in their schools, the coordinators introduced the professional development in a variety of ways and with a recognition of the variation in teacher ICT abilities. Some provided weekly sessions with curriculum examples, some prepared a CD sampler with suggested ICT use under different teaching situations, whilst others took a slower approach and provided training over 2-3 sessions. Their progress on this part of the project was tracked using blogs on each of the three hub sites. One of the difficulties coordinators experienced was the lack of self selection of teachers for this training. It will be argued that for this PD model to be successful, it needs to manage the dissemination of training in schools much more closely, providing explicit structures and encouraging school commitment to the process through more attention to schools feeling a sense of ownership of the particular innovations they put in place.

From these data sets it was clear that there were still some existing blockers to the successful implementation and integration of ICT into classroom use. The research has highlighted the inequalities in rural schools, in different locations and with differing circumstances, in terms of rural student access to the technologies they need to take up the promise of ICT for classroom learning, and communication. A number of reasons for this continuing inequality, and the impediments to progress in negotiating change in teachers' practices in relation to ICT, are drawn out from the surveys and interviews with the participating coordinators, teachers and students. They include, but are not restricted to, the impact of:

- degree of remoteness/ rurality,
- the size of the school,
- resources/ facilities available,
- teachers' ICT skill level,
- teachers' ability and confidence to integrate ICT in classroom,
- curriculum requirements – e.g. Victorian Essential Learning Strategy promotes an integrated approach with ICT,
- the inclusion of ICT in programs of study- add-on, carrot- motivator, reward, etc
- expectations of the rural/remote teachers, students and community,
- additional requirements placed on teachers,
- students' learning, the impact of the PD on students' learning, LE, attitudes etc
- nature of the school and its philosophical foundation, ICT culture (policies, leadership, collegial support)

Overall, the project contributed significantly to the knowledge of the use of ICT in rural schools and provides some insight into the practical implementation of ICT into the curriculum.

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EDUCATION FOR SUSTAINABLE LIVING: CANADIAN PERSPECTIVES OF ENVIRONMENTAL CONSCIOUSNESS AND CITIZENSHIP

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Abstract: This paper is intended to engender thought among primary teachers, pre-service educators and academics concerned about environmental education and curriculum. We draw on ecological and critical theory discourses in an effort to reconceptualize environmental education and to describe the relationships between curriculum, environmental consciousness, and citizenship. By reviewing two official curriculum documents as they pertain (or not) to environmental consciousness, citizenship and sustainability, we explore the tensions and contradictions between environmental education and the context of Alberta, Canada. This will undoubtedly help science and social studies educators better understand the complex relationships in teaching towards education for sustainable living.

Objectives

Environmental education in many education jurisdictions in Canada is not offered as a discrete subject, but rather is subsumed primarily within the subject of science. Östman (1994) argues that science education constructs a particular view of the human-nature relationship and of the world around us and that "it is therefore not possible to isolate or to separate the teaching of science concepts from socialization in to some kind of environmental consciousness" (p. 142). If Östman is correct, science teachers must ask themselves how they are 'socializing' their students. What kind of 'environmental consciousness' will students develop? How does curriculum, especially in terms of environmental consciousness and citizenship, challenge teachers and students? How does the discourse of curriculum – both in science education and social studies education – mediate the various dimensions of ecological literacy? These three critical questions are of particular relevance in light of the current impetus for education for sustainable living, as part of the United Nations Decade of Education for Sustainable Development (2005-2014) (UNESCO, 2005). Rethinking how to recognize the interconnectedness of environmental consciousness and citizenship, however, challenges educators to approach education for sustainable living in different ways.

In Canada, education falls under provincial jurisdiction; consequently, how provinces approach environmental education differs greatly, from cross-curricular integration (e.g. (British Columbia Ministry of Education, 2005) to a piecemeal approach (e.g. Alberta Education, 2005; Alberta Learning, 1996). However, in order to learn how to live sustainably, citizens need to be ecologically literate. Broadly defined, ecological literacy implies a basic understanding of the natural world and the interconnectedness of life. Such an understanding would necessarily be grounded in the study of ecology, natural history, biogeochemical cycles, and the importance of place (Orr, 1992; Thomashow, 1995, 2002). Ecological literacy education also fosters an ethic of care and responsibility

(Orr). Drawn to Orr's (1992) notion of ecological literacy and Thomashow's (1995, 2002) notion of ecological identity, we speak to the importance of place in developing an environmental consciousness and ethic of care in students as environmental citizens. In particular, we used two curriculum documents from one Canadian province, Alberta, the place where we live and teach. While the science education and social studies education curricula make mention of sustainability and the human relationship with the natural environment (Alberta Education, 2005; Alberta Learning, 1996), we suggest that they do not make environmental education in general and education for sustainable living in particular a priority. In this paper, we draw on ecological and critical theory discourses in an effort to reconceptualize environmental education and to describe the relationships between and among curriculum, environmental consciousness, and citizenship.

Significance

The province of Alberta is world-renowned for its natural beauty and diverse landscapes, from the Rocky Mountains to the Badlands, from the Boreal Forest to the Prairie Grasslands. Alberta is also known for its significant economic dependence on the fossil-fuel industry and conservative politics. Within this context, curriculum documents produced in Alberta present a particular view of the environment and our relationship to the natural world. It is therefore important for teachers to approach government-mandated curriculum with a critical eye. Teachers need to pay particular attention to the place in which they teach (Chambers, 1999; Sumara, Davis, & Laidlaw, 2001) and how the discourse of environmental education is shaped by this context. Teachers need to be aware of the discourses of these curriculum texts and of the messages they may unknowingly be bringing into their classrooms.

If our hope is to foster a sustainable, ethical, and responsible attitude and value system towards Earth and all her inhabitants, one in which knowledge and understanding are carried over into actions, then a curriculum framework that includes ecological literacy in all its aspects is essential. By reviewing and rethinking two curriculum documents as they pertain (or not) to environmental consciousness and citizenship as well as sustainability, we explore the tensions and contradictions between environmental education and the context of Alberta. This will undoubtedly help science and social studies educators better understand the complex relationships in teaching towards education for sustainable living.

Theory

Bonnett (1997), Orr (1992), Stables (1996; 2001) and Stables and Bishop (2001) argue for a reconceptualisation of environmental education to one that goes beyond even a cross-disciplinary approach. Stables (2001) argues for a "within-disciplinary" approach and Bonnet (1997) suggests "there is an important sense in which we must regard *all* education as environmental education. We must examine the attitudes and understandings that are engendered across all aspects of the curriculum and school experience from an 'environmental' perspective" (p. 250). A curriculum that embraces ecological literacy offers a "coherent framework for developing differing kinds of environmental awareness within existing disciplines" (Stables & Bishop, 2001, p. 96). Furthermore, Stables and Bishop (2001) suggest ecological literacy is not a component *within* environmental education, but rather subsumes environmental education, providing an overarching conceptual framework.

The curriculum text plays a role in enacting ideas around politics and power, shaping experience and, ultimately, identity (Apple, 2000). Text is not a neutral purveyor of knowledge; rather, it acts to construct a particular view of reality. What counts as knowledge, culture, or beliefs is recreated and legitimated through texts (Apple). As discourses, texts can function ideologically, contributing to maintaining social relations of privilege and power (Lemke, 1995). Consequently, it becomes important to critically examine the underlying meaning, social stances and hegemonic ideologies embedded in government-mandated curriculum documents that effectively act to carry forth and shape identity, views of nature and the environment, and social practices.

Power relations and Antonio Gramsci's concept of hegemony are important aspects of critical research. Kincheloe and McLaren (2000) state, "critical theory is intensely concerned with the need to understand the various and complex ways that power operates to dominate and shape consciousness" (p. 283) and beliefs. Bell and Russell (2000) suggest that the exploitation of nature can be likened to the hegemonic exploitation of marginalized persons. Ideological hegemony is of central concern; our values and human-nature relationship are intricately tied to dominant discourses—discourses that may be 'finding' their way into our schools through curricular documents.

Design and procedure

The selected documents address the Grade 4 Science topic *Waste and Our World* (Alberta Learning, 1996) and the Grade 4 Social Studies topic *Alberta: A Sense of the Land* (Alberta Education, 2005, 2006). Both instructional topics include environmental/human impact learning objectives and cross-curricular connections. For example, while the social studies curriculum invites students to demonstrate an awareness and understanding of the "principles of sustainability," the science curriculum does not. At the same time, both documents recognize the need for students to understand their place as citizens in a complex and changing world, and to make informed and responsible decisions with an understanding of natural and social processes. In this analysis, the language of government-mandated curriculum documents relating specifically to the notions of environment and sustainability are critically examined and interpreted, with the intent of characterizing the discursive management of the dimensions of ecological literacy (Orr, 1992; Stables, 1996, 1998). Program Rationales, specific learning objectives and key terms and concepts are also examined, specifically in relation to sustainability, personal responsibility, and environmental consciousness and citizenship.

Findings

In laying the Grade 4 science and social studies curriculum documents alongside one another, interesting differences and similarities become apparent. The differences are due, in part, to the ten year separation in publication dates, but also to the different foci of the subject disciplines. Similarities are representative of the Alberta context for curriculum development.

With regards to the Alberta elementary science curriculum, the focus is on science and technology with limited attention to environmental issues. While there are some environmental statements in the Grade 4 curriculum, the emphasis is on how human practices affect humans, rather than on how they impact the environment as a whole system. For example, Grade 4 students are asked to learn that "personal action in reducing, reusing, and recycling materials can help decrease the waste we accumulate" (Alberta Learning, 1996, p. B.19). What this objective is *not* saying is how our consumption patterns impact the natural world; thus, this statement implies that we should act to reduce waste so as to not inconvenience humans (especially in juxtaposition with other objectives in the program of studies). Generally speaking, Grade 4 science education emphasizes growth and progress instead of sustainable living. In fact, the term 'sustainability' does not figure in the elementary science program of studies in Alberta.

Interestingly, sustainability is an important concept in the Grade 4 Alberta social studies curriculum. Elementary students are encouraged to appreciate "how land sustains communities and quality of life" and how Alberta's parks and protected areas are "important to the sustainability of Alberta's natural environment" (Alberta Education, 2006, p. 3). What this recognizes is how citizenship and identity are shaped by the environment. Specifically, students are asked to "demonstrate a consciousness for the limits of the natural environment, stewardship for the land and an understanding of the principles of sustainability" (Alberta Education, 2005, p. 2). While students are expected to understand the dynamic relationship with the natural world, "stewardship for the land" suggests a perspective of management and ownership. Furthermore, the "natural environment and resources" are embraced in terms of Alberta's "growth and development" (p. 7).

Overall, the discourses in the science and social studies curriculum documents tend to illustrate the capitalist and economic patterns of growth and development, which is in line with conservative politics and the dominance of the fossil-fuel industry, especially in Alberta. If society wants its citizens to live responsibly and sustainably, then curriculum developers and teachers must recognize the importance of environmental education across all disciplines. In Alberta, if teachers are to provide a comprehensive framework for education for sustainable living, then they must bridge the science and social studies communities to prepare ecologically literate young citizens.

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DIFFERENT POPULATIONS' INFORMAL ARGUMENTATION REGARDING SOCIOSCIENTIFIC ISSUES

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Abstract: The purpose of this study was to investigate the awareness, attitudes and models of informal argumentation concerning three topics of SSI from 10 populations of six different educational levels and four different professional communities. There were a total of 865 participants' answers analyzed. From the results, the percentage of participants' awareness regarding GM food and DDT were increased with the levels of education. However, the percentage of the awareness about GM food was highest in the group of PhD students, but their attitudes toward buying were lower than senior high students. Three models of informal argumentation were revealed as well, and this study will suit academics.

Objectives

Over the past few decades, together with the progress of Internet technology, much research has emphasized the importance of argumentation in science education. The goal of science education ought to be not only learning specific scientific knowledge but also developing skills of scientific thinking (Driver, Newton, & Osborne, 2000; Kuhn, 1993; Zohar & Nemet, 2002). In addition, due to modern science and societies share a complex interdependence (Sadler & Zeidler, 2004), more and more socioscientific issues (SSI) have been emergent in our daily life. People's informal argumentation toward SSI has become important for science educators and policy makers. In this study, besides presenting the definition of informal argumentation, the awareness, attitudes and models of informal argumentation concerning three topics of SSI from 10 populations were investigated by the quantitative research method. An instrument for this study was developed to answer the specific questions, which were: 1. whether individual's awareness of SSI was different from different populations; 2. whether individual's attitude toward SSI was different from different populations; 3. whether individual's model of informal argumentation of SSI was different from different populations.

Significance

In everyday life, people normally judge and draw conclusions based on beliefs or evidence they have (Kuhn, 1993). Meanwhile, the skills of argumentation have been taken as an important element of higher-order thinking, such as the aspects of creativity, problem solving, reasoning and critical thinking (Coles & Robinson, 1989); and the skills of argumentation are essential for modern citizens and professionals, so it should be taught in school (Driver, Newton, & Osborne, 2000; Nussbaum, 2002). Following the same trend for promoting scientific thinking, since 1998, Taiwan has made intensive efforts to promote scientific thinking in schools. In Taiwan's last curriculum reform, "habits of mind" is one of the curriculum indicators applied in grades 1-9, which assumes students have the ability to integrate information, make judgments and infer from SSI, solve problems, and so forth (MOE, 1998). In addition, together with Taiwanese first referendum held in 2004, how people judge and generate their own arguments has become important to investigate. The significance of this research is that the findings will give us insights into the understanding of individual's awareness, attitude, and the model of informal argument regarding SSI, and those information will make science educators and policy makers know more about their students' and citizens' thinking for benefiting future instructional design and policy making.

Theory

Based upon the idea that 'reasoning is the core of argumentation' (Means & Voss, 1996), we could say argumentation is a form of discourse embracing a process of reasoning (Halpern, 1996; Voss & Means, 1991). Reasoning is categorized as either formal or informal (Means & Voss, 1996; Sadler, 2004; Voss, Perkins, & Segal, 1991; Zohar & Nemet, 2002). Unlike the categorical syllogism structures of formal argument, an informal argument is central to its evaluation, and the evaluation may vary with a person's attitude, beliefs, knowledge, and/or values about the topic (Means & Voss, 1996; Voss & Means, 1991). According to the definition of informal reasoning, informal argumentation could be taken as the argumentation when people use informal reasoning to argue about daily life issues. The difference between formal and informal argumentation, firstly, regarding formal argumentation, all premises are fixed, and it is not allowed to add or delete the content of a premise; however, in terms of informal argumentation, individuals could change the premise based on information from personal knowledge, belief, newspapers, textbooks, and so on (Perkins, Faraday, & Bushey, 1991). Namely, informal reasoning contains cognitive and affective features (Perkins, Faraday, & Bushey, 1991; Sadler, 2004; Voss, 1991). Second, from the perspective of reasoning structure, formal reasoning normally proceeds as a linear structure; however, this kind of reasoning model is not considered to be practical in daily life (Nickerson, 1991). In our everyday lives, individuals often draw on information from multiple sources in informal reasoning and come to a possible conclusion which is more tentative by nature so that the reasoning structure could be represented as a tree-like feature with many branches (Means & Voss, 1996; Perkins, Faraday, & Bushey, 1991).

In light of the descriptions above, informal argumentation shows the reasons and claims people make while dealing with SSI, and the claims are categorized into three models, which are factual model, value model and policy model (Rieke & Sillars, 1997). Factual model is about the observable fact or objective data existing in the physical world; value model us referred to personal belief or judgement which can not be validated by contemporary information or data; policy model is regarded as the rules or clauses made by government or law. In this study, individuals' models of informal argumentation were probed according to these three categories.

Design and procedure

There were a total of 1069 individuals invited to join this study. All the participants came from 10 populations, which were from six different educational levels (elementary school students, junior high students, senior high students, undergraduates, master students and PhD students) and four different professional communities (the fields of business management, agriculture, education and industry). In the end, a total of 865 participants' data analyzed, and 58.6% participants were males and 41.4% participants were females. The detailed distribution of subjects will be presented further.

An instrument was developed to explore informal argumentation based upon my past qualitative research in terms of evaluating undergraduates' skills of informal argumentation. The instrument includes three multiple choices items and different numbers of the Likert scale items in each topic of SSI. Three topics of SSI are GM food (14 Likert scale items), organic food (13 Likert scale items), and DDT and malaria (15 Likert scale items). The reliability of the instrument is 0.87 (Alpha).

Findings

From the results, the percentage of participants' awareness regarding GM food and DDT were increased with the levels of education. However, this result was not shown in the topic of organic food. From the perspective of different professional communities, the awareness about these three topics was all lower in the group of industry. Regarding the attitudes toward SSI, it was surprised to find that the percentage of awareness about GM food was highest in the group of the educational level of PhD student, but their attitude toward buying was lower than senior high students. Besides, no matter which topic of SSI investigated in this study, the percentage of positive attitude was not increased with the level of education. However, buying organic food gained highest support from the whole 10 populations. On the contrary, the attitude toward buying GM food and using DDT in the undeveloped country were all shown negative from these 10 group of subjects In terms of the models of informal argumentation, when dealing with the topics of GM food and DDT, the whole different populations chose fact model to support their arguments most. However, concerning organic food, the 10 different groups of participants liked to use policy model to support their arguments. The detailed results and discussion will be presented further.

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DIAGNOSTIC OF JUNIOR HIGH SCHOOL STUDENTS' MICROCOSMIC PARTICLE CONCEPTIONS OF PURE SUBSTANCE AND AMALGAM

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Abstract: The purpose of this study was to explore students' understanding of microcosmic particle conceptions and proof the consistence of explanation to application questions in pure substance and amalgam. we used the questionnaire, interviews and pictures which the students drew to evaluate thirty-seven students' ideas in the grade-8. The results indicated that□(a) The students' microcosmic particle conceptions about pure substance and amalgam could be classified into three types. (b) Most students classified the matters as pure substance or amalgam by the spontaneous description definition. (c) Very few students could apply the microcosmic particle conceptions to explain the advanced questions.

Objectives

The scientific concept learning to many students is difficult. Engel Clough and Driver (1986) reported that students were using different alternative frameworks in response to parallel questions. Thus, it appears that in many cases, students do not apply their conceptions in a way that a scientist would consider to be consistent. Reif (1987) concluded that novice students' knowledge about a scientific concept is highly fragmented and does not specify how to interpret a concept in specific instances. Most people who hold misconceptions are not aware that their ideas are incorrect. Possessing misconceptions can have serious impacts on our learning.

The purpose of this study was to explore junior high school students' developing understanding of microcosmic particle conceptions by examining students' cognition of pure substance and amalgam. Through the definition of the concepts, using their ideas to class with ten different matters and drawing pictures, the students' conceptions would be confirmed and accordable. The results of this study would supply accurate information about students' understanding of pure substance and amalgam. Further, we examined the consistence of students' thoughts between understanding and application. Further, we investigated the consistence with students' explanation between understanding and application, and our research questions were as follows: (1)What do the students understand about microcosmic particle conceptions of pure substance and amalgam?(2)What do the students express the concept image knowledge of pure substance and amalgam? (3)How are the consistence of students' conceptions about pure substance and amalgam between understanding and application?

Significance
This study provided a detailed description of these students' ideas about the microcosmic particle conceptions of pure substance and amalgam. We studied not only the content and the class of the students' ideas but also examined whether the students' ideas were coherent between understanding and application. The results of this study provide important information about the class of students' conceptual understanding and concretely present students' image knowledge by drawing pictures. Ultimately, this research will help teachers develop appropriate instructional strategies to facilitate student learning.

Theory
1.Theoretical Perspective
Scientific explanations incorporate existing scientific knowledge and new evidence from observations, experiments, or models into internally consistent, logical statements. Different terms, such as "hypothesis," "model," "law," "principle," "theory," and "paradigm" are used to describe various types of scientific explanations. As students develop and as they understand more science concepts and processes, their explanations should become more sophisticated. That is, their scientific explanations should more frequently include a rich scientific knowledge base, evidence of logic, higher levels of analysis, greater tolerance of criticism and uncertainty, and a clearer demonstration of the relationship between logic, evidence, and current knowledge(NRC, 1996). Students' constructed knowledge typically has two properties: it can be incorrect, and it can often impede the learning of conventionally accepted knowledge (Chi & Roscoe, 2002).

Many research assumed that people spontaneously generate ideas to account for phenomena in the natural world(Carey, 1991 ; Driver & Easley, 1978 ; McCloskey & Kargon,1988 ; Osborne & Wittrock, 1983). These spontaneously ideas, although often inaccurate from the perspective of scientific theory, help people organize and explain events around them (McCloskey & Kargon, 1988;Vosniadou & Brewer,1992;Wiser,1988).The middle school students could not be classified as having consistent knowledge frameworks because their ideas were very fragmented. The fragmentation of middle school students' ideas about matter probably reflects the difficulty of assimilating the microscopic level scientific knowledge acquired through formal instruction into students' initial macroscopic knowledge frameworks (Nakhleh, Samarapungavan, & Saglam, 2005).

2.Prior Research
Most of the middle school students interviewed knew that matter was composed of atoms and molecules and some of them were able to use this knowledge to explain some processes such as phase transitions of water. In contrast, almost no elementary students knew that matter was composed of atoms and molecules. However, the middle school students were unable to consistently explain material properties or processes based on their knowledge of material composition(Nakhleh, Samarapungavan, & Saglam, 2005). Garnett, Garnett and Hackling (1995) indicate that it is difficult for introductory chemistry students to develop adequate conceptions of the unobservable entities (atoms and molecules) and events involved in chemical reactions.Thomas and McRobbie (2002)

found that secondary school students frequently explain material phenomena at a macroscopic rather than a microscopic level. Reviews of microcosmic particle conceptions research indicate that it is difficult to develop for students (Abraham, Grzybowski, Renner & Marek, 1992 ; Benson, Wittrock ; Baur, 1993 ; Kokkotas & Vlachos, 1998). Because of microcosmic particle conceptions are abstract model theory. However, we have found no in-depth studies that specifically examine middle school students' cognitive level of microcosmic particle conceptions about pure substance and amalgam.

Design and Procedure

1.Sample Description

We conducted the present study with eighth graders at an suburban middle school in the South Taiwan in the fall of 2005. The author interviewed a class of students including thirty-eight persons. This class students' academic achievement presents the habit distribution.

2.Methodology

The questionnaire and semistructured interview guide are two major tools in this study. The questionnaire which the authors designed was implemented into two steps□First, investigate students' understanding in definition, property and composition of pure substance and amalgam. In order to assist in explanation, students were asked to give examples and draw pictures□Second, according to the conceptions of pure substance and amalgam, ask students to classify ten different matters. In advance, students explain and draw pictures to answer the questions about matters' shape and composition. After analyzing the data gathered from the students' answers to the questionnaire, the author employed semi-structured individual interviews with thirty-seven students in the grade-8 to confirm students' ideas.

Findings

1.The students' microcosmic particle conceptions about pure substance and amalgam could be classified into three types□the spontaneous description definition, the matter's property definition, and the microcosmic particle conceptions definition. Most students(48.6%) define pure substance and amalgam by the matter's property. The spontaneous description definition is secondary(43.2%). Very few students(8.1%) have microcosmic particle conceptions in definition.The first type students drew pure substance which were composed of the same particles and amalgam which were composed of above two kinds different particles. It means that the students have the conceptions about matters are composed of small particles. However, the microcosmic particle conceptions are a kind of model theory. The students' observation methods just like using a magnifying glass. It expressed that the students didn't have the microcosmic particle conceptions. The second type students' ideas about pure substance and amalgam were very fragmented. These ideas were affected by school teaching. Through the school teaching activities, the students learned about the boiling point of pure substance is fixed, but it is not certainly fixed of amalgam. Furthermore, the students thought the boiling point of all kinds of pure substance is 100^0C. If the matter's boiling point is not 100^0C, the matter must be a kind of amalgam. Only three students are the third type(8.1%). They could use microcosmic particle conceptions to explain the words of pure substance and amalgam. In addition, the chemistry nouns of "element" and "compound" were used in interview.

2.Most students(89.1%) classified the matters as pure substance or amalgam by the spontaneous description definition. There are 34.2% students based on the meaning of the words and 45.9% students considered the composition of the matter. Very few students(10.8%) use the microcosmic particle conceptions and nobody(0%) applied the matter's property.

On the whole, the students classified the solid matters as pure substance or amalgam making more mistakes (the copper metal 56.8%, the carbon 16.2% and the glucose 45.9%). Most students thought the carbon is a kind of amalgam not pure substance. The interview data asserted that the students are more familiar with the matters is easier to have many ideas. However, these ideas are uncertain correct. The students classified the liquid matters as pure substance or amalgam (the water 75.7%, the cement 97.3%, the soft drink 97.3% and the salt water 94.6%) more correct. The student indicated that the water and the salt water are often used in teaching activity and the soft drink and the cement are frequently contacted in daily life. The students classified the gas matters as pure substance or amalgam had the contradictory situation. Many students thought carbon dioxide is a kind of pure matter (67.6%), but only 56.8% students thought the air is amalgam. It means that there are some students who thought in the air do not include the carbon dioxide. Although the students had studied the conceptions about the air in the elementary school , but the research asserted that many students still do not understand the composition of the air. In spite of the students could give oxygen, hydrogen and carbon dioxide for examples to explain the air but they could not think the air is a kind of amalgam.

3.Very few students could apply the microcosmic particle conceptions to explain the advanced questions about the composition, shape and phase transition of matter. Most students(72.9%) still keep macroscopic knowledge frameworks. Minority students(16.2%) can propose the conceptions about atom or member. Even though the students used atom or member to explain questions, their pictures still presented macroscopic knowledge frameworks. Very few students(10.8%) understand the microcosmic particle theory. There are four students have the knowledge of the microcosmic particle conceptions and also use the ideas to explain questions about the material shape for example solid, liquid and gas. It asserted that the students have coherent cognition about the microcosmic particle conceptions between between understanding and application.

4.The results of this study can assist science teachers to understand students' learning about the microcosmic particle abstract conceptions and provide reference resources for designing instructional materials and methods to help students constructing scientific conceptions.

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AM I A SCIENTIST□
--THE HISTORY OF SCIENCE IN THE VIDEO WORLD

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Abstract: Based on the videos about HOS, inquiry experiments, and science courses, we constructed the AIH□Anchored in History□instruction to investigate the preservice teachers' perception of this instruction. Twenty seven preservice teachers finished a course about Galileo and heliocentric theory, a unit of the AIH instruction, in eight weeks. Before and after the course, we used interviews to evaluate the changes of them. The results showed they approved this instruction, but also mentioned this kind of videos were not easily accessible. Besides, this instruction had the functions of HOS education and could resolve some issues in HOS teaching.

Objectives

Teaching the history of science [HOS] is effective in transforming the contemporary nature of science [NOS] and promoting science literacy (Southerland, Johnston, & Sowell, 2006). Since Conant (1951) advocated the incorporation of case studies based on HOS in college education, the subject has gradually influenced science education. Not only has it extended from college to K-12 grade education, it has also included the use of multiform teaching models/strategies (Lin & Chen, 2002). Further, the authority of curriculum design was also transferred from experts to teachers. Scholars suggested that teachers could integrate videos on the HOS (Becker, 2000) and inquiry experiments (Bybee, 2000; Flick & Lederman, 2004) into the science course to enhance the efficacy of HOS (Abd-El-Khalick & Lederman, 2000; Hanuscin, Akerson, & Phillipson-Mower, 2006). Based on the above ideas, we formulated the anchored in history [AIH] method of instruction in order to explore the viability of this mode of HOS teaching for preservice teachers. Therefore, the purpose of this study was to investigate the perceptions of the preservice teachers regarding the AIH instruction, and our research questions were as follows: (1) What difficulties do preservice teachers encounter in implementing HOS teaching prior to instruction? (2) What are the functions of AIH instruction according to preservice teachers? (3) What difficulties do preservice teachers encounter while implementing AIH teaching?

Significance

Researchers have mentioned that the inadequacy of time and the pressure of the formal curriculum frustrated attempts by teachers to implement HOS education (Becker, 2000). Becker (2000), Bybee (2000), and Hanuscin, Akerson, & Phillipson-Mower (2006) claimed that we could integrate videos, inquiry experiments, and science courses in order to resolve these issues and improve the quality of HOS education. Moreover, researchers opined that even though teachers had appropriate views as regards NOS, they were unable to implement NOS teaching because they considered it to be of no value in students' education (Cunningham & Helms, 1998). Hanuscin, Akerson, & Phillipson-Mower (2006) advocated emphasizing NOS teaching for preservice teachers: being in the formative stage as teachers, they would have an opportunity to learn not only the manner in which scientific methods are applied but also how they may be taught. Hence, this approach would present a unique opportunity to inculcate in the teachers a belief in the value of NOS teaching. We thus attempted to use AIH instruction in a way that would potentially help investigate the perceptions of preservice teachers.

Theory

1. The AIH instruction

In 1994, with consideration to the power of the media and the time constraints operative on formal science curriculums, the Southwest Regional Laboratory (now WestEd) led by Barbara Becker developed the first video-based HOS curriculum that was entitled MindWorks (Becker 2000). Flick and Lederman (2004) acknowledged the significance of the efforts made by WestEd, but they suggested that this kind of curriculum should also provide learners with an opportunity to have more inquiry experiences. Monk and Osborne (1997) proposed that the element of inquiry experiment be included in HOS instruction. With this is in view, they advanced a teaching model for HOS that covered the following aspects: presentation, elicitation, study of history, devising tests, the scientific idea and empirical tests, and review and evaluation.

The instructional approach that we have been testing is called AIH. In this approach, the instructor uses a video—featuring historical content related to HOS—as an anchor to create the learning context to help learners learn more effectively. To emphasize the importance and enhance the efficacy of such video programs, we revise the teaching model developed by Monk and Osborne and lay down the following steps for the AIH model□Engagement, immersion, consolidation, planning, experimentation, examination, and clarification.

The most significant difference between AIH instruction and the teaching model proposed by Monk and Osborne lies in the fact that the former replaces the phases of presentation and elicitation with engagement and immersion. Engagement is the step involving the provision of reading references about the case to be studied under HOS by the instructor, so that the learners can have adequate background information on the content of the video program. Immersion refers to the stage wherein the learners watching the video experience the context of the HOS lesson just like the scientist featured in the program.

Consolidation refers to the step wherein the instructor fields questions to help the learning groups collate the historical information that they obtained from the video and shape their own ideas about the anomalies in the video. Planning refers to the groups attempting to construct/design their own model/experiment to clear the anomalies. Experimentation refers to the step involving the implementation of the model/experiment by the groups. Examination indicates the process wherein the groups report and critique their experiments and the results obtained therein. Clarification is a step post-examination wherein the learners revise their model/experiment and enhance their understanding of the theory discussed in the video.

2.Eka-Scientist
The video combined images and sound, so it could more authentically depict historical places and the perceptions of a scientist. Applying Lacan's notion of the mirror stage to film narratology (Turner, 1988), we presented the concept of an "Eka-Scientist" to explore the functioning of AIH instruction. The mirror stage represents the emblematic period in an infant's development, when it recognizes—or rather, misrecognizes—itself in the mirror and thus begins to define the ego narcissistically as a unified and visible body. Based on this theory, many researchers draw an analogy of sensation between films and the mirror stage (Turner, 1988). According to them, when the audience view the video, they will recognize and infatuate the roles/episodes in the same manner as the baby recognizes and infatuates its own image in the mirror.

Similarly, when the audience see the content of the HOS video, they will confuse their sensation of the movie lead (scientist) with their own real lives; subsequently, they will recognize and infatuate the scientist/episodes, and then experience the depicted figure as a virtual reincarnation of the scientist. We called this reincarnated entity the "Eka-Scientist." At such a moment, the audience will transform into the scientist, and consequently, they will "truly" possess the perceptions of the ancient scientist in the HOS lesson. In other words, through the phenomenon of Eka-Scientist, the audience would be transported to the historical fieldwork, and they would better appreciate the lifestyle and the social culture of the time, thus developing the desired scientific spirit.

Design and procedure
This study was primarily designed along the lines of a case study. The title of the video used was "Galileo's Dialogue," and it was a Discovery Channel production. In order to concretize the lesson, we combined the contents of this video with the relevant HOS concepts. By implementing this approach, we aimed to draw general conclusions regarding the influence of video-based teaching on the participants. The participants were interviewed twice—once before and once after the course—in order to evaluate the changes in each participant's approach toward HOS teaching. The data were analyzed using the quality method in order to compare the trends pre- and post-instruction.

Twenty-seven preservice teachers participated in the study, and their regular classroom teacher was responsible for instructing them as well as providing them with the study materials. They were all pursuing a master's degree and belonged to non-science backgrounds. The participants were divided into 5 groups; this was done so that they could cooperate and mutually accomplish the task set down in the lesson.

Findings
Prior to the instruction, a majority of the participants (n = 20) believed that their own lack of HOS knowledge was the main obstacle to teaching it effectively. Some participants (n = 3) were of the opinion that HOS teaching took up too much of time and that more time should be allotted to teaching scientific theory instead. A few participants (n = 3)

believed themselves to be incapable of choosing appropriate HOS cases/episodes or felt that they lacked good story-telling techniques; hence, they found it difficult to implement HOS teaching. One participant was of the opinion that it was not necessary for students to possess multi-theoretical awareness of a concept and that the proposed method of teaching only resulted in a confusion between obsolete theories and the theories laid down in the textbooks.

After the instruction, a majority of the participants (n = 11) acknowledged that the biggest advantage of AIH instruction was its varied representation. They regarded this kind of representation as being vivid and multiform. Some participants (n = 9) felt that it would hold greater appeal to learners, further boosting the latter's motivation and interest. Some participants (n = 9) believed that this approach could help in visualizing the theories and contextualizing the episodes covered in the HOS lesson. According to them, the use of computer animations to explain the geocentric and heliocentric systems would facilitate the examination of the differences between these theories and generate a better understanding of their implications. Moreover, by viewing a recording of the scientist's workplace, habitation, and environment, and by witnessing the portrayal of his role, the audience would better appreciate the scientist's perceptions and study. One participant felt that it could potentially reduce the preparation required for his HOS teaching. With the help of a video that was produced by experts, he would not have to spend excessive time on learning the details (for example, chronological facts) or choosing the cases/episodes for presentation.

More than half of the participants (n = 15) mentioned that such videos were not easily accessible; therefore, they were mainly concerned with a strategy that would help them in optimally using the resources available. Some participants (n = 11) were of the opinion that this instruction could not allow for swift feedback; hence, the content of the video should be divided into sections, so that the audience could immediately discuss their queries. A minority (n = 4) believed that it was necessary for the audience to possess sufficient background knowledge; this would contribute to reducing the students' cognitive overload. A few participants (n = 2) referred to the authenticity of the content of the video; they felt that the video was deeply affected by the subjectivity of the director, scriptwriter, and others, making it imperative for the teachers to be careful in selecting and introducing videos.

Although these concerns lingered in their minds even after the AIH instruction, the participants no longer had the mental blocks that were evident in the first interview. Some participants admitted that this instruction helped them realize that any scientific theory comprises causal links, and this change in attitude reflects the true value of HOS teaching. Thus, in addition to demonstrating the essential functions and characteristics of HOS teaching, the AIH instruction even resolved some important issues pertaining to the subject. All participants also admitted that they were very impressed by the process of the inquiry experiment. This data indicated that the practice of integrating an inquiry experiment into HOS teaching is sagacious and essential.

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SHARING GOOD TEACHING PRACTICE: PRACTICAL STRATEGIES TO INTEGRATE ICT INTO THE CLASSROOM

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Abstract: Situated in regional areas of Victoria, a group of 16 primary and secondary teachers participated in an intensive program of professional development designed to assist them in embedding ICT into their classroom practice. Most teachers made significant changes to their teaching practice becoming risk-takers and problem solvers.This paper reports on the strategic innovations introduced by the teachers including training, preparation, curriculum planning, software evaluation and selection, classroom management strategies, cooperative learning strategies and embedded assessment tasks. The paper will explore the ways these innovations responded to a variety of constraints including limited resources, time and support.

Objectives:
Situated in regional areas of Victoria, a group of 16 primary and secondary teachers participated in an intensive program of professional development designed to assist them in embedding ICT into their classroom practice. The cohort of schools was diverse in their size, available ICT resources, religious affiliation and location. The aim of this paper is to report on the variety of practical strategies that teachers have used in their quest to integrate ICT into their classroom and to highlight how teachers respond to their particular needs.

Theory
Contemporary society is changed by the escalating influence of technology- the digital revolution. Policies are in place for our teaching and learning to reflect these changes. Goal 1.6 of the National Goals for Schooling in the Twenty-first Century: ***"****When students leave school they should be confident, creative and productive users of new technologies, particularly information and communication technologies, and understand the impact of those technologies on society*."(MCEETYA report). Meeting these expectations for all students in all regions becomes difficult when there are limited resources, when the reliability and availability of internet connection is not assured and when teachers are ill-prepared to achieve this objective (Rabbit and Pagram, 2004).

Information Communication Technology (ICT) can be used to provide an active, engaging, flexible learning environment (Huffaker, 2003). ICT tools such as e-mail, Internet, multimedia and blogging can be used constructively in the classroom to allow for a more student-centred classroom with tasks selected according to each child's learning style. Technology can break down the geographical barriers of being in a rural location by for example, working in a virtual space. For gifted children living in remote rural locations, the use of technology has been seen to provide opportunities for creative and problem solving tasks (Gregor, 2005). The capacity of learning to be tailored to an individual's needs and preferences referred to as the my-ification is a significant aspect of the technology (March, 2006). The variety of forms and the far reaching impact of technology can be a valuable resource for teaching and learning.

Recognising the potential of the ICT, responding to the rapidly changing resources and identifying how they can be used effectively in the classroom presents challenges for the classroom teacher. Understandably, teachers often lack the expertise and confidence to be able to capitalize on using technology in the classroom to enhance the learning environment. The divide between the students – referred to as digital natives, and teachers – often described as digital immigrants can form a significant barrier to change. The curricula emphasis on ICT has challenged teachers to change their pedagogical approaches in order to be able to meet the needs of their students (Prensky, 2001). Teachers and institutions have responded to close the digital divide through professional development, interpreting curriculum, providing resources and adopting new practices.

In promoting social equity and educational opportunity it is important to include the regional areas of Victoria that are the location of this project. While there is now infrastructure for broadband access in even remote areas of Australia, the reliability and access is not assured **(**Rabbitt & Pagram 2004). The availability is not restricted only by location; however it is often aggravated by it. The availability of resources and access to the Internet is influenced by the infrastructure available. Rabbit and Pragram refer to the "hidden technological disadvantages" (2004, p. 24) in terms of time and money in providing for example access to a technician or fast internet.

Significance

This paper is significant because it identifies change in teachers practice with respect to the use of ICT in a variety of classroom situations. It reports on the pedagogical strategies teachers used to integrate ICT into their classroom practice in meaningful ways and accommodate their particular situation. The paper is significant in highlighting the variety of ICT resources available in the selected schools. The teachers who initially classed themselves as digital immigrants became ICT literate through participating in the project.

Design and Procedure

This project involved 12 schools- diverse in their size, religious affiliations and location. There were 5 small school (<100 students), 4 medium schools (100-300 students) and 3 large schools (>600 students). The schools were divided into three dispersed hubs across Victoria (Australia).

There were 16 teachers – called coordinators selected to participate in a train - trainer model. At each hub, the Australian Independent Schools Association provided an intensive five day professional development program for the coordinators from that hub. Some resource support for those in need was provided and follow-up mentoring was provided to all coordinators over six months. The train – the- trainer model required a commitment of time, an obligation to train others and the opportunity to become a leader in their school in ICT.

Data was collected from the teachers as to their ICT competencies and use of ICT in the classroom at the beginning and end of the project via interview and questionnaire. Teachers were invited to participate in a blog, providing regular reflective comments about their frustrations and successes. The ICT specialist reported on the teacher's progress as a result of his mentoring visits.

Findings

The opportunity to be involved in the project provided an impetus for all the teachers to improve their current practice with respect to information communication technology. The demands on a classroom teacher meant that all teachers involved found it challenging to take on the added responsibility and commitment that the project involved.

The initial surveys showed that all schools did not have equal access to the technologies, for example a large private grammar school with over 600 students had a sophisticated computer networking system and a large range of resources while a small community school with less than 60 students had a variety of old computers that did not function properly with capacity for only 6 computers to access the Internet at any one time. There was no observable trend in the number of students to computers and the number of computers didn't indicate their usefulness. The results of this project demonstrate how teachers adapt to the available resources. For example, in a small schools with one data projector and limited computers, the teacher used a wireless mouse so all students could work together. This teacher reflects in her blog entry:

"I am getting quite good at setting up and using the data-projector now. It was interesting to see one group of grade 5 boys using the data-projector and screen like I do in the classroom - to stand out the front near the screen and get a student to use the mouse and click on the relevant things. What made it interesting is, that this is the first time that I have ever had the grade 5's in this situation. They had quickly cotton onto how useful it is to use the screen in this fashion".

Not all schools had curriculum policies for the use of ICT and there was a lack of planning or structure to the curriculum development that included and integrated ICT. Despite high level of resources at some schools, the integration of ICT was not guaranteed and there was little evidence of integration of ICT with the other discipline areas.

The initial interviews indicated that the teachers had a variety of backgrounds in the use of ICT and they did not use or think about computers and technologies in the same way. Ten (10/15) of the co-coordinators indicated they use a computer "as much as [they] can" and "for class preparation". Ten or more coordinators indicated they did they could: create diagrams, send email, create slide shows or presentations, research using the Internet, use a laptop, a scanner and a digital camera. Despite having the skills, most were not confident to use the ICT in the classroom. As a results of the project the teachers worked with the curriculum - fitting ICT into existing curriculum and rewriting programs. This teacher coordinator from a well resourced school discussed on the blog what she was doing:

"I met with the other staff and we talked about some of the hurdles (finding time to meet, time release), and ways of attempting to overcome them - we're working on making small changes initially. ICT isn't the only priority - it's finding ways of incorporating it into the existing curriculum, without increasing teachers workload. Becoming familiar with the curriculum requirements and formulating teaching programs that included ICT" Another teacher's comments drew attention to how she worked within the constraints of the limited resources.

"...I realise that I may yet again - have to reassess what I do in computers. Currently I am using computer time to teach the students about the different programs eg. word, excel, powerpoint and typing skills. But now I am thinking that I will have to start teaching numeracy, and literacy using ICT during the computer time allotted".

On Friday, I again used ICT during Grade 6 Numeracy. The children all say how much they appreciate having time to use the computer to do mathematical tasks. Usually computers is only used to type up assignments (using word). I would like to make the computer session meaningful for the students - but now I am unsure of where to go. As I only have each child on the computer for 20 minutes per week, which I don't feel is enough time"

The teachers at this school actively discussed the role of the ICT in the curriculum, not wanting to compromise the basics.

Physical changes helped the implementation such as having booking sheets for the equipment and placing lists of student-friendly search engines on the wall, getting files and internet sites onto the internet, having the smartboard at a low level- suitable for children. A comment from a teacher during the final interview displays her resistance to using ICT *"I felt quite intimidated by the whole setup (computer lab) and I didn't feel I had the skills to handle a crisis and when things were going wrong I didn't know the steps to help the children so it was in the too hard basket."* The coordinator did some team teaching which helped this teacher overcome her anxieties. Some coordinators gave classes – putting the teacher in the position of the student.

A cooperative approach was actively encouraged between the teachers and the students alike. So for example students were trained to ask three other people before you ask the teacher, and they had a buddy system where fellow students helped each other. The skill of being a problem solver and a risk taker was recognised and applauded. Students in one class were encouraged to keep a journal of their frustrations and accomplishments on the computer. Through their logs students provided critical evaluations of software programs.

Management strategies became very important for schools with slow internet connections. One teacher always had three tasks for her students – getting them to work on an alternative task while waiting for the internet to connect. Another had students turn the computer screens only off to ensure that they were listening to instructions, several teachers used a rotation method, with one using an egg timer to manage the rotation.

The instruction on the role of ICT in the curriculum formed a foundation for most teachers, so that the use of ICT was not seen as introducing new software packages. The data records the teachers' attempts at the integration of ICT in a meaningful way.

Because the physical problems, limited resources and infrastructure and time limitations make the task challenging, teachers have reported their frustrations and their actions in the blog and the interviews. Common strategies focused on the curriculum planning, pre-planning and organisation of lessons, behaviour management techniques and cooperative learning strategies.

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TEACHER-INDUSTRY-UNIVERSITY PARTNERSHIP IN PROFESSIONAL DEVELOPMENT: HANDS-ON EXPERIENCE OFFERS TEACHERS PRACTICAL APPLICATIONS OF SCHOOL SCIENCE

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Abstract: The objectives of the program reported on in this paper are to: 1. Develop a series of professional development activities for secondary science teachers that would allow participants to gain a greater understanding of the mineral processing industry. 2. Develop an on-going network of secondary science teachers in order to allow for communication with academic and industry scientists and researchers. 3. To open communication with school students concerning career options within the mineral processing sector through enhancing teacher knowledge within the area.

Objectives
The objectives of the program reported on in this paper are to:

- Develop a series of professional development activities for secondary science teachers that would allow participants to gain a greater understanding of the mineral processing industry
- Develop and on-going network of secondary science teachers in order to allow for communication with academic and industry scientists and researchers
- To open communication with school students concerning career options within the mineral processing sector through enhancing teacher knowledge within the area

Significance
On the most basic of all levels, everything that we human beings consume is at some stage mined, pumped or grown. In Australia the mining and mineral resource sector is by far the largest wealth-creating industry for the country. Approximately a third of Australia's export income is dependent upon this industry. Specifically, during the 2004-2005 financial year the income from the overseas sale of minerals and energy resources totalled in excess of $40 billion and that represented over 30% of all the money Australian earned through merchandise exports (Australian Commodities, 2006).

Four factors act simultaneously to drive the industry to a desperate skills shortage. Firstly, the mining and minerals industry has historically "lived by the boom and died by the bust" presenting cyclical opportunities for employment. Still, there are few economic projections that indicate that the likelihood of any real slowing of economic activity for the simple reason that China and India continue to grow at an increasing rate with great demand placed on Australia's mineral wealth. Secondly, environmental concerns, demands for more sustainable mineral processing and the fear of global warming all place an added demand on bright, technically skilled graduates to solve problems facing the industry. Thirdly, a generation of baby boomers begin to retire, taking with them the collective knowledge of a lifetime of both skilled research and practical plant experience. And finally, the supply of young science graduates gaining the academic credentials and experiences in the Science, Technology, Engineering and Mathematics (STEM) needed to maintain a qualified workforce continues to dwindle. The problem has been well documented, but no easy solution has become apparent (Nicol & Woffenden 2002, Bartier, Tuckwell & Way, 2003, Churach, 2003, Churach 2004a).

It is this increasingly difficult skills shortage that has moved an Australian Cooperative Research Centre and a university extractive metallurgy program to collaborate in a unique teacher professional development program aimed at giving secondary science teachers a real life, hands-on look into the mining and minerals resource industry.

Theory

One Australian Cooperative Research Centre (CRC) which conducts research in the mining and mineral processing industries has viewed this issue with particular concern. Operating under the assumption that there can be no research without researchers, the Centre for Sustainable Resource Processing (CSRP) sought a method to involve the mining and mineral processing industries to raise community awareness. In particular young people who may be interested in the mining and mineral processing industries as a career choice needed to receive correct and up-to-date information in an efficient and cost effective manner.

The answer to this question can be answered in terms of where young people receive their inputs and who they turn to when they are looking for information, especially concerning academic subject selection and career choice. The Western Australian Government's Youth Survey (2003) surveyed 7,919 young people aged 12-25 years across all socio-economic backgrounds and educational circumstances. The study showed that teachers are held in high regard and that they have influence over their lives. Teachers are well positioned to positively influence their students' attitudes towards science and encourage them to consider careers in science and industry (Churach, 2006). A more recent study was done by the Australian Government, Department of Education, Science and Training (2006) supports the contention that teachers have a strong influence on their students' subject selection. Using a sample of 1830 year 10, 11 and 12 students from all Australian states and territories, the study explored issues that entered into student selection of courses of study. In reporting the factors that influenced year 10 students development or lack of development in school subjects, students responded that the most influential people having an impact on the selection of science subjects (i.e., making them "like sciences") were teachers (71%). Students ranked their teachers even above parents (66%) and peers (57%) in influencing subject selection towards choosing science courses.

In a sense, these findings support the old notion that "the best salesman is word of mouth". Why does word of mouth carry such weight? Simply put, most people place a stronger value of influence on input from those whom they know best and with whom they have a longstanding relationship. That parents and friends rank high in being influential on student opinions is easily predictable. In the same sense one can understand the high ranking of teachers as opinion influencers. For the most part, young people spend their "working days" in the company of teachers and in many cases, interact with some teachers for more hours per week than they would normally interact with a parent. If all things would be equal, the target audience to be reached would be parents and friends, though in terms of numbers, there is little leverage to be gained in attempting to reach (for example) 20,000 parents in order to influence 30,000 of their children. We can say with great confidence that the teacher-student relationship is real, they are strong and that these relationships already exist (certainly in the Australian experience).

Does this influence go beyond the classroom and impact upon career choice? A study looking at what motivational factors affects career choice in the minerals resource and energy sector employed a questionnaire exploring career drivers (Churach & Rickards, 2006). Though the questionnaire features 36 questions divided into 6 scales (financial, academic, relationship, lifestyle, altruistic and personal esteem), it also includes several open-ended questions concerning influences of teachers on career decisions. The pilot study included 82% of respondents currently working in the industry with the remaining being students of either metallurgy, chemical engineering or mining engineering. 46% of these researchers, managers and scientists took time to volunteer the positive effect that one or more of their teachers had on their career choice ("My high school science teacher always encouraged me and challenged me to ask why…"). 16% of those in this sample spoke of teachers having a negative effect ("I wanted to prove that I could do it even though my high school chemistry teacher said I never could."). These data seem to indicate that at least for people who have chosen careers within the mineral and energy sector, science teachers are often heroes.

Design and procedure

During the past few years the Centre for Sustainable resource Processing and Murdoch University have collaborated with a range of some dozen industries to offer an array of educational activities for secondary teachers initially in Western Australia and during the past 18 months in Queensland. Other programs offer teacher professional development activities and some can be quite intensive. The Colorado Mining Association and Colorado School of Mines have offered a summer teacher program going back several decades (Witkowsky, 2004), though this program calls for a group of K-12 teachers participating only for the duration of that single summer course. Building on Hackling, Goodrum and Deshon's (1999) assertion that effective teacher professional development must be on-going, the Murdoch-CSRP project places the emphasis on the continuing nature of the program. This is based on the idea that in order to have long term effects on student perception of the industry, participating teachers need to undergo a variety of experiences involved with resource processing. Ideally, teachers would gain the greatest benefit form being exposed to a variety of both academic experiences (e.g., hands-on laboratory work and lecture-type offerings) and industrial experiences (e.g., plant and mine tours and work experiences) over a period of time. This would allow the teachers involved to develop relationships with scientists and industrialists to a point where they feel comfortable in asking questions and sharing experiences (Churach, 2004b). Over a period of time (a few years) it would seem natural for teachers to gradually integrate their newfound knowledge into the curriculum and to have positive impacts on their students' perceptions of the industry. There is support for this approach in the literature. One project carried out in Alberta, Canada, indicated more positive outcomes when career options became infused into the curriculum and not taught as separate items (Millar, 1995). This research indicated the need for a strong dose of professional development to be provided to teachers.

These professional development activities were provided to a group of over 200 teachers in Western Australia and an additional 40 teachers in Queensland. These activities included:

- One-day short courses ("The Chemistry and Physics of Extractive Metallurgy", "Advanced Extractive Metallurgy", "Online Interactive Learning – Providing a Minerals Industry Context for Secondary Student Learning Workshop", "Geology and Mineralogy in the Resource Sector")
- 60 or 90 minute after school workshops ("Copper recovery from oxide ores by leaching, cementation and electrowinning", "Alumina production from bauxite by the Bayer process", "Mineral properties and identification")
- Research facility and industry tours (atomic force microscopy, CSRIO Minerals research Centre tour, gold mine tour, bauxite mine tour, alumina processing tour, etc.)
- A variety of resource processing community lectures (70 minute demonstration filled talks concerning individual metals including aluminium, copper, gold, cobalt and nickel, silver)

Group sizes varied from 5-6 to 30 for the hands-on laboratory activities and up to 400 for community lecturers. Teachers were encouraged to remain networked via e-mail and in most cases participants were involved in more than one activity. In some cases individual teachers took part in 5, 6 or more events.

Findings

The authors of this paper state unequivocally that they do not support any professional development activities to merely be a public relations campaign for any industry. That said, it is apparent to these researchers that many of the positive aspects of what goes on within the mineral processing sector in Australia is never seen by the community at large. The professional development activities undertaken in this research allowed a group of several hundred teachers to gain an insight to the high-tech nature of the mineral processing industry today.

The paper will report on a pilot study involving 40 participants that was conducted using a questionnaire and follow-up interviews to gain feedback from teachers. Anecdotal findings are also reported. There is evidence that the professional development program has resulted in teachers acquiring a newfound appreciation for the application of the theoretical chemistry and physics they teach within the school curriculum. There is also strong evidence that a better understanding of the diversity and availability of career paths within this industry. Also reported are associations between teacher participation in this professional development program and changing attitudes towards the industry in a positive way. Additionally, an unintended outcome of this project has become apparent in that secondary science teachers participating in these professional development activities have welcomed the chance to network with other teachers, with academics and with industrial scientists. In a few cases participating teachers have opted to gain post graduate qualifications with the intention of following a new career path into the industry.

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A FUTURES MODEL FOR BIOTECHNOLOGY EDUCATION

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Abstract: The New Zealand school curriculum requires students to understand how science and technology impact on society. A model was developed to incorporate futures thinking concepts into a framework for delivering programmes in biotechnology. This paper will discuss the outcomes of trialling lessons based on the model in different classrooms (5, 8, 14 and 16 year olds). Findings suggest that the model can be effectively used to develop questions which target biotechnological issues at local, regional, national and global levels. Constructivist approaches that promote understanding the current situation, analysing trends, identifying drivers, exploring possible, probable and preferable futures are also explored.

Objectives

The purpose of the project was to research how futures thinking approaches could be used as a framework for developing teaching and learning about biotechnological issues in New Zealand schools as part of a project commissioned by our Ministry of Research, Science and Technology (McKim et al., 2006). This involved a comprehensive literature review to provide the basis for developing a conceptual framework for the model. Lessons were developed at multiple curriculum levels and were trialled in different classrooms to test the model and provide feedback/evaluation about how futures-thinking concepts could be applied in contexts that require students to consider issues related to the impact of science and technology on society and the environment. Classroom evaluated the effectiveness of the model.

Significance

Currently, both the Science and Technology learning areas within the New Zealand Curriculum explicitly require students to obtain an understanding of the future impacts of science and technology on society and the environment. This is retained and strengthened in the new draft curriculum, particularly in technology (Ministry of Education, 2006). Biotechnology is a named teaching context within this curriculum area. A framework that guides teaching and learning about issues related to biotechnology, that is based on the futures-thinking concepts of possible, probable and preferable futures, therefore appears to be well situated within the New Zealand Curriculum.

Futures thinking concepts provide a framework for inquiry into how society and its physical and cultural environment could be influenced in the future. In a classroom environment, futures thinking encourages teachers to approach complex, authentic learning contexts by developing teaching and learning approaches which challenge students' relevant prior knowledge, and develop students' knowledge skills related to examining these sometimes controversial issues from a variety of points of view. Because futures-focussed approaches can include multifaceted teaching and learning activities, they also allow for the development of the five key competencies proposed in the new draft New Zealand Curriculum (relating to others; managing self; participating and contributing; thinking; and using languages, symbols and texts) (Ministry of Education, 2006). Such teaching strategies include modelling learning processes, facilitation, and providing information and formative feedback to students. Conner (2004) has described how the role of the teacher as a facilitator is important in such contexts.

Theory

While futures thinking can be considered to be an integral part of being human (Lloyd & Wallace, 2000), it has only recently formed part of international thinking about curriculum, teaching and learning (Carter & Smith, 2003; Delors, 1998; Hicks, 2003; Hipkins, 2004; Rawnsley, 2000) and reference to futures concepts in school curricula internationally is very variable.

Futures thinking can empower individuals and communities to envisage, value, and work towards alternative futures (Caldwell, 2005). Ellyard (1992) reminds us that: "Humans can only work to build a future if they can first imagine it". He suggests that the process of visualising "preferred futures" is an essential component for working towards what is desirable. Parker (1990:2) agrees in the following statement:

Visions are powerful mental images of what we want to create in the future. They reflect what we care about most, and are harmonious with our values and our sense of purpose. The tension we feel from comparing our mental image of a desired future with today's reality is what fuels a vision.

In order to consider future challenges as part of their learning, students need to experience activities that challenge their current understandings and that enable them to be aware of multiple perspectives related to particular issues. Such activities also need to promote students' critical thinking skills and the ability to use, critique, and adjust their thinking through a range of discourses (Conner, 2003).

When learners focus on possible, probable and preferable futures they are encouraged to use visioning (as emphasised above) and reflection on their own and others' values. This requires students to clarify their own opinions and beliefs.

A social constructivist approach is advocated as a useful means for students to clarify their ideas because they can participate in hearing how others consider or view an issue. Such an approach stresses the importance of exploring prior knowledge, purposeful social interaction, and community participation. This is consistent with futures thinking and learning approaches, which encourage the interchange of thoughts and perspectives through critical discourse, which may lead to social action (Bell, 1998). A consideration of the social context within which these changes might take place - how people respond, react and adapt to change - is also critical.

When personal opinions and beliefs are considered as part of the influences on decisions about the future, it is important that a trusting learning environment is established so that the value positions held by members of the class are respected (Conner, 2004). Students need to trust that the teacher or others will not judge them for their ideas, even though they may be subject to vigorous discussion within a mediated environment. Although these approaches make use of collaborative participation, individuals are encouraged to reach their own conclusions about issues within the boundaries of the law and social appropriateness.

Learning that includes a futures framework can facilitate a more confident, proactive, and hopeful outlook towards the future, particularly if it can respond to young people's hopes and fears (Hutchinson, 1998). Through analysing future challenges as part of their learning, students can be given the chance to critically consider multiple perspectives and worldviews, and look for and interpret patterns and connections between influences on the ways decisions are made. This is consistent with complex models of learning as described by Davis, Sumara and Luce-Kapler (2000). To explore the complexity of each component, teachers and students are encouraged to think about the responses to a number of questions in relation to a local, regional, national and global perspective and consider how these might influence each other.

Design and procedure

A model that uses a futures focus for teaching and learning about biotechnology was developed collaboratively, by considering aspects that have been considered important in futures-learning contexts in the literature and utilizing the teaching and learning experiences of the team of researchers/developers. A teaching and learning framework based on futures concepts provides opportunities to examine issues that impact on their own and society's future in a structured way. For example, most futures studies by government and businesses incorporate input data, trends, drivers, outcomes, predictions, and explorations of possible and probable futures, and favour the use of scenarios as starting points for discussion. These ideas have been incorporated into our futures-focussed model for teaching and learning about biotechnological issues. The key components of the model thus reflect the following five elements:

- An understanding of the current situation;
- An analysis of relevant trends;
- Identification of the drivers underpinning relevant trends;
- Identification of possible and probable futures; and
- Selection of preferable future(s).

Classroom lessons were written at multiple curriculum levels to provide examples of how the model might be translated into practice. These were trialed at four separate schools, two primary and two secondary.

Each classroom trial involved working with the teacher to plan the classroom programme and clarify the components of the futures thinking model in relation to the following topics, with a biotechnology focus at the year levels indicated: Healthy food for a healthy future, *junior primary (5 – 7 year olds);* Dairy farming in the future, *middle primary (8 – 11 year olds);* Future foods, *junior secondary (12 – 15 year olds);* and Future possibilities for genetically modified foods, *senior secondary (16 – 18 year olds).*

Data used to evaluate the implementation of the model included lesson observations, samples of students' work, and teacher and/or student feedback through tape-recorded conversations or written questionnaires.

Findings

The lesson observations, teacher and student feedback and students' work indicate that the conceptual model proposed does provide an effective framework for using futures thinking and learning in classrooms, especially in the biotechnology contexts chosen. Further, we demonstrate that a variety of teaching and learning activities can be used to help students develop an understanding of each component of the model, and these can be modified to be appropriate for different levels of the curriculum.

Although some of the futures language, such as 'trends' and 'drivers', is not familiar to students, the classroom trials demonstrate that students as young as eight were able to develop an understanding of these concepts, and that this subsequently allowed them to explore possible, probable and preferable futures within a particular context (e.g., future foods). All students, including five year olds, demonstrated an ability to understand the existing situation and the implications for possible futures. Importantly, students eight years and older began to visualise and articulate preferable futures based on discussions of the trends and drivers rather than simply 'best guess' ideas. The proposed futures model thus provides students and teachers with a structured framework in which to explore possible, probable and preferred futures.

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AN EXPLORATION INTO THE EFFECTIVENESS OF ASSESSMENT FOR LEARNING STRATEGIES IN SECONDARY CLASSROOMS.

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Abstract: It is widely recognized that Assessment for Learning can enhance student learning and achievement. This paper reports on a collaborative research study between a group of secondary teachers and University researchers, initiated by the teachers, into the practice and impacts of assessment for learning in science, geography and history classes. The findings highlight the importance of external support, shared teacher knowledge and beliefs, professional experimentation, and shared reflection on student responses to classroom innovations. A strategy is suggested for how university researchers and teachers can collaborate so that teachers lead and drive the research agenda within their school strategic vision.

Objectives

It is now widely recognized that Assessment for Learning has an important role to play in enhancing student learning and achievement. This paper reports on a collaborative research study between a group of secondary teachers and University researchers, initiated by the teachers, into the practice and impacts of assessment for learning in science, geography and history classes. The teachers' purpose for the research collaboration was to promote both student learning and student willingness and ability to take responsibility for their own learning and self-assessment. This aligned with the focus of the school strategic plan that aimed to lift student achievement in the senior school.

Significance

In line with international trends (Black and Wiliam, 1998), assessment for learning has been of interest in New Zealand since the late 1980's with the publication of the *Assessment For Better Learning* (Department of Education, 1989) policy statement. Assessment for learning is mentioned explicitly in the *New Zealand Curriculum Framework* policy document (Ministry of Education, 1993) and implied within the national curriculum statements of the 1990's. It is further emphasized in the new draft curriculum statement released for consultation in 2006 (Ministry of Education, 2006). Assessment for learning has been the focus of numerous professional development initiatives, dating from the mid 1990's internationally (Black, Harrison, Lee, Marshall and Wiliam, 2003), and in New Zealand. Currently the New Zealand Ministry of Education employs *Assess to Learn* facilitators who provide in-school professional development and support for assessment for learning practices and many New Zealand teachers, particularly in the primary sector, are now familiar with the key aspects of assessment for learning. There is no research that documents teacher use of assessment for learning strategies across a range of curriculum subjects in New Zealand secondary classrooms.

The research reported in this paper involved practicing teachers, working in a range of curriculum areas, who in collaboration with each other and University researchers have been investigating their individual assessment for learning practices. A particular feature of the research is the collaboration between experienced teachers (heads of departments/ faculties) from different subject domains and the involvement of University researchers at their request.

The significance of this research is that the findings provide insights into how teachers and university researchers might work collaboratively to develop a research and practice agenda that is driven by the teachers rather than the researchers. It highlights the importance of teachers understanding and valuing the underlying principles of an educational innovation. The teachers in the research team used their understanding of the underlying principle of assessment for learning as students taking responsibility for their own learning when modifying and critiquing their classroom practice.

Theory

An increased understanding of the links between teaching, learning and assessment has contributed to an appreciation of the role that assessment can play in enhancing student learning and achievement. Black and Wiliam (1998) provide evidence that assessment for learning and feedback can significantly enhance student learning. They identified feedback and students taking responsibility for their own learning and assessment as key aspects of assessment for learning. Follow up professional development and research by Black and colleagues (Black, Harrison, Lee, Marshall and Wiliam, 2003) and Torrance and Pryor (1998) has highlighted the value of teachers and researchers working together to explore and enhance teacher assessment for learning practices.

Clarke and Hollingsworth (2002) propose that professional growth has four change domains: external sources of information, teacher knowledge and beliefs, professional experimentation and salient classroom or student outcomes resulting from experimentation. Carless (2005) found this a useful framework when he worked with teachers in Hong Kong to extend their assessment for learning practices. His work also explicated the influence of the school context on teacher change and assessment for learning practice. This study takes account of and incorporates the four domains described by Clarke and Hollingsworth to explore teacher driven development of assessment for learning.

Design and procedure

This project began after an approach to the University researchers by an experienced Head of Department on his return from a staff scholarship where he visited Scotland and became interested in assessment for learning. He and some colleagues, also Heads of Department, were keen to improve their assessment for learning practices. After an initial presentation by the University researchers they all expressed interest in being involved in a research project that investigated the impact of assessment for learning on their classroom practice and student learning. The initial research question that guided the overall study was: What do teachers see as the impact of their use of assessment for learning on student learning and student motivation and willingness to take more responsibility for their learning?

Teachers were involved in a series of workshops with the University researchers to develop a shared understanding of assessment for learning. They shared and critiqued potential assessment for learning strategies (some sourced from research and others from the teachers themselves) and then followed this with classroom trials of these strategies. The teachers developed individual teacher research questions and plans that focused on the aspects of assessment for learning that they believed would support independent student learning in their classroom. The team as a whole met regularly to share ideas and experiences and to refine the research and practice focus. The teachers were concerned to promote both student learning and student willingness and ability to take responsibility for their own learning and self-assessment. The data collected included student work samples, teacher reflections, student survey and interview data and audiotapes of research team meetings.

Findings

The findings are presented as a series of stories of change, one from each teacher involved in the project, followed by a discussion the wider implications of the collaborative research approach that was adopted.

Simon's experience

Simon chose to work on feedback using written comments rather than grades. Simon's experience confirmed research elsewhere that "Students are wedded to idea of grades" and that changing classroom practices requires teachers to renegotiate with students classroom norms and expectations. His students pressurised him to give them grades. Simon was able to resist this pressure and justify this to his students because of the insights he gained from student responses to his feedback. He identified that many of his students had failed to understand fundamental concepts and the vocabulary essential to good history writing. He explained, "I wrote 'Generalizations need work', and a student asked what a generalization was". By monitoring student responses to his feedback he came to appreciate that his students needed more extended comments to help them move forward. He concluded, "students to use the feedback to improve their work is the key thing'. He noticed a change in student attitudes and found his involvement in the project "successful and rewarding"

Campbell's experience

Campbell explored if and how learning intentions could provide a focus for asking effective questions for both the teacher and the students. He gave the students learning outcomes at the beginning of each lesson and then negotiated the success criteria with the students. He worked on his questioning skills and reported that, "I have developed several new strategies that I have been able to trial and anecdotally I have noticed that my students have benefited by; provide better answers in more detail, more students are now involved in answering and discussions, student confidence in their own ability has increased. I have noted that my planning and preparation has also improved and that I am trying to be more innovative in the activities that I do." He also worked to support his students to pose questions about the key ideas of a lesson/ unit to themselves and their peers. This generated productive discussions because students were expected to have some understanding of the answers to the questions they posed.

Colin's experience

Colin developed personal learning plans with each of his students, this process aimed at helping his students to plan ahead and to take more responsibility for their own learning. He interviewed them several times during the year. He felt more empathy with his students and reported that the 'snippets of information' divulged by the students gave him a better understanding of their motivations for studying chemistry and their expectations from him and his course. He also developed a better understanding of each individual student's approach to learning and how they did, or did not, individually monitor their learning and how he might assist them with this. He described the process of working with his students over time to develop their self assessment skills as one of the most invigorating and satisfying of his career.

Wider implications

It was notable that the discussions we had as a research team always converged on the importance of students taking responsibility for their own learning. This factor, which underpins assessment for learning (Sadler, 1989), emerged as the guiding theme for teacher decision-making and evaluation. As a result of their focus on assessment for learning the teachers considered they had greater insights into their students' understanding of the content, the ways individual students approached learning, and teaching strategies that contributed to better student engagement with their own learning and assessment. They reported that the involvement of the university researchers as external 'moderators'/'mentors'/ 'support people' had been essential to the success of the project. The teachers doubted that time lines and milestones would have been adhered to without the ongoing support of the University researchers. The importance of working with colleagues on a shared agenda was also highlighted. Working in a cross curricula team enabled cross-fertilization of ideas as teachers "fed off the positives they had experienced." They felt they gained a more comprehensive understanding of assessment for learning by being able to "bounce ideas and get different points of view", including those of the University researchers. The findings highlighted the importance of external support, shared teacher knowledge and beliefs, professional experimentation, and shared reflection on student responses to classroom innovations. The findings offer a mechanism for how University researchers and teachers can collaborate so that teachers take the leadership role and drive the research agenda for their own purposes within their school strategic vision.

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AN AFRICAN (MOZAMBICAN) PERSPECTIVE ON GLOBAL, RESPONSIBLE, AND SUSTAINABLE EDUCATION

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Abstract: This paper is based on my doctoral thesis research. A key motivation for my inquiry was to identify major factors determining the huge number (over 20%) of students at the secondary level that are lost to the Mozambican education system. I used critical auto/ethnography to generate rich data about my lived experience, and I employed dialectical thinking, postcolonial theory, non/dualism and postcolonial theory to focus the inquiry. A partial finding is an understanding of my own multicultural identity. I discuss the findings and their implications for my life and praxis as a science teacher educator.

Objectives

I have been educating science teachers since 1994 at Pedagogical University after teaching at secondary level (from years 8 to 12) Physics and Mathematics for 11 years. My career has been a rewarding, stimulating, and challenging process and I would like to continue teaching for the rest of my life. This paper is part of my ongoing doctoral study in which I am investigating (1) the development of my own teaching skills; (2) how I and other teachers in several parts of Mozambique can develop with students a curriculum that includes Mozambican cultures, and (3) how to promote critical scientific literacy. These aims are addressed through the general research question: *How can school science serve better the cultural development of local school communities?* My motivation for doctoral study is to deepen the understanding gained in my Masters' degree (Cupane, 2003) about how the problem of losing a huge number of students in the secondary level can be overcome by including local culture in the learning/teaching process.

I see myself, especially my identity, as part of the problem and part of the solution; hence I have chosen critical auto/ethnography to respond to the above questions. One problem made explicit by this research is the lack of addressing sustainability in my teaching. There are several forms of sustainability: physical sustainability (usually called environmental), educational sustainability, social and personal sustainability. My aim in this paper is to discuss how the different notions of sustainability, incorporated in the perception of identity, can facilitate the teaching/learning process in Mozambique.

Significance

Mozambique was under Portuguese colonial rule for 500 years. The main feature of this colonial system was assimilating Africans into Portuguese culture and making sure that the 'natives' hated their own culture. This process occurred over a long period of time, and created a culture of 'contradiction'. Sometimes we pretend to be Europeans: using their language and attitudes, eating the same food, and denying our cultural capital. At other times we behave like Africans: using our own language, habits, and beliefs. One result of this long period of colonization is that each of us (Mozambicans) is a multicultural person who combines European and several African cultures.

In Mozambique, where I was born, schools are not helping students to see themselves as they are, probably, because our cultural diversity has never been included in the school curriculum. For example, in Maputo province where I live, a strong influence on family life is hunting. In hunting, there are many concepts of physics involved, such as resistance of materials, elasticity and velocity. In my earlier Masters' degree (Cupane, 2003), I have addressed the questions of how I can incorporate this knowledge in my teaching, how I can make my students proud of their identity, and how each of them can be enriched by their peers' knowledge in a centrally developed curriculum. The significance of my Master's degree was to legitimate the inclusion of everyday material in the science curriculum. The significance of my current research is to teach world modern science as an equivalent to local knowledge, thereby enabling Mozambican students to develop a worldview inclusive of multiple perspectives.

The central role of sustainability in the science classroom is the second significant aspect that has emerged from this research. I have been involved with student-teachers from different parts of the country with the aim of introducing Mozambican cultural context and 'indigenous knowledge' in science classrooms, producing in this way an integrated teaching. As my work progressed it became clear that integrated teaching can be made possible by sustainable education. My study is also invaluable for science teachers in general, especially those interested in culture. It investigates how science teachers in Mozambique can integrate teaching more fully into their own lives, school life and local community, instead of teaching being largely an obligation to be enacted daily in the isolation of their schools.

Theory

I view sustainability as the pacific coexistence of different species with/in their physical and social environments. In this view sustainability is grounded in four systems (i) the biophysical system that is responsible for the existence of all species; (ii) the economic system that provides opportunities for human beings to contribute to their communities and obtain means of living; (iii) the social and cultural system that enables people to live together in peace, and (iv) the political system that deals with equity and power distribution. Each system depends respectively on the application of the principles of conservation, appropriate development, peace and equity, and democracy (Fien, 2001).

One of the main obstacles to achieving sustainability is the dominance of the technical interest, especially in education. Technical, practical, and emancipatory interests are inherent in human knowledge and are important in any consideration of curriculum development (Grundy, 1987). The characteristic of curriculum shaped by the *technical interest* is to prescribe what students should know, without looking at who they are as people and where they are living. *The practical interest* characterizes the curriculum called *phronesis* (Henderson & Kesson, 2004), where the focus is on development of students' moral dimension, including the ability and skills to communicate meaningfully about their learning. The *emancipatory* interest is promoted when students learn how to improve societal and cultural institutions and associated beliefs (P. C. Taylor & Campbell-Williams, 1993). The emancipatory interest promotes sustainability by advocating social action or praxis, which aims to resolve social injustice and inequity associated with the dominant and hegemonic technical interest. The implementation of a curriculum shaped more strongly by practical and emancipatory interests enables students and teachers not only to question critically the role of science and technology in serving narrow economic interests and their impact (e.g., on the physical environment) but also to suggest ways in which basic conditions for a 'good' life can be created. In this more balanced curriculum, a pedagogy of sustainability incorporates cultural sensitivity, involving everyday materials for learning by doing, and incorporating local knowledge and language.

Thus I see the challenge for Mozambican science education as developing a culture-sensitive pedagogy for promoting sustainability. In this research I have adopted a socio-cultural perspective on knowing to analyse culture-sensitive aspects of my own learning and teaching experience. In particular, my intention was to investigate how the introduction of local culture into school science can promote 'critical scientific literacy' in Mozambique. Critical scientific literacy is composed of (i) the capacity to understand scientific text, (ii) having knowledge and skills required for employment, (iii) having knowledge and skills that take into account the interaction among science, technology and society, (iv) having knowledge and skills that help the country to grow and compete economically within the global village, and (v) being prepared for sociopolitical action (Hodson, 2003).

Curriculum reform successes depend on how students and their ways of learning are considered. My view is that critical scientific literacy is needed to prepare future responsible citizens. Curriculum reform from this perspective means that teachers' role is to promote sustainability by investigating the local cultural context where schools are located, how this culture can be included in the teaching learning process, and how to empower students as vectors for promoting a more culturally inclusive and socially just society.

Design and procedure

Critical auto/ethnography, that is, an auto/biographical genre of writing and research that displays multiple aspects of individual awareness about the environment where she or he lives (Ellis & Bochner, 2000), allows me to focus on my experience of teaching and learning. The main advantage of this method is to let the researcher act sometimes as a researcher and other times as a research participant (Luitel & Taylor, 2005; Song & Taylor, 2005). According to Geelan (in press), the value of critical auto/ethnography is its ironic validity and verisimilitude. Ironic validity means that stories represent in various ways the lived situation, showing the advantages and limitations of each situation. Verisimilitude is indicated by the extent to which the listener is engaged by the story because it is seemingly realistic without questioning its credibility. Another dimension that gives value to critical auto/ethnography is its 'pedagogical thoughtfulness'. A good critical auto/ethnography creates the reader's passion to act (P. C. Taylor & Settlemaier, 2003).

Critical reflexivity and vulnerability are two other dimensions used to assess the quality of critical auto/ethnographic research. Critical reflexivity, according to Mezirow (1991), is linked to the emancipatory interest, as it questions accepted codes of conduct that determine an individual's interior and exterior reactions and interactions among people. It allows the writer to expose himself, therefore becoming more understandable for the readers and avoiding being a narcissist. Vulnerability is the condition of achieving decolonization. It allows the writer to show beliefs, uncertainties and emotions, and by doing so is engaging the reader in the search for better ways of living. Another quality criterion used to evaluate critical auto/ethnography is the extent to which the writer shows that the participants in his study are not objects, but a complex driving force of the group being studied.

Data were generated through my writing of stories about teaching and how everyday life can be included in the science classroom in Mozambique. The stories were followed by interpretive commentary.

Findings: My cultural identity

Critical auto/ethnography helped me to find my identity, to know 'who I am' both as a Mozambican and as a professional science educator. I used this method by combining dialectical thinking with critical reflective analysis of my experience of living in a colonial time, a socialist/communist time, and a free market time. My purpose was to investigate my identity in order to understand how it was imposed, especially by school science curricula. The resultant understanding has enabled me to clarify my view of future science curricula for Mozambique, given that we are living not only in a free market period but also within previous times and that this entanglement is dangerously invisible to us. In other words, we are living simultaneously in a complex and dynamic mix of cultures shaped by traditional, modern and postmodern worldviews. However, school science curricula continue to serve only the modern worldview, ignoring the urgent realities of the traditional and postmodern worldviews of contemporary Mozambican society. By making clear who I am and which curricula are adequate for our complex situation, my colleagues and students may benefit, as they are facing similar problems of curricula and cultural identity.

An important implication is how incomplete is the cultural identity given by my ID card. The environment, my cultural capital, the weather, and my students are stimuli that elicit bits of me but my ID card states that I am a science teacher educator without feelings. I believe that my full professional identity can parade in the science classroom only when these stimuli are in a sustainable relationship. This understanding helps me to be at peace, first and foremost with myself as a Mozambican, an indigenous person, a World citizen, and a science teacher educator. By embracing the four dimensions of sustainability in my professional practice, I will be able to present to my students with a multifaceted cultural identity, accepting and celebrating their cultural differences and enabling them to prepare their own students as multicultural world citizens adept at critical scientific literacy

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TEACHERS NEGOTIATING SUBJECT BOUNDARIES: ORIENTATIONS TO RELEVANCE AND MEANING-MAKING IN MATHEMATICS AND SCIENCE

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Abstract: The research reported in this paper addresses our limited understanding of how subject culture influences teachers as they negotiate boundaries between school mathematics and science. As part of the Improving Middle Years Mathematics and Science (IMYMS) project, this research used teachers' reflections from a modified video stimulated recall technique, interviews and classroom observation to explore relationships between subject culture and pedagogy. This paper focuses on the different ways that teachers attempt to make the subject matter meaningful for their students by representing a humanised and relevant subject. Suitable for middle years teachers and educational researchers.

Objectives

Despite the impact of educational reform in Australia in science and mathematics education over the past 30 years, the disparity between the science and mathematics education being offered and the needs and interest of students continue to be of growing concern. A number of inquiries into the state of school science and mathematics in Australia have emerged in the passed six years (Department of Education, 2003; Education Training Committee, 2006; Goodrum, Mark, & Rennie, 2001). All of them report on falling enrolments in post-compulsory science and mathematics, and student disenchantment with a curriculum that is often considered irrelevant. The Education Training Committee (2006) found that one of the major factors contributing to student engagement in Years 7 to 10 is the lack of connectivity between students' lives in the real world and mathematical problems. Similarly in science, the Committee recognise a need for curriculum approaches that focus on, among other things, relevance to students' lives, as well as making strong links between future education and career pathways. In 2006, Victoria introduced the new Victorian Essential Learning Standards (VELS) as the guiding curriculum document. Relevance to students' lives features in the aims of the new VELS curriculum documents for both mathematics and science (VCAA, 2005a, 2005b), but a shift towards relevance will require understanding how teachers view relevance in mathematics and science.

Compounding the issue is that in many Australian schools there is an expectation that teachers "trained" in one subject will teach in both areas. In some schools, timetabling and teacher allotments are organised so that one teacher assumes responsibility for mathematics and science for one group of students. The research reported in this paper, as part of the Improving Middle Years Mathematics and Science (IMYMS) project by Deakin University, addresses our limited understanding of how subject culture influences teachers as they negotiate boundaries between school mathematics and science. Such negotiation requires that a teacher understand the language, epistemology and traditions of the subject, and how these things govern what is appropriate for teaching and learning.

The research questions guiding this research are: 1. How do teachers experience the subject cultures of maths and science?; 2. What pedagogies can be identified as being representative of the subject cultures?; 3. In what ways is pedagogy shaped by teachers' experiences with the subject cultures? Allowing teachers to reflect on their practice through a modified video stimulated recall technique and observation of classroom practice provided insight into the differences between teachers' conceptions of mathematics and science teaching and learning. A thematic analysis highlighted major points of divergence in the ways science and mathematics teachers experience, conceptualise, and negotiate boundaries between the subject cultures of mathematics and science. This presentation focuses on one major point of divergence: the different ways that teachers attempt to make the subject matter meaningful for their students by representing a humanised and relevant subject in mathematics and science.

Significance

How teachers understand and incorporate relevance in their classrooms depends on their assumptions about the role that the disciplinary and school versions of mathematics and science can potentially play in students' lives. Little research exists that investigates how teachers internalize and deal with these assumptions. Since mathematics and science are different disciplines with distinguishable epistemological and methodological underpinnings, research is needed to understand how teachers experience the different demands that school mathematics and science place on teaching and learning. Understanding how teachers in maths and science conceptualise relevance and how they connect subject matter to real life can inform teaching practice in two ways. Firstly, comparing the role of relevance in maths and science illustrates the various meanings that relevance can have for teachers. Secondly, it illustrates that expecting teachers to make the curriculum relevant is not necessarily unproblematic because the meaning of relevance is not collectively understood, nor is it the same for maths and science. For teachers moving between subjects, especially when moving into a subject for which they have limited appreciation or experience, understanding how the subject can be made relevant for their students, and themselves, is valuable information. Teachers having stories to tell appears to be important, not only in terms of sharing anecdotes in the classroom that reveal the teacher's view of the subject with students in an effort to draw them into the subject, but also reflects back on the teacher as part of their personal response to the subject. In this way, stories have a reflexive character as they have the potential to give the teacher a confidence and level of commitment that may be evident as a passion for teaching the subject to students.

Theory

As a discourse operating in both maths and science, relevance and relating the curriculum to students' life worlds is well established as being important in making the curriculum accessible and meaningful for students (Education Training Committee, 2006). The curriculum documents of the Victorian Essential Learning Standards (VELS) for maths and science recognise relevance as one of the premises of the Discipline-based learning strand: "students develop deeper understanding of discipline-based concepts when they are encouraged to reflect on their learning, take personal responsibility for it and relate it to their own world" (VCAA, 2005b, p.3).

Newton's (1988) perusal of science education literature led him to critique the construct of relevance as encapsulated in science education research and raised the question of what is considered relevant and for whom. Newton's discussion of relevance centred on four major groups of aims: M*oral aims* are concerned with empowering people in their choices, *Contextual aims* are those concerned with placing science in broader contexts so that students see the significance of science to people's lives, and *Philosophical and epistemological* aims are concerned with presenting science as it is practiced and which presents an appropriate image of the nature of science. The question is, for whom are these teachers making the curriculum relevant? "Relevance requires a relationship in the presence of some need, aspiration or expectation" (Newton, 1988, p.8), and as such, teachers' pedagogical decisions, and curriculum emphases, are based on certain assumptions about what might be relevant for their students. Newton suggests that if what is taught is thought to be relevant to the needs of people, then which people: individuals, groups, age groups? Catering for students' interests in the immediate, he suggests, can be problematic on the one hand since students' needs are transient and change over the course of their education, and a student's "limited experience and immaturity make him a poor arbiter" (p.10) of what might be relevant for the future. On the other hand, he recognises that "it may well enhance interest and encourage favourable and positive motivation" (p.10). Alternatively, catering to adult needs may well render the school curriculum irrelevant for students; therefore, he advocates a healthy balance between meeting the students' immediate needs for motivation and casting the curriculum as knowledge needed for the future.

Newton (1988) also describes the notions of external and internal relevance. "External relevance" is outward looking and refers to science that is relevant to life in some way. "Internal relevance," is inward looking and presents science as a neat, structured, coherent and unified assemblage of knowledge. In this view, pattern and unity is expected to be more attractive and makes the content easier to acquire. Consistent with this view is that, traditionally, intellectual knowledge acquisition provides a basis by which students progressed to the next level of a science course (Aikenhead, 2006). This construct of internal relevance in science is comparative to the psychological rationale for a building blocks metaphor in mathematics (Lerman, 2000). According to Lerman, this is a traditional view of curriculum where "[a]nalyses of mathematical concepts provided a framework for curriculum design and enabled the study of the development of children's understanding as building of higher order concepts from their analysis into more basic building blocks" (p.22). The result was pedagogy dependent on drill and practice, and positive and negative reinforcement. Lerman states that mathematics education has changed to embrace a "humanistic image of maths…as a quasi-empiricist enterprise of the community of mathematicians over time rather than a monotonically increasing body of certain knowledge" (Lerman, 2000, p.22).

Design and procedure

Various qualitative methods were used over 18 months to periodically observe, video and interview six secondary science and/or mathematics teachers. I observed teachers' classroom practice during a sequence of teaching in mathematics and/or science, then two lessons were videoed for each teacher. A reflective interview with each teacher followed a private viewing of video footage from their classrooms (a modified video stimulated recall process). By capturing classroom practice and stimulating teachers' reflections on their classroom teaching practice, I was able to get a sense of how teachers constructed the two subjects, which could then be juxtaposed against their personal commitments, background and experiences with respect to school and disciplinary mathematics and science. A focus group discussion involving four of the teachers and myself followed, with discussion based around three broad statements arising from a preliminary analysis of the reflective interviews and classroom observations, and relevant literature.

Many of the ideas below were elicited from teachers in response to my questioning about the use of stories in maths and science as ways of making connections between the subject matter and students' lives. During the analysis I became aware of other strategies that teachers used to make the subject matter meaningful, so I also use other references to the broader notions of meaning-making and relevance. The categories are written to emphasise differences between the role and implementation of meaning-making in maths as compared with science.

Findings

Three types of pedagogical approaches were found to be representative of how the teachers recognised what needs to be made meaningful and relevant and how this can be portrayed for students. These were labelled as categories of meaning making will be described in the full paper. The table shows the common elements of each category, then summarises how this type of meaning-making might appear in maths and science. The first category included illustrations of relevance, and these related to the ways teachers and students used familiar things to connect students' lives with the subject matter. These were often referred to by teachers in the interviews as examples of stories they would use to relate the subject matter to students' lives. This second category related to those instances where contexts were used to challenge students to think more deeply about the subject matter. These contexts were built around the students' interests, or were generative of new interests. These third category included stories that were used either implicitly or explicitly to humanise mathematics and science. Some of the stories focused on the disciplines of mathematics and science, and included stories about the "heroes" of science and mathematics, those historical and contemporary figures that have contributed to the development of scientific and mathematical knowledge. These stories demonstrated the development of science and mathematics ideas over time. Other stories related to the ways teachers modelled or emphasised in their teaching the human endeavour of science and mathematics, including how mathematics and science provide the means by which we can live our lives as functioning human beings, and include examples of how mathematics and science affect our lives and teachers' personal encounters with maths and science.

Different teachers referred to and used these different categories of meaning making in different ways. For example, where one teacher had a focus on contextualising the students' experience of maths and science so as to make connection between the subject matter, and between subject matter and students' lives, another teacher impressed a need to humanise the subject by sharing anecdotes from history. Also, a teacher who had a strong commitment to story telling in science expressed frustration with not being able to transfer this approach into maths.

All teachers felt that it was important that the subject is related to students lives in some way, so relevance could be considered a fundamental and powerful discourse. However, how teachers conceptualise this notion of relevance, and the fact that different teachers emphasised relevance in different ways by using different types of stories in the classroom suggests that a teachers' decision about what to tell and why they tell it is more dependent on the personal aspects of the teacher rather than on a cultural scripting. Teaching across subjects requires an understanding of not just the stories that can be told, but also what is appropriate for the subject in making the subject relevant to students' lives.

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NEW WINE IN OLD BOTTLES:
RE-CONCEPTUALISING A CREATIVE DIRECTION FOR MEANINGFUL LEARNING IN SCIENCE AND TECHNOLOGY.

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Abstract: In the modern world, science and technology are closely related and even interdependent. Advances in one require consideration of the other. In secondary education, we endlessly debate the boundary positions whilst learners (except the elite) become bored and develop fixed ideas of what science and technology mean. Researchers and secondary teachers will note that the author uses theoretical and empirical research to establish that creative approaches are needed to innovate the curriculum, teaching and learning. Learners' emotions and intellect must be engaged if sufficient impact is to be made upon their values to stimulate and educate them in meaningful ways.

Objectives:
This article uses research-based evidence from the author's theoretical and European-based empirical studies. It explores the mismatch between policy-maker's desire for a high status, high standard, meaningful science and technology education, and the declining interest, poorly achieving reputation that science and technology education holds for many. The possibilities of creative, research-led approaches to curriculum design and delivery will be explored, that consider values and engage emotions in addition to intellect and cognition.

Significance:
Countries throughout the world are perceiving the importance of learner creativity in secondary school educational programs as they consider how to gain economic advantages. Science and technology education are considered by policy-makers and politicians to be cornerstones for educational change linked to maximizing wealth creation opportunities and building social and cultural capital for the majority.

Centralised political frameworks that have been created to ensure accountability of individuals and groups in western consumer-driven, market-led societies however, are making it difficult to allow a creative element to flourish in schools.
Owers (2004; pp. 21-25) feels that the UK government's wishes for a prosperous economy, creativity and a knowledge economy are seriously at risk. He feels that the role of technology in the wealth creation process is pivotal and is generally misunderstood and ignored by political decision makers because it is not valued. Much of modern empirical science relies on technological innovation to create appropriate instrumentation. On the other hand, technology generally utilises well-established 'old science' (not the latest theories and results of scientific endeavour). (Schaffer, 1983; cited in Grove, 1989; p. 30). Owers also notes that school based experience is based on failure (and this happens often in science), leaving learner self-esteem in tatters. He bemoans the centralized prescriptive approach of Government but feels that the major difficulties

are those identified with negative values in common culture that undervalues the roles of science and technology in society. Owers conducted research with 3000 Advanced level students (17-19 year olds) through 2 surveys, firstly in 1995/96 then again in 2001 / 02 to establish what students thought about their educational experiences. His research identifies how little creativity is perceived to be present in science and how difficult the subject is perceived to be despite recognition of its importance. He also explored attitudes to design and technology (DT). The worrying aspect of the DT surveys was the evidence of negative trends in perception of the importance of the subject to society through its applications.

Theory:
McGinn (1991; pp 2-15) describes the centrality of science and technology in the major events (successes) of human society: the landing on the moon; civilian jet-engine transportation; polio vaccines; the discovery of DNA; the PC; confirmation of Big Bang Theory. Then its failures: Bhopal, Chernobyl; the Challenger Space-shuttle disaster; environmental degradation; diseases due to irresponsible scientific and technological practices. He stresses the need to consider science and technology together with their impact upon society as an integrated knowledge base and he sums them up with four meanings:

Technology	**Science**
Technics (material products of human making)	Knowledge (organised, well-funded body of knowledge of natural phenomena)
A technology (complex of knowledge, methods, materials and if applicable constituent parts)	A field of systematic enquiry into nature
A form of human cultural activity	A form of human cultural activity
A total social enterprise (the complex of knowledge, people, skills organisations, facilities, technics etc.)	A total social enterprise (the complex of knowledge, people, skills organisations, facilities, technics etc.)

McGinn argues that science and technology can be differentiated and related by looking at similarities and differences in their characterizations in terms of inputs, outputs and functions. He notes the growing interdependence of science and technology (pp. 26-27) with both successes and failures. Technical projects generally have technological and scientific components working closely together, for example, space shuttle launches or particle accelerators. So there is a sense in which we need to consider technology as applied science and science through applied technology. Without either, neither would develop properly nor indeed be of any use. So is it any wonder that there is a crisis of identity and confusion about purposes in schools for the teaching and learning of both areas. New knowledge structures need to be built and re-enforced and new values promoted. Technological contexts need to be exploited for teaching science coupled with a range of 'technological values', and scientific contexts need to be explored for teaching technology, introducing a range of technological values incorporating a concern for such factors as those associated with relating function and form.

In considering the methods of science education, we must give due consideration to attitudes and values in addition to knowledge and skills. Hoyinghen-Huene (1946; p. 149) in his interpretation of Kuhn's philosophy of science, emphasises the 'scientific values' of: accuracy; consistency; scope; simplicity and fruitfulness, amongst others. Kuhn (Kuhn, T. cited in Sharrock & Read, 2002; p. 12) himself argues that science does not develop by constant or linear or logically smooth accumulation. Yet in science education, an implicit value often portrayed is that it does. There are grounds to argue, that learners need to experience uncertainty in the way in which they build knowledge and skill through reflecting carefully upon what they construct, considering its fitness for purpose - a core technological value. Kuhn (1962; pp. 15-16) states that technology has often played a vital role in the emergence of new sciences, through giving ready access to 'facts'. In the modern age, all eyes are focused on the interfaces between branches of scientific and technological knowledge. This also needs to be reflected in educational settings, which in turn demands that a reflexive approach be applied in teaching. Recognition is needed that the moral, personal and social values of teachers have great impact on the behaviour and attitudes of learners in science and technology. They can induce greatly positive or negative reactions to the subjects by students, despite how well the knowledge and skills are taught. We have to consider with great urgency the future of science and technology education at a time when it seems the greatest efforts are to teach in accordance with the values of 'past times'. Due consideration needs to be given to how learners view their experiences in a 'what's in it for me', consumerist way. An example of this approach is given by Saunders et. al. (2004; pp. 36-39) who describe the importance of developing new curricula and appropriate pedagogy in higher education to widen access and decrease alienation to learning in science and technology. They have devised curricula for astronomy and science fiction to interest and engage adult learners and younger students at risk of educational alienation in the south Wales valleys. The authority of science and technology needs to be re-invented. Faith needs to be recreated that the subjects have both meaning and relevance to peoples' lives at a personal level and creativity is a tool that may help.

In Einstein's case it was imagining the relationship between particles and waves that was key to unlocking the door of relating observable properties to explanations of cause and effect and being able to select when to think of for instance electrons as waves or particles. For learners, building up satisfactory models of the natural world depends upon them holding meaningful ideas and images in their minds that they can operate upon, answer questions and make predictions.

Design and Procedure:

The author undertook a detailed phenomenological study (Moustakis,1994) of creativity in the context of design and technology (Davies, 2002). A range of issues and difficulties were identified associated with creative teaching and how to promote creativity with learners. The author identified a case –study school recognised for its creative work in the subject and conducted detailed semi-structured interviews with pupils, teachers and curriculum managers using research tools derived from 'personal construct' theory (Bannister, 1970). A further three -part study was conducted through a European survey of 75 teachers and their work. They had all participated in one of a number of European courses that were built around creativity in European schools (Davies, 2006). All curriculum areas were represented in this study including around 25% of the cohort that were either science or technology specialists.

Two 'Google' searches conducted in 2005 illustrate the depth of the problem. A search on 'Creativity' and 'Europe' threw up only 475 hits of which none of the top three represented key work in Europe. A search on 'Creativity', Education and 'Europe' threw up a measly 59 responses of which only one activity (in the UK) was noted. This is despite the Lisbon agenda of 2000 identifying the desperate need for innovation in European science and technology agendas (Buster, 2004). In 2003, Davies & Gilbert reported their view on how modelling can forge a link between science and design and technology. This study seeks to explore ways in which new directions can be find to enthuse students, help teachers to establish a set of values that reflect a modern relationship between scientific method, technological realisation and local and global citizenship.

Findings:

Findings from the Author's empirical studies identified that:

- More emphasis needs to be placed on effective, creative leadership and vision-building;
- The curricula in too many countries is content-heavy accompanied by rigid time-tabling and demands 'excessive conformity';
- Programme requirements are too restrictive and lessons are dull and boring, the topics of little interest to the learners. Pupils need opportunities to have some input into lesson planning;
- The emphasis is too excessively weighted on theoretical components of core subjects, including science, with limited recognition of the role of 'aesthetics' in all subjects;
- Fear of schools, especially examinations is throttling the ability of pupils to think freely and feel free;
- Curriculum enrichment is often minimal and teachers are too pressurised to follow-up worthwhile lines of investigation and enquiry and the depth of learning experience is minimised;
- There is little attempt to use assessment of creativity in a formative way;
- Emphasis on the performance of the school outweighs concern for performance of the learners;
- 'Creative collaborative work' between teachers and learners is underemphasised;
- Thinking time for teachers and learners is not respected – neither have 'space' for creative activity.

That creative work is not rewarded led the author to hypothesise that minimal attention is given to any role that creativity might play in the teaching and learning of science and / or technology. Even when it is given explicit consideration, prescriptive requirements and accountabilities limit achievement and risk-taking, hence the building of 'creative cultures' in school laboratories and workshops does not take place.

Teachers of science and design and technology do not share the same understanding or methods of developing pedagogy through the strategies and tactics used in the classroom. Indeed they represent different cultures. In Canada, New Zealand and Pacific rim countries, there is evidence that closer integration is achievable, as they are subject to less regulation. (Barlax, 2000) rejects the 'integrationalist' view, that the curricula for science and for design and technology can be unified, on the grounds that:

> 'Science and design and technology are so significantly different from each other that to subsume them under a 'science and technology ' label is both illogical and highly dangerous to the education of pupils' (p. 42)

Even though teachers might accept the principles of novel changes, their implementation is likely to reflect the comfortable traditions and secure pathways that represent well-trodden paths and well-established practise, even when at odds with the novel approach. This is confirmed more fundamentally through Kelly's (1955) fundamental postulate that all people construct their worlds of the present and future based on past experience – i.e. that they are always victims of their own history. This is why in both science and technology teaching, key questions are often asked about the relevance and purpose of both the curriculum content and the approaches used to teach them as subjects. No matter what is mandated or advised, new approaches and changes need to be constructed and supported incrementally. If science is to have any individualised meaning, it cannot just be presented as a set of unchanging facts, laws and theories. Sears argues passionately that science should not be taught as a 'fenced – off' part of the curriculum into which science teachers smugly retire, but should be contributing to imaginative projects that will enable pupils to see science as inter-linked and inextricably interwoven with other aspects of educational tradition (Sears & Sorensen, 2001; pp. 48-49). Davies & Gilbert (2003; pp. 77-79) suggest how modelling can be used as a strategy to make the interlinked teaching of science and technology more relevant, more interesting and more effective. The core commitment of design and technology is to producing solutions to human problems. As such, two interactive, roles of modelling were identified by (Kimbell et. al., 1991). They are modelling ideas in the mind (the role of communicating with oneself) and modelling ideas in a material form (the role of communicating with others).

It is often the 'emotional labour' of science and technology teaching that leaves teachers angry, frustrated or feeling inadequate that results in them concentrating upon classroom management issues, not reflecting upon the nature and quality of the learning environment. The emotional impact that the teacher can make upon the student often leaves them confused, feeling inadequate or inferior. In the western world, it has been normal to idealise reason and demonise emotion, rather than harmonise both which are likely to stimulate both hemispheres of the brain most dramatically and effectively.

Risk and accountability are tightropes that need to be walked with breathtaking care by those in authority if meaningful change and improvement is to occur. The balance between efficient management and effective management of change is critical but if science and technology are to remain a force for good in our societies, but change we must.

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FROM 'NATURE' TO 'SCIENCE': A CASE STUDY OF PRIMARY TEACHERS EXPERIENCING SCIENCE LEARNING AND TEACHING AS INQUIRY IN MAINLAND CHINA

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Abstract: This paper is a case study of 4 Chinese primary science teachers making a transformation from teaching science as mere knowledge to teaching science as inquiry in response to the current primary science curriculum reform intending to shift from 'nature' to 'science' in China. It is aimed to explore the complex nature of teacher change through a research project that tries to facilitate experienced primary science teachers in undergoing continuing professional development by involving them in a collaborative action research focusing on assessment for learning as part of their newly-tried inquiry-based teaching. It is intended for international science education researchers.

Objectives

Primary science learning and teaching in mainland China is now undergoing a major transformation as the current reform of science curriculum and instruction has been under way since the beginning of the new millennium (Ministry of Education, 2001). Prior to the reform, it took the form of 'nature (study)' which was similar to that in form in other countries but different in kind, due to the Chinese intellectual traditions that emphasize acquisition of knowledge on the part of pupils through instruction. By contrast, the reform of the current primary science curriculum and instruction, however, places priority to inquiry learning and teaching, a somewhat alien conception for Chinese primary science teachers (Ding & Hu, 2005). Although the reform of primary science education has been implemented for a few years in China, it is widely recognized as quite hard for primary science teachers to make the transformation towards inquiry-based learning and teaching. The objectives of the research reported in this paper were to explore how--and to what extent-- a few purposefully selected primary science teachers with years of teaching experiences in science in Beijing could adapt themselves to the shifts in conceptions of learning and teaching science required of them in the science education reform through a collaborative action research with the present author. More specifically, the research questions were: 1. What changes in learning and teaching science happen in the classrooms of those teachers studied as a result of the collaborative action research? 2. How do the teachers' views of science and of science learning and teaching change in the course of the research project? 3. What implications do we obtain from this research for primary science education in general and for continuing professional development of primary science teachers in particular?

Significance

Most of Chinese primary science teachers, like their counterparts in many other countries, are fairly weak in science subject knowledge since they were not exposed to science very much during their initial teacher education period, which in the Chinese context means that many of them were initially prepared in normal schools at secondary education level.

This lack of subject knowledge on the part of primary science teachers is further aggravated by the fact that nearly none of them experienced learning and teaching science as inquiry. In the current reform of primary science education in China, practising primary teachers are informed, either by curriculum documents or experts in workshops that new ideas such as constructivism and other theories are guiding principles in the new science curriculum schemes and textbooks that are expected of them to implement in their classrooms; yet it seems that few teachers are clear about what inquiry learning and teaching is all about, and how to effectively teach science in an inquiry-based way. What they are doing is, as expressed in a popular Chinese saying, "to cross the river by fumbling about the riverbed pebbles". The results of such an approach to the primary science reform, obviously, seem not to have been desired, as 6 years have passed since the reform started at the beginning of the new millennium, with little positive gains in terms of teacher development or student learning to show for.

Much research indicates that school teachers are experiencing a re-professionalisation in the present wave of science education reform (e.g., Whitty, 2000). Even in such countries as England and the US, where primary/elementary science first had experienced an innovation in the 1960s and early 1970s, and where primary/elementary school teachers learned more science and science instruction methods than did their Chinese counterparts, they have to take part in professional development activities from time to time, and focus on inquiry learning and teaching activities (Asoko, 2000). By contrast, Chinese primary science teachers have much poorer science backgrounds and most of them have no ideas about the inquiry-based approach to science learning and teaching in action. Thus the traditional approach to learning and teaching science characterized by rote learning is overwhelmingly dominant and prevalent in the classrooms and dies hard. What science textbook writers, practising teachers, and society at large expect is to teach (or tell, to be precise) students some basic scientific facts. The significance of the present studies is, therefore, to explore a feasible and effective way of continuing professional development for primary science teachers in the circumstances of lacking resources in primary schools typical of the cases in most developing countries. It will, hopefully, inform the science teacher education policy and practice in China by providing a more effective model of teacher education, and, thus, promote teacher learning, change, and development in primary science education.

Theory

Constructivist views of learning, socio-cultural views of learning and integrative views of knowing and doing (Wang et al, 2002) were chosen as the theoretical bases of this research. Like student learning in general and student science learning in particular, teacher learning and development is also better explained in the context of constructivist views of learning, both personal and social. Bell and Gilbert (1996) assert that 'constructivism has enabled a powerful and fruitful research programme in science education and is an important base for a coherent approach to teacher development in science education.'(p.44). In this research project, participating science teachers were all much concerned with constructivism, which was encouraged to inform their classroom teaching. It is, therefore, very important for them to have been immersed in such a theory while learning and developing professionally themselves, so that they would believe in and live it both through their independent learning and during the salons, or workshops that brought them together. In such salons or workshops, socio-cultural views of learning was emphasised and practised, where inquiry-based learning and teaching as a foreign culture of education was enculturated to these primary science teachers through the interaction between them and science teacher educators.

Unlike the two above-mentioned views of learning adopted from the west, integrative views (or union) of knowing and doing are, by contrast, originated from ancient Chinese philosophy which has come down to the present times and permeated the social learning of adults in China, including primary science teachers. Wang et al (2002) cite Yangming Wang (1472-1528) as saying that ‘it is only in doing that what one knows is real knowing, and that there exists knowing in doing’ (p.25). These views of knowing and doing informed the present research by emphasizing that participating teachers in the project should put their newly-acquired knowledge and skills of science and science learning/teaching into practice in a creative and practical way.

Design and procedure

The research design was a qualitative case study of 4 experienced primary science teachers who took part in a larger project that focused on inquiry learning and teaching in primary science classrooms with assessment for learning as an integrated and embedded part of it. It was also a collaborative action research between the present author and the 4 primary science teachers, with the intention of facilitating shifts in instruction of primary science from teacher lecturing and/or a questioning and answering format to inquiry-based learning and teaching, underpinned by the in-depth transformation towards a constructivist pedagogy. Data collection consisted of naturalistic observation (Cohen et al, 2000), semi-structured interviews of teachers and students, and a monthly salon or workshop in which ‘talk as action’ (Frankham and Howes, 2006) and/or conversations were employed as a means of research.

Naturalistic observation was done once a week in the 4 teachers’ classrooms in turns by the present author with the help of the graduate students under his guidance beginning from early September, 2006. These teachers, before and during the project, had learned about constructivist views of learning, ideas of inquiry learning and teaching, and assessment for learning in the workshops. So naturalistic observation was focused on how they conceived of and implemented their visions that arose from these ideas in their instruction. Semi-interviews were conducted often after classroom observations in order to ascertain how the teachers changed their styles of teaching more in line with the inquiry-based instruction, and why. They revealed the rationales behind the decisions made in the classroom by the teachers. And the monthly salons or workshops, serving as a learning opportunity for all the participants involved, provided a forum on which emerging ideas and practices were communicated and shared among the participants. Talks and conversations were always recorded and transcribed as data, and analysis was made of it. Together the three methods were used in order to achieve triangulation of the congruence of ideas and actions of the target teachers.

Findings

Prior to and in the first stage of the research project, all the participating teachers, regarded as leading specialist science teachers in the school districts or citywide, had known or heard of the such catch phrases as constructivism, learning and teaching science as inquiry, and formative assessment, etc., but in the beginning salon discussions it was revealed that they understood these concepts only at face value, and classroom observations for the first few weeks confirmed that what they claimed as inquiry learning and teaching was limited to hands-on activities in the classroom.

Driven by the research project, all of them came to reflect on their conventional teaching practices and tried new pedagogies suggested by the author. One teacher, Yun by name, first tried the new ways of questioning by focusing on person centred questions (Harlen, 2000). Another teacher, Mei, tried the wait-time strategy and activated her class to deep thinking. A third teacher, Hua, was led to recognize how to make use of the recordings students made in class and identify the misconceptions within them as feedbacks for further and in-depth learning. And a fourth teacher, Yang, combined assessment for learning with autonomous learning of students in science lessons with satisfactory results as well. (As the research is still going on, the findings reported here are only preliminary.)

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PROMOTING PEACE AND NATIONAL INTEGRATION THROUGH INCULCATION OF SCIENTIFIC ATTITUDES IN LEARNERS

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Abstract: Science, Technology and Mathematics Education (STME) has humanitarian goal and it is very important to link the relevance of the ethos on which STME is based with citizenship and the balancing of interests of different groups in society. This approach immediately introduces the concept of STM for citizenship. This paper reports the outcome of a 90-minute interactive session in which teacher trainers (N= 40) from West Africa explored the foundations of the scientific enterprise and generated ideas on how STM teachers can exploit the teaching and assessment of scientific attitudes in fostering national integration and peaceful coexistence.

Objectives

In many parts of the world today there are wars and rumours of war. Civil strife within nations is occurring at an alarming rate. The question all right thinking people are asking include: Is nationalism dying? Where is patriotism? Why are people with common destiny killing each other and are so willing to tear their country apart? What can we do to reverse this trend?

Traditionally, the issue of peace is dealt with as elements within subjects such as social studies and Civics (Paul, 2002). Consequently, there has often been a failure to recognise the significant inputs that Science, Technology and Mathematics Education (STME) can make to the development of a well-functioning citizen (Matlin, 2004). Considering the fact that STME has humanitarian goal, it is important to link the relevance of the ethos on which STME is based – respect for factual evidence and carefully applied logic; encouragement of logical reasoning and the need to question beyond superficial appearances; and deliberate effort to eliminate personal bias or falsification of data and conclusions – with citizenship, democratic processes and the balancing of interests of different groups in society. This entails identifying the scientific knowledge, skills and attitudes citizens need to enhance their capacities to participate pleasantly in the variety of societal contexts that constitute living in increasingly developing technological societies. This approach immediately introduces the concept of STM for citizenship (see Layton et al., 1993; Irwin & Wynne, 1996 and Jenkins, 1997) situated in the numerous societal issues within which citizens are involved. The objectives of the interactive 90 minutes session presented in this paper were two fold: 1) to examine two social concepts (nationalism and national integration) that are vital to the sustenance of peace and personal well-being of citizens; and 2) to explore the foundations of the scientific enterprise namely, intellectual attitudes and through hands-on and minds-on activities develop ideas on how STM teachers can promote peaceful coexistence through inculcation of scientific attitudes in learners.

Significance
Our global existence depends on learning to live together without the threat of violence and conflict. Educators have the unique opportunity to promote peaceful co-existence by bringing the processes of peacemaking and peacekeeping to the attention of their students in the classroom. Peace Education is concerned with helping learners to develop an awareness of the processes and skills that are necessary for achieving understanding, tolerance, and good-will in the world today (Duffy, 2006). Establishing a lasting peace is the work of education. According to UNESCO, since wars begin in the minds of men and women, it is in the minds of men and women that the defenses of peace must be constructed. The reasons for educating for peace in the STM classroom are:

- to make learners aware of the basis of conflict and how to resolve conflict in their daily lives;
- to prepare students to become good citizens of their communities, nations, and the world with skills to promote peace and human dignity on all levels of interaction;
- to use the classroom as a small version of a just world order, in which the global values of positive interdependence, social justice, and participation in decision-making processes are learned and practised.

Theory
Proceedings of the Peace Education Committee meetings held in Durban, South Africa on June 23, 1998 are highly illuminative on extant knowledge on Peace Education Theory. The works of Elise Boulding and Paolo Freire cited during the meetings have powerful impact on our understanding of Peace Education Theory. Boulding has been acknowledged for feminist peace theorizing about personal and interpersonal violence and her emphasis upon future thinking and the key role of international nongovernmental organizations in promoting peace. Paulo Freire contributes an emphasis upon developing a questioning attitude towards the violence of the status quo and a pedagogy that relies upon a dialogue between teacher and pupil where both together seek alternatives to violence. Peace educators produce critical thinkers who query the emphasis upon the pursuit or celebration of military ideals found all around the world. Peace educators create democratic classrooms that teach cooperation and encourage positive self esteem among their students. Teachers serve as peaceful role models to help to counteract images of violent behaviour young people take up through popular culture and in their homes. Peace education is based on a philosophy that teaches nonviolence, love, compassion, trust, fairness, cooperation and reverence for the human family and all life on our planet. Skills include communication, listening, understanding different perspectives, cooperation, problem solving, critical thinking, decision making, conflict resolution and social responsibility.

Design and procedure
Following the introduction of the interactive sessions by the presenters, the attendees formed :
- Small syndicate discussion groups (eight groups of five participants each). The activities of the syndicate groups were directed by six Worksheets on Nationalism,

National Integration. Knowledge of Humanity, STME for Citizenship, Multicultural STME and Assessment of Affective Outcomes.
-Syndicate group discussions – Two large groups emerged from the small syndicate teams, compared notes and reached some consensus. Two rapporteurs – one for each group - recorded the proceedings of the groups.
-Whole group discussions. The two rapporteurs reported to the general session. One report emerged which was basically the consensus of the entire group.
Findings
The following represent the consensus of opinions on the issues raised in three of the six worksheets:

WORKSHEET 4: STME for Citizenship
One of the dimensions of scientific literacy is the acquisition of attitudes and values which are in harmony with those of science and a free society. Irwin and Wynne (1996) called this *citizen science* while Fensham (2004) labelled it *science for citizenship* Qualities that concern students' attitudes towards and interests in STM are generally referred to as affective characteristics. Scientific attitudes are not only foundational to the scientific enterprise but are also essential for enhancing interpersonal relations in a just and egalitarian society. Several areas in the affective domain can be nurtured through the use of appropriate instructional situations in STM. Such attributes and their overt behaviours are summarized in Table 1. The consensus at the sessions was that STME should be more concerned with contents that show it as human activity motivated by both extrinsic and intrinsic factors (namely, its intellectual and social history), practical reasoning, and habits of mind (see Atkin & Helms ,1993).

Table 1: Intellectual Behaviours of the Scientific Enterprise

S/N.	Scientific Attitude	Overt Behaviour
1.	Open-mindedness	Willingness to consider new ideas or opinions; willingness to work cooperatively with others.
2.	Objectivity	Tendency to be impartial or free of bias, personal emotions or prejudices.
3.	Intellectual honesty	Demonstrable scientific integrity
4.	Rationality	Reasonableness; sensible thinking and judgment, based on reason rather than emotion or prejudice.
5.	Willingness to suspend judgement	Avoidance of rushing to conclusion
6.	Respect for evidence	Reliance on fact, sign or proof of the existence or truth of something that helps somebody to come to a particular conclusion.
7.	Willingness to change opinion	Non-dogmatic, flexible
8.	Scepticism	State of disbelief; doubtful of what others accept to be true

9.	Humility	Modesty, unassuming nature, respectful
10.	Critical mindedness	Analytical in thought and thinking
11.	Self-criticism	A display of censure
12.	Reverence for life	A show of respect for life

WORKSHEET 5: Multicultural STME

The concepts of *multicultural* and *anti-racist* STME are subsets of STME for Citizenship. Multicultural STME is an attempt to provide a curriculum which allows students to explore other cultures as well as their own so that an ethical framework of respect and tolerance is set up... leading towards a state of social cohesion (Dennick, 1992; Hodson, 1993). In modern world, multicultural and antiracist STM education have become relevant for all countries as the process of globalisation has shown that security, trade, health, environmental management and conflict in one country are inextricably linked to some other countries of the world. The consensus reached on Multicultural STME is as follows:

1. Quality STME enables citizens to participate meaningfully in the many decisions that societies and politicians make about a complex set of socio-scientific issues.

2. STME for citizenship, in the interest of peace, should be taught at all levels of education. Some materials may need to be dropped from existing curricula to accommodate STME for citizenship.

WORKSHEET 6: Assessing Affective Characteristics

In spite of the emphasis that is often placed on the development in students of positive attitudes and affective characteristics, efforts at assessing these qualities are sparse. The reason for this is related to the technical and methodological difficulties that are associated with the assessment of affective outcomes. Teachers lack appropriate skills and tools. Another reason is concerned with the assessment of values. Both give rise to the question of whether and to what extent it is possible for technical and ethical reasons to engage in assessment of students' attitudes and related attributes that cannot be elaborated or observed in any direct way. To assess affective characteristics the group agreed on using

- formal and informal interviews, either 'open—ended' or 'structured' between student and the teacher.
- Direct observation of students in situations that require the display of affective qualities.

It was recognised during the interactive sessions that STME can make significant contributions to the preparation of the citizen and the promotion of peaceful coexistence. To take advantage of these contributions, STME for Citizenship should be located in existing national curricula rather than being a separate subject on its own; and STM teachers should be reoriented through seminars or courses of short term durations focusing on the skills of inculcating a culture of habits of mind that provide models for fostering peace.

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THE IMPORTANCE OF MORAL DISPOSITIONS IN TEACHING SCIENCE

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Abstract: It is widely understood that science teaching is a rich and complex act requiring a range of qualities. Many teaching standards attempt to describe science teaching in terms of the 'measurable' attributes of teaching knowledge and skills, leaving aside the 'unmeasurable' moral and aesthetic domains. In this paper, we report on a project involving experienced science teachers who examined video teaching episodes for evidence of various standards, including the moral disposition of *sincerity*. We show how these teachers were able to identify the moral aspects of teaching in the video cases, and call into question the wisdom of omitting moral dispositions from science teacher standards.

Objectives

Professional teaching standards have emerged as a major focus of teacher reform. In the USA, Canada, UK, Australia and elsewhere we find significant activity in the development and use of standards (National Project on the Quality of Teaching and Learning, 1996; National Board for Professional Teaching Standards, 1991; National Research Council, 1996; New Standards, 1996; Ontario College of Teachers, 1999; Teacher Training Agency, 1996). One of the more notable projects in recent years was that conducted by the Australian Science Teachers Association (ASTA, 2002). This project, like most others, articulated standards in terms of lists of knowledge and skills, accompanied by qualifying statements or indicators. Rarely do standards incorporate the moral and aesthetic dimensions of teaching, notwithstanding the extensive and long-standing literature indicating the central role of these aspects in teachers' work (Campbell, 2003; Sockett, 1993; Tom. 1983). The most common reason given for this absence is that moral dispositions are 'below the surface' of teaching, not easily recognised or able to be 'measured' in the work of teachers. This study re-examines this assumption through a detailed analysis of video segments of classroom teaching. We use a panel of experienced teachers to help us look for evidence of the moral dimensions of teaching in teachers' actions. In broad terms, we explore the issue of whether teaching standards can usefully and practically incorporate moral aspects as well as knowledge and skills.

Significance

It has often been said that what isn't measured isn't valued. When we examine this apparent truism in the context of the teaching standards movement we are faced with an interesting and troubling conundrum. While it is commonly understood that teaching is a rich and complex act requiring a range of qualities, we seem compelled to reduce our lists of standards to a subset of 'measurable' attributes of teaching (knowledge and skills) leaving aside the 'unmeasurable' (the moral, ethical and aesthetic domains). The teaching standards movement, it would seem, has foundered on this important point—how to measure that which is valued and, in turn, value that which is measured. In this project, involving a detailed analysis of classroom video by a panel of experienced teachers, we begin to explore how the moral dimensions of teaching might usefully be injected into the standards debate.

Theory

The nature of professional standards.

In this study, we take the position that standards should be built around short lists of non-technical words — including moral dispositions as well as knowledge and skills. Our experience is that standards are best understood when accompanied by rich exemplification in the form of case and other material, including video (Louden, Wallace & Groves, 2001). In our work on standards, we have been influenced by Kilbourn's (1998) principles of teaching, which he describes as guides for describing and analysing teaching. Three of Kilbourn's (1998) standards or principles — *ownership, rigour* and *sincerity* – have proved particularly useful in our study. We have also preferred to follow Kilbourn's Deweyan strategy of using the principles as guides for 'judging suggested courses of action' rather than rules to be slavishly followed (Dewey, in Kilbourn, 1998, p. 37).

Moral dispositions as standards.

One of the moral standards that we have found useful is sincerity, which Kilbourn (1998, p. 44) explains as "the intent to have clean, straightforward, honest interaction between the learner and the teacher". Others also advocate the importance of moral dispositions in teaching. Banner and Cannon (1997), for example, use qualities such as learning, authority, ethics, order, imagination, compassion, patience, character and pleasure to describe teaching. Another framework is proposed by Fallona (2000) who applies Aristotelian moral virtues to teaching, including bravery, friendliness, truthfulness, wit, honor, mildness, magnanimity, magnificence, generosity, temperance and justice.

Teaching as professional action.

Since Philip Jackson's (1968) book *Life in Classrooms* detailed the inescapable complexities of classrooms, there has been a growing recognition of the complexity of teaching. In this project, we highlight the notion of teacher as dilemma-manager (Berlak & Berlak, 1981; Lampert, 1984; Wallace & Louden, 2002). We are interested in the decisions that teachers make in their moment-by-moment classroom interactions and in how they handle the tensions or trade-offs between and among different standards.

Design and procedure

This study involves the in-depth analysis of videos of lessons from five experienced high school (Grades 8-10) science teachers. The project team collected the videos prior to the study. Video examination was conducted by a panel of twenty experienced science teachers who met six times over a fifteen month period. During these meetings, the panel examined pre-selected segments of the classroom videos for evidence of particular moral dispositions — for example, sincerity. By way of comparison, we also examined how some other knowledge and skill standards, for example rigour and ownership, were enacted in the videos. Sub-groups of the panel teachers recorded short audio commentaries on how each of the standards was enacted in the video segment. Each sub-group also recorded an audio commentary on how the videoed teachers handled dilemmas associated with the standards. The videotaped teachers, who were also members of the panel, prepared their own videotaped commentaries introducing the context of the school and the lesson, and critiquing their own performance in relation to the standards.

The data for the study, therefore, consist of videotapes of lesson segments from five teachers, videotaped interviews with each teacher, audiotaped commentaries from experienced colleagues and audiotapes of parts of the panel discussions. In some cases we also have videotaped interviews with students from the classes. These data were subsequently examined by the project team for themes and issues.

Findings

Standards as principles underlying accomplished teaching.

The moral standard of sincerity was found to provide a useful tool for the teacher panel in describing and analysing science teaching. Early in the project it became clear that working within a standards framework helped the panel observe, discuss and understand the video evidence. The panel teachers avoided the rush to judgement often seen in similar situations. The panel teachers noted similar kinds of teacher actions across the different video segments with respect to the moral aspects of teaching.

Sincerity, moral standards and teaching trade-offs.

The commentaries, interviews and panel discussions confirmed the importance of moral dispositions in teaching. While some of the knowledge and skill standards (eg. rigour and ownership) appeared to be in tension with each other, sincerity was not traded-off by the teachers in the videos. The videoed teachers maintained a high level of sincerity even when under pressure. This finding confirms Kilbourn's (1998) contention that the moral principles, such as sincerity, are ends in themselves rather than means to the end of improved student learning. In this regard the moral standard of sincerity appears to operate in a different way from knowledge and skill standards.

Moral dispositions as seen in teaching actions.

Sincerity was manifested in the teaching by several kinds of teaching actions. Examples included a relaxed, comfortable, caring style; using appropriate, friendly language; being accepting of all student responses; and, honesty in all interactions with students. Kilbourn (1998) referred to aspects of sincerity regarding the 'student as a person' and the 'student as a learner'. It is of particular interest that the panel teachers were able to recognise sincerity in these two forms and, importantly, to describe the related teacher actions.

Conclusion

We conclude with several observations. Firstly, we suggest that moral dispositions underpin good science teaching, colouring all that a teacher does. Second, we recognise that the task of making moral dispositions explicit is a difficult task, often fraught with controversy. Finally, however, we are firm in our conviction that this is a task that is achievable and must be done. Indeed, we assert that it is the morality of teaching that makes the difference.

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THE IMPACT OF INTEGRATED ILLUSTRATED INSTRUCTIONS ON COGNITIVE LOAD AND UNDERSTANDING WITHIN SECONDARY SCHOOL SCIENCE PRACTICAL WORK

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Abstract: This study investigated the cognitive effects of splitting attention between instructional materials and equipment on understanding instructions for practical work in science. 96 junior secondary school students who were unfamiliar with content knowledge and the equipment commonly used in practical work to support the topic of electricity took part. The students were divided into two groups to complete practical tasks. One group was given modified instructions containing integrated text and illustrations and the other group was given conventional instructions containing text only. Student's performance on the task, their time to completion, perceived cognitive load and task difficulty, and pre and post test scores were measured. The modified instructions produced significantly higher levels of performance on task, lower time to completion, lower perceived cognitive load and task difficulty and higher post test scores than the conventional instructions.

Objectives

Practical work is a fundamental component of practical work in secondary school science. Practical work involves manipulating often unfamiliar equipment which is foreign as it is not used in everyday life. Doing practical work involves manipulating scientific equipment, understanding instructions and learning science concepts, theory or principles in the process. Often these all together are too much for students and the result is frustration which inhibits understanding and learning from this experience. This is a result of cognitive overload. Reducing cognitive load could result in greater understanding and learning from practical work.

Significance

Science is a practical subject that is conducted worldwide in laboratories as a significant part of student's science education. One of the reasons for including practical work is to help develop manipulative skills. However, all too often manipulative skills development is hindered by the difficulty students experience understanding instructions for working with unfamiliar, complex equipment. This is especially true in the context of using electrical equipment. The literature suggests that girls experience greater difficulty especially in physics topics (Murphy, 2000). In fact Murphy (2000) found that gender differences with respect to skill in handling equipment becomes evident at an early age. A potential reason that all students might experience difficulty developing skills through practical work may be the high cognitive load inherent in most practical work instructional settings. Sweller, van Merrienboer & Paas (1998) suggested that cognitive overload can reduce motivation in what is traditionally a motivating activity in science. Practical science work is particularly well suited to benefit from integrated illustrations (in order to reduce the cognitive load), given the need to integrate information from two different mediums, i.e., text and science equipment.

This study looks primarily at improving the understanding and learning from practical work actually performed by students in secondary schools by modifying the presentation of the instructions students are required to follow to complete these practical tasks which involve integrating information from two different mediums (written instructions and electrical equipment). The instructions were modified using guidelines from the Cognitive Load Theory (Sweller, 1999; Paas, Renkl, & Sweller, 2003) and the Theory of Multimedia Learning (Mayer, 2003). This study extends previous research by assessing the influence of integrated illustration and text on reducing the split attention between two different mediums, i.e., science equipment and written material. In addition, this study looked at the effect of gender on understanding and learning in a practical context in science.

Theory

Hodson (1996) describes the goals of science education as being divided into learning science (content), learning about science (the nature of science) and doing science (engaging in and developing skills for problem solving and inquiry). Science curricula in many countries reflect an emphasis on the "doing science", i.e., practical work. Research has found that practical work can improve student achievement in science (Lock, 1992) and facilitate the development of students' problem solving skills (Hodson, 1993). Research has also found that female students are less interested, participate less enthusiastically and fall behind male students in skills development resulting from practical work, especially in the physical sciences (Whyte, 1986). Finally, "practical work" skills development is often hindered by the difficulty students experience understanding instructions for the manipulation of unfamiliar, complex equipment.

One avenue for better understanding why many students experience difficulty developing skills through practical work is to investigate the cognitive load inherent in most practical work instructional settings. Sweller, Van Merrienboer and Paas (1998) suggest that cognitive overload can reduce motivation in what is traditionally a motivating activity in science.

Current views of the cognitive processing system suggest it is made up of a working memory and a long term memory (Baddeley, 1992). Working memory is the limiting factor in the cognitive processing system as it has a limited capacity for processing and in certain circumstances (i.e., novices with little prior knowledge) can easily be overloaded if the amount and complexity of information exceed working memory capacity (i.e., cognitive overload)(Paas, Renkl & Sweller, 2003). When cognitive overload occurs understanding and learning are negatively affected. Instructions presented in a practical work context often consists of a large number of independent chunks of information that need to be processed simultaneously (i.e., high element interactivity), hence, cognitive load is likely to occur (Marcus, Cooper & Sweller, 1996). Understanding the impact of cognitive load on student learning is critical to the effective design of instructional materials (Chandler & Sweller, 1992). Research indicates that instructional formats which impose a high extraneous (avoidable) cognitive load on working memory can interfere with further cognitive processing which is critical for facilitating understanding and learning (Mayer & Moreno, 2003). Unfortunately, many science texts and written material containing instructions for practical work, are written without taking into account the effects of instructional presentation on the cognitive processing system. A high level of extraneous cognitive load can occur within a practical context when students are asked to manipulate scientific equipment and read related written instructions.

Research on the use of illustrations in text has found that illustrations aid in the building of mental representations of text information and concepts presented in text which increases understanding and decreases cognitive load (Mayer & Moreno, 2003). Mayer (2003), within the context of his Theory of Multimedia Learning, refers to instructional formats which integrate pictures within text in order to foster understanding and meaningful learning as " multimedia instructional messages". Research on using integrated illustrations within scientific text found that integrated instructional materials had a positive effect on understanding and learning (Mayer & Moreno, 2003).

Design and procedure

96 junior secondary school students who were unfamiliar with content knowledge and the equipment commonly used in practical work to support the topic of electricity took part. The students were divided into two groups each with their own set of instructions. One group was given modified instructions containing integrated text and illustrations and the other group was given conventional instructions containing text only. The experiment was conducted in four phases.

1) The *pre-testing phase* consisted of a pre test, giving the subjects practice at reading values from a voltmeter and experiencing and recording the beeps used in the secondary task.
2) The *instructional phase* consisted of subjects being given time to read and understand the instructions. During this phase only the subjects with the conventional instructions could see the electrical equipment. The modified instructions were designed to be self-contained and intelligible on their own without the need to look at the electrical equipment.
3) The main *experimental phase* involved subjects: a) using the instructions to complete two practical work tasks and concurrently completing a secondary task which required them to record the exact time when randomly presented beeps sounded. On a separate sheet which the subjects were instructed to put to one side but keep accessible they recoded the time that they heard a beep sound. Subjects read off the time from one of 2 large digital stop watches located at the front and back of the room. During the experimental phase subjects recorded their practical work results on a separate answer sheet. Immediately after each of the two practical work tasks, respectively, the students completed their subjective questionnaires on task and instruction difficulty. There was a maximum time allowed for each task, ten minutes for the first task and 15 minutes for second.
4) The final *post test phase* consisted of the subjects completing a post test.

Finally, student's performance on the task, their time to completion, perceived cognitive load and task difficulty, and pre and post test scores were measured.

Findings

A series of MANOVAs found that the modified instructions produced significantly higher levels of performance on task, lower time to completion, lower perceived cognitive load and task difficulty and higher post test scores than the conventional instructions. This data suggests that for practical work in science, when learners are inexperienced and the information is complex that physically integrating mutually referring sources of information reduces split attention and hence cognitive load, and therefore makes instructions easier to understand. Given the existing literature on gender differences in science performance, attitudes and achievement, we included it as one of the fixed factors with instructional treatments. Significant gender effects were found for the time to completion and on all performance measures. Of particular importance to the results of the present study, is the fact that no significant treatment X gender interactions were found on any measure. This indicates that the treatment effects were robust and not moderated by gender.

The results of the present study indicate that subject's understanding was facilitated to a higher degree in the modified instructional treatment compared to the conventional instructional treatment and are consistent with the notion that the annotated, integrated illustrations made the instructions easier to understand (Marcus, Cooper & Sweller, 1996; Mayer & Moreno, 2003) and were successful in eliminating any split attention effect (Chandler & Sweller, 1992; Kalyuga, Chandler & Sweller, 1998; Sweller, 1999). In addition there is some evidence that the modified instructional materials facilitated greater learning as indicated by the post test scores.

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MYTH BUSTING AND TENET BUILDING: PRIMARY AND EARLY CHILDHOOD TEACHERS' UNDERSTANDING OF THE NATURE OF SCIENCE

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Abstract: The purpose of this research was to identify the understandings of the nature of science of a cohort of New Zealand primary and early childhood teachers, enrolled in a semester long science course as part of their Bachelor of Education degree. The research explored their initial understandings of the nature of science and mapped these understandings over the duration of the course in order to identify shifts in understanding and aspects resistant to change. This explicit reflective course incorporated a set of generic science-content-free activities which were seen to have a positive effect on the teachers' understanding of the nature of science.

Objectives

A fundamental goal of science education is to provide students with the level of scientific literacy required to enable them to participate in, and avail themselves of, a society increasingly dependent on science and technology. An understanding of the nature of science (NOS) as being one of the essential components of scientific literacy is a consistent theme in research (Murcia & Schibeci, 1999). This recognised importance of NOS can be seen internationally in science education documents and reform initiatives, and likewise in the education reform that has taken place in New Zealand education. If the expectation is that our students should develop an understanding of NOS, it follows that there is the need to establish whether our teachers possess a sound understanding of NOS.

The purpose of the research project was to identify the understandings of NOS of a cohort of New Zealand primary and early childhood teachers, enrolled in a semester long science course as part of the upgrading of their qualifications to a Bachelor of Education degree. The research sought to examine their initial NOS understandings and mapped these understandings over the duration of a five month course in order to identify shifts in understanding and aspects of NOS resistant to change.

Significance

There are very few studies that examine primary teachers' understanding of NOS and none have been found on early childhood teachers' NOS understanding. Most international research relating to prospective or practicing teachers' understanding of NOS has focused on secondary teachers (Koulaidis & Ogborn, 1995). Furthermore, much of the research related to teachers' understanding of NOS has focused on pre-service (rather than in-service) teachers, who have not had opportunity to include science into their professional practice and, therefore, whose views of NOS may be of little help in understanding the views of practicing teachers (Lunn, 2002). This research study will contribute to the knowledge base about practicing teachers' conceptions of NOS.

Theory

It is argued that scientific literacy is necessary on two broad levels: macro, relating to society; and micro, relating to the enhancement of the lives of individuals (Laughksch, 2000). At the macro level, it is contended that the economic well-being of a nation requires successful competition in international markets, that is supported by research underpinned by a steady supply of scientists (Elshof, 2000). Furthermore, a level of scientific literacy is increasingly required by the general citizenry in order to make informed decisions about broader public policy in science. For example, public debate on issues such as G.E. crops and stem cell research requires a level of scientific literacy (Jenkins, 1994).

Scientific literacy also has a transformative and emancipatory function. Citizens who are able to ask fundamental questions, analyse and challenge accepted norms, make judgments, use critical thinking and solve problems can remain interested in scientifically related issues. Conversely, if the general citizenry remain scientifically illiterate, uninformed and/or disinterested, the privileged with access to the knowledge stay privileged, and the scientifically illiterate remain powerless and marginalised (Keske, 2002). At a micro level it is argued that there are intellectual, aesthetic and personal benefits of scientific literacy to individuals. It is widely accepted that knowledge of science is an important element of what it is to be an educated person (Laugksch, 2000).

The need for an understanding of NOS as a requirement of scientific literacy is well argued in the literature (e.g. Abd-El-Khalick & BouJaoude, 1997; Clough 1997). It is difficult to define NOS, partly because it is a social construct and as such is neither universal nor stable. However, there is consensus and general accord regarding the salient aspects of NOS for education (Abd-El-Khalick, Bell & Lederman, 1998). At this level of generality little disagreement exists among historians, philosophers, and science educators. Lederman, Abd-El-Khalick, Bell and Schwartz (2002) have suggested the following five NOS tenets as being the most appropriate for K 1-12 (i.e. primary to secondary school) learning: the tentative nature of scientific knowledge; the empirical nature of science; the inferential, imaginative and creative nature of science; the subjective and theory laden nature of science; and the socially and culturally embedded nature of science.

In order to understand NOS, it is also helpful to explore common myths (misunderstandings or misconceptions) about NOS. Much research in science education in the past 25 to 30 years has addressed the issue of misconceptions or alternative conceptions (Wandersee, Mintzes & Novak, 1994). These myths of NOS are commonly included in science textbooks, classroom discourse and in the minds of children and adults alike. For the purposes of this research study 15 myths were examined. For example: scientists use 'the scientific method'; evidence carefully accumulated will result in sure knowledge; science is more procedural than creative; experiments are the principal route to knowledge; scientific conclusions are reviewed for accuracy; and science is a solitary pursuit (Mc Comas, 1998). These five tenets of NOS and 15 myths were used as two frameworks to analyse the data gathered over the duration of the course.

Design and procedure

The research was embedded in critical social science methodology since critical research can enable individuals to be empowered and can initiate change (Neuman, 2003). An explicit reflective approach was used throughout the course to teach, and make explicit, the selected NOS tenets. Data was collected using: four open-ended questions; the Views on Science, Technology and Society (VOSTS) questionnaire developed by Ryan, Aikenhead and Fleming (1989); and regular, structured, reflective journal writing using prompts. Data was analysed using the myths and the NOS framework developed for this research study.

Contextualised instruction occurred as the course content was used overtly to draw attention to NOS. For example, in the geology component of the course the tentative nature of scientific knowledge was explored within the context of the history of the development of the theory of continental drift. In addition to addressing NOS concepts within the context of the science content, specific 'science-content-free' activities were also used to make NOS aspects explicit. Five of a set of activities developed by Lederman and Abd-El-Khalick (1998), were used to explicitly introduce the teachers to target aspects of NOS: 'Tricky Tracks', 'That's Part of Life', 'The Hole Picture', 'The Aging President' and 'Young and Old'. Details of these activities can be found in McComas' (ed.) *The Nature of Science in Science Education: Rationales and Strategies* (1998). These activities were selected as they have been successfully used with school students, tertiary students and science educators.

Findings

Analysis of the teachers' pre-instruction views using the NOS framework showed that the only NOS tenet expressed by more than 50% of the teachers was the empirical basis of NOS. Each of the other NOS tenets was considered to be lacking in their views as a cohort. The teachers' initial understandings of NOS were fragmented, lacking in depth, and inconsistent.

Analysis of their pre-instruction views, using the myths framework, in both the open-ended questions and the VOSTS questionnaire, showed that all of the teachers held several myths concurrently. The most prevalent myth, expressed by 88% of the teachers, was that scientists follow the scientific method. Other prevalent myths presented a view of science as more procedural than creative, with experiments being given as the principal route to accumulating and proving knowledge. This knowledge was considered to be sure and was frequently equated with truth. Laws and ideas were deemed absolute. The scientists' role was to record what exists rather than use their imagination, originality, creativity, or other individual attributes.

At the conclusion of the course, the data showed that 24 of the 25 teachers were able to articulate a contemporary understanding of at least one of the NOS tenets in their open-ended questions. Eight teachers clearly articulated contemporary understandings of all of the five selected NOS tenets and 21 incorporated three or more of the tenets in their final journal entries. Using the myths framework to analyse the final data showed that two thirds of the teachers expressed no myths at all in their final journal entries and open-ended responses.

Further analysis of this data was carried out to identify the factors which contributed to these shifts in understanding. A key finding was the role of the generic, science-content-free NOS activities used in this course. The data gathered showed that no significant increase in NOS expression was seen until these activities were introduced. The first of these activities, 'Tricky Tracks', was the first occasion in which the teachers recorded a significant number of NOS related responses in their journals. From this point onwards in the course a steady positive shift in the number of NOS related comments was evident.

In examining reasons for the positive impact of these activities it can be seen that each of these activities has been purposefully designed to be generic in nature, i.e. science-content-free, with the assumption that removing the unfamiliar science content would enable learners to understand more readily the specific NOS tenet being addressed. Teaching NOS and science content separately might distribute the cognitive load for learners, in that NOS instruction is not complicated by the science content (Clough, 1997). When NOS activities were provided that allowed these NOS tenets to be taught devoid of any new science content to master, the data indicates that the teachers more readily understood the NOS tenets being taught. This finding clearly has important implications for the use of such activities when teaching NOS, at any level.

Furthermore, each activity was followed by whole class and group discussion which aimed to explicitly highlight the target aspects of NOS and involve the teachers in active discourse concerning the presented ideas. Discussions were found to be important for providing the teachers with opportunities to clarify their own, and their peers', understanding of NOS. These generic activities also provided opportunities for further reflection. Reflection on experiences within science, either in the classroom or in authentic settings, has been identified in the literature as a critical element necessary for formalising views of NOS (Schwartz & Crawford, 2004).

This research has indicated that the use of generic science-content-free activities within an explicit, reflective teaching approach is pedagogically effective in increasing teachers' understanding of NOS. Translated into classroom practice, such contemporary understandings could be a critical factor in the development of the scientific literacy required by our students in order for them to fully realise the benefits of and participate in an increasingly scientific society. These findings indicate a need for NOS to be addressed in both pre-service teacher education and in-service teacher professional development programmes.

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ISLAM ON EDUCATION FOR SUSTAINABILITY PRACTICES

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Abstract: The paper shows that Islamic guidelines for sustainable lifestyle can enrich curricula of Education for Sustainability in line with UNESCO's decade of 'World Education for Sustainable Development'. The Quran and the Tradition depict social, economic and environmental sustainability issues which are integrated in the five pillars of Islam: belief, contemplation, abstention, charity and pilgrimage. Jihad, a mandatory striving, activates these five pillars. A case study in Bangladesh shows how synergies between the five pillars and Jihad not only refrain people from unsustainable consumption of nature's finite resources, but also help expand its regenerative capacity. The presentation will suit learners, teachers, and sustainability practitioners.

Objectives

Muslims believe in the Quran as the divine Scripture that claims itself to be the complete guidance for humankind[8]. The main objective of this paper is to investigate whether the teaching of the Quranic values and the Islamic traditions[9] can contribute towards transforming people of the 21st century into adopting more sustainable practices?

The Quran opens with "Show us the straight path. The path of those whom thou hast favoured; Not (the path) of those who go astray" (1:5-7). The "straight path" denotes simple living and this is consistently stated throughout the book.[10] On the other hand, the Quran calls the people who go astray as wasteful, extravagant, corrupts, mischief and Satan.[11] The Quran addresses them:

> Woe unto every slandering traducer.
> Who gathered wealth (of this world) and arranged it.
> He thinketh that his wealth will render him immortal.
> Nay, but verily he will be flung to the Consuming One.
> Ah, what will convey unto thee what the Consuming One is!
> (It is) the fire of Allah, kindled.
> Which leapeth up over the hearts (of men).

[8] This is the Book, there is no doubt in it, a guidance for those who guard themselves against evils (2:)2).
[9] The Islamic Tradition (or the Tradition) in the case of Bangladesh includes the sayings and practices of Prophet Mohammad and the Sufis.
[10] Examples include 3:101; 4:48 and 66-68; 6:39, 87.126,153, and 161; 16:121-124; 22:54; 48:2 and 20; 36:60-61; and 42:13.
[11] See 2:60 and 205; 5:64; 7:31; 56; 17:26-27; 28:4; and 3:138.

Lo! It closed in on them.
In outstretched columns (104:1-9).

With the growing consumerism of finite natural resources, including the uptake of consumerism in fast developing countries, the Islamic Tradition and education can offer an alternative code of development that puts less emphasis on material wealth. This could enable people to pursue a lifestyle that underpins local and global sustainability, including providing them with an educational basis for the social, economic, technological and environmental aspects of sustainability (Huckle and Sterling,1996:3).

Muslims find the Quran a complete code of life (Murata and Chittick, 1994: 182-184)[12] and the Quran has many lessons that can constitute a curriculum for education for sustainability and guidance for more sustainable practices. The house of Islam rests on five pillars that intrinsically link sustainable management of natural resources and socio-economic sustainability, namely: belief, contemplation, abstention, charity and pilgrimage. These Islamic values need to be acquired as personal ethics that transforms human life and spirituality. Jihad[13], or the personal struggle to build these values, allows the building a way of living that complies with the five pillars. Jihad is also seen as the 6th pillar of Islam (Murata and Chittick, 1994:21-22) and is at the core of the practice in maintaining peaceful sustainability conditions. The concept of Jihad and the teachings of Jihad can inspire people to develop a behaviour that questions the way of living with unsustainable consumption patterns.

According to Islam, the need for values education arises because, unlike other creatures, humans have freedom of will, thought, choice and action. Values education is an explicit attempt to teach about the limits to freedom. The present systems of education in the West are primarily designed to make students competitive in the job market and achieve economic wellbeing. However, the other aspects of sustainability (e.g. social or environmental) are not well catered for. Students need to grow in a culture that cares for the natural environment, encourages economic responsibility and self-reliance, socio-cultural vibrancy and community engagement. (Secular) schools also often fail to instil values such as commitment to hard work, individual endeavour or work ethic (Welch, 1996:61).

The paper attempts to explore an alternative approach to education through the integration of Islamic values in the curriculum development that can promote a more sustainable way of life. A case study, conducted in 2006 at an Islamic school (Madrasa) in a Bangladesh village, depicts how the values required for sustainability management need to be acquired. It also stresses that this is part of a lifelong learning (Williams and Humphrys, 2003: 48-49).

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[12] The Quran reads: We have sent down to thee the Book as an Elucidation of all things, and as a Guidance and a Mercy, and as good news to those who submit (16:89).
[13] The Quranic usage of the term "Jihad" is far broader than what the current political use of this term might imply. Jihad means 'struggle' in the path of God – the Straight Path. In many ways Jihad is the complement to Islam (Peters, 1979:117-8; Murata and Chittick, 1994:20-21).

Significance

The importance of values education has been emphasised recently in Australia as critical to the development of educational outcomes of students. The 2005 *National Framework for Values Education in Australian Schools*[14] provides the general context for values education and the nine specific values that government, non-government and independent schools should strive to achieve[15]. During the UN decade of education for sustainability, all these values are essential in the developing of a culture of sustainability that endorses a holistic view of the world communities. The paper however shows how Muslim schools teach students the cultural aspects of sustainability improvement arguing that there is potential for incorporating some shared core values in building the global foundations for sustainability.

Most countries have Muslim populations who are often misunderstood by others as a rebellious tradition, though Islam means peace and submission. On the one hand, it is significant to understand what makes Muslims pledge for Jihad in order to protect their sustainability, but on the other, some Islamic values such as alms-giving, perseverance, kindness, modest consuming and Jihad can be seen as core shared values between different cultures which also contribute to sustainability. They can be integrated in the educational curriculum, and Hicks and Slaughter (1998:59) argue that in the future more influence on education is likely to come from the non-West, e.g. from the indigenous traditions and Islam. An integration of Islamic perspectives in the curriculum can facilitate the present generation to build a more sustainable future.

Theory

The paper links concepts and teachings of Islam with the contemporary understanding of sustainability arguing that the five pillars of Islam and the values taught in the Islamic Tradition could be seen as a basis for sustainability education.

According to Blewitt and Cullingford (2004:30), education for sustainability emerges not as a result from a conscious decision to change one's way of life, but from a reflexive relationship between thinking about priorities and the actual experience of living in the world, of making a living and protecting the prospects of the next generation. It is straightforward to assume that problems in the world occur due to misdeeds that arise out of ignorance; however when there is enough evidence, awareness and knowledge about the negative consequences of such actions, the need for reflexive re-assessment of our relationships with the natural and the human world can be underpinned by the value system and the beliefs we hold.

"Mischief has appeared on the land and sea, because of (the need) that the hands of man have earned, that (Allah) may give them a taste of some of their deeds: in order that they may turn back (from evil)" (30:41). "Lo! We have created everything by measure" (54:49). This teaches Muslims to be sustainable in using the limited natural resources.

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[14] ttp://www.curriculum.edu.au/values/newsletter_01.htm, accessed on 20 April 2005.

[15] Care and compassion, doing one's best, fair go, freedom, honesty and trustworthiness, integrity, respect, responsibility and understanding, tolerance and inclusion.

Islam strictly prohibits over-exploitation and incorporating this aspect of Islam in education for sustainability is, thus, likely to contribute to the common goal.

There are numerous verses (about 500) that guide humans how to deal with the environment. "… and who so followed My guidance, there shall be no fear come upon them, neither shall they grieve (2:38)". There is still the perception that environmental problems can best be solved by scientists, economists and other learned people and that Islam is meant to give guidance only on spiritual matters (Khalid and O'Brien, 1992:2). What this paper argues is that Islam can also give a perspective on contemporary sustainability issues and education.

The Quran confirms[16] that the revelations concerning values were revealed in the earlier Scriptures. Islam deals with individual, social, political, economic and environmental values, and the Islamic culture, all over the globe, manifests those values in unity, though in an utter diversity. Human obligations to the sustainability of fellow beings and the more-than-human world are at the centre of all the values that are understood and practiced complying with the climatic, geographical and cultural conditions of a place. The Islamic culture constitutes a blended system of thought and behaviour (von Grunebaum, 1961) growing out of a fundamental impulse and enveloping humans in all their relations – to the Creator, the environment, the universe and themselves. There are interrogatories in the Quran that encourage (re)discovery of the natural universe: "Don't you understand?, don't you have any sense?, don't you reflect? don't you remember, don't you apply your reason?" These appear frequently aiming at the notion to look, experiment, observe, think and finally come up with the facts of this vast universe. Such a way of reflecting on and re-assessing of human actions is important in the change towards a more sustainable way of living.

Design and procedure

The materials of the paper draw on secondary sources and field data from Bangladesh. It is designed to depict why Islamic teaching and learning deserve consideration for inclusion in the curriculum of education for sustainability. The intended headings for the paper are:

1. Islam from a sustainability perspective (depicts how Islamic literature and practices deal with sustainability)
2. Pillars of Islam as pillars for sustainability (describes the intrinsic elements in the five pillars of Islam that underpin sustainability)
3. Jihad – the pillar of pillars (establishes that Jihad is the driving force to make a change to sustainability)
4. Teaching and learning sustainability: the case of a Madrasa (shows how sustainability is at the core of the Islamic educational systems in an Islamic school in a Bangladeshi village)
5. Conclusion (stresses that precepts and practices of Jihad in curriculum placement would add a new dimension to global sustainability management).

[16] See chapters such as 2:41, 2:97, 2:144-2:146; 3:3; 5:48; 6:92; 9:111; 10:37; 12:111; 19:64; 23:68.

Findings

In Islam, values are the acquired qualitative attributes that reflect some of the qualities of God, the Sustainer[17]. Von Grunebaum (1961: 191) recognises that Islamic values are a belief in the unity of the creator; charity and fellowship among humankind; subjugation of the passions and an accountability for human actions. All these values promote sustainability through recognition of the primacy of the natural environment, social equity and concern for fellow human beings, moderate consumption and taking responsibility for the short-term and long-term results of our activities.

Islam places Jihad as the moral tool that can foster sustainability of fellow beings and non-beings in nature. The Islamic culture globally manifests these values diversely. It is human obligation to develop the spirit of Jihad in order to practice the core shared values, though differently, depending on the curriculum that is developed under the specific climatic, geographical and cultural conditions of countries.

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[17] "Colour yourselves with the colour of God" (2: 138).

DUAL VISION: A METHOD FOR CAPTURING THE LEARNING JOURNEY OF PRESERVICE PRIMARY TEACHERS OF SCIENCE

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Abstract: This research extends an existing research method, based on critical incidents, to capture the details of how pre-service primary teachers learn about science and science teaching. This paper outlines the trial and evaluation of the method, called 'dual vision'. Dual vision is constructed through the combined lenses of the pre-service teacher and the researcher, allowing both voices to be heard, and providing the researcher with an opportunity to move into the reality of the pre-service teacher. The trial consisted of the description and interpretation of the science learning journey of one pre-service primary teacher over a 10-week science methods course.

Objectives

Case studies have been widely used as a means of presenting stories to describe and explore teachers' beliefs, experiences, knowledge and understanding (Carter, 1993). However, many of these cases use decontextualised quotes to support common themes that have been identified, written and interpreted through the lens of the researcher (Wallace & Louden, 2000). The use of such secondary source material has resulted in static, disjointed descriptions of a continuous learning process. Moreover, the voice of the pre-service teacher tends to be diminished, and interview excerpts allow only a limited understanding of the learning process. As one means of overcoming these problems, and gaining a greater understanding of how pre-service teachers learn science and science teaching, Wallace and Louden (2000) suggested that researchers should attempt to move into the reality of the pre-service teacher. This research attempts such a shift in perspective and reality.

This paper extends an existing research method to capture and describe in detail how pre-service teachers learn about science and science teaching. The research method has been called 'dual vision', and is based upon critical incident stories. The objective of the research presented in this paper was to describe the use of the dual vision approach and, through a pilot trial, enable the researcher to reflect on this process and make assertions about the advantages and limitations of the method. Dual vision is constructed through the lenses of the pre-service teacher and the researcher, allowing both to have a voice. The trial consisted of describing and interpreting the science learning journey of one pre-service primary teacher over a 10-week science methods course.

Significance

Based on their diverse backgrounds and their individual experiences, particularly of previous science study, pre-service primary teachers bring a unique and challenging set of characteristics with them when they are learning science. Most pre-service primary teachers have limited science knowledge, narrow perceptions of the nature of science, poor previous science experiences, low confidence to teach science, poor attitudes and beliefs about science, and limited ideas on how to teach science (Skamp, 1989; Watters & Ginns, 2000). Many different strategies have been incorporated into science methods courses in an attempt to overcome these issues, and improve the confidence of pre-service teachers towards science and science teaching (Abell & Bryan, 1997; Rice & Roychoudhury, 2003; Watters & Ginns, 2000).

The challenge for primary science teacher educators is to provide meaningful and relevant science learning experiences within the science methods course. But how effective are such science learning experiences? What do pre-service teachers learn from these experiences in terms of understanding science and science teaching? These questions are difficult to answer as the process of learning science and science teaching is a very subtle and continuous one that can only become evident through a detailed analysis of an individual's experiences (Wideen, Mayer-Smith, & Moon, 1998). The significance of this research lies in the new, continuous and narrative approach to describing pre-service teachers' science learning experiences. The use of dual vision has the potential to create new knowledge to inform teacher educators in constructing more meaningful and relevant learning experiences within their science methods courses.

Theory

The theoretical basis of this research comes from the notion of critical incidents. Critical incidents tend to mark significant turning points or changes in a person or in some social phenomenon (Tripp, 1993). Critical incidents are not characterized as being critical due to any drama or sensationalism attached to them. Rather, their criticality is based on the justification, significance, or meaning given to them by participants (Angelides, 2001). Typically, critical incidents are only recognized after the consequences of the incident are known, often making them unplanned, unanticipated and uncontrolled (Angelides, 2001). Critical incident vignettes are short, personalized, narrative accounts of a particular event, which provide specific detailed information about the author, making them excellent primary data sources (Brookfield, 1990).

A number of approaches have been used in constructing critical incidents. The most common technique is to have the participants themselves identify, write and reflect on the critical incident. A second approach is for the researcher to discuss the phenomenon under study with the participant, and then the researcher identifies, writes and interprets the critical incident (Angelides & Ainscow, 2000). Wildy, Louden and Robertson (2000) introduced a third approach where critical incidents are identified by the participant, but written and interpreted by the researcher. This paper extends the third approach, where critical incidents are identified by the participant, but written and interpreted by both the participant and the researcher.

Design and procedure

This research focuses on the science learning experiences of one 28-year-old pre-service primary teacher, Sam (a pseudonym). It was conducted over a 10-week science methods course during the second year of a four year Bachelor of Education (Early Childhood) degree at an Australian university. Weekly workshops during the course aimed to develop students' pedagogical content knowledge through active scientific inquiry. The first author was the tutor in the workshops, and the primary researcher in the data collection, analysis and interpretation. The science learning experiences within the workshops were characterised by participation through an engage, explore and explain model; placement within an authentic early childhood context; discussion of children's views of science; and learning within a social constructivist environment.

Semi-structured interviews were held after each weekly workshop. In these interviews Sam was asked to identify and describe a critical incident during the workshop that influenced her with regard to learning science or science teaching. Such critical incidents could relate to science content, pedagogy, epistemology, learning environment, teacher educator, or a combination of these. The influence of the incident could be positive or negative.

Short narrative vignettes were constructed from these interviews, by the researcher, each containing the critical incident identified by Sam. Each vignette was written in the voice of Sam, reflecting her language and her construction of reality. In constructing these vignettes, the researcher tried to recreate Sam's lived experiences for others to read, while also trying to be part of Sam's reality. This process gave rise to the term dual vision.

Once the vignette was considered representative of Sam's critical incident, the researcher interpreted the vignette from the perspective of Sam's growth as a science learner and teacher. The checking of the vignettes for authenticity and interpretation was achieved through cycles of reflection (Wallace & Louden, 2000) by both Sam and the researcher. This iterative process allowed Sam to become a silent author in this research; to take some ownership of the process; and assist in the construction and interpretation of thevignettes (Kvale, 1996).

Findings

Seven vignettes covering eight workshops were constructed to describe Sam's science learning experiences across the semester. Her critical incidents were centered on pedagogy, nature of science, and the learning environment, and covered both positive and negative events. The vignettes reflected Sam's immersion into science, which helped her to see science through the eyes of a child, and showed her how to teach science to young children. This immersion, which provided time and opportunity to connect with science, helped to increase Sam's confidence towards science and science teaching. The vignettes highlighted Sam's new perceptions that science can be simple, play-based, hands-on, fun and involve cooperative learning. These new views of science provided an avenue for Sam to access science. The vignettes also revealed Sam's commitment to connecting the children with science to assist them in developing positive attitudes towards science.

Sam was off-task in one workshop, which was reflected in a corresponding negative critical incident vignette. This vignette produced deeper and richer reflections than the other positive vignettes. When confronted with her own negative behavior in the workshop, Sam readily explained why it happened. She then related this incident to her future science teaching and learning, discussing various strategies for identifying children when they are off-task, and employing appropriate engaging activities to keep children on-task. This illustrated the potential of the dual vision process to turn a negative experience into a positive one, through encouraging deeper reflection.

Based on this pilot trial, various assertions can be made about the advantages of the method. Dual vision provided a useful tool for describing how Sam came to understand science and science teaching. The critical incident vignettes highlighted personal, concrete and contextually specific aspects of Sam's science learning experiences. Taken over one semester, the vignettes provided a detailed analysis of the learning process, and enhanced the interpretation of the case study. Dual vision provided a unique opportunity to be part of Sam's lived experiences, and to observe, describe and interpret these experiences from her perspective. The process encouraged deeper levels of interpretation, due to the collaborative inquiry approach between Sam and the researcher. Further, as the researcher was an integral part of the learning environment, both context and interpretation were easier than having to rely on third party reports. Dual vision provided a means of quickly gathering rich, qualitative data that could be supported by detailed audit trails.

As with all research methods, dual vision has its limitations. The critical incident vignettes were constructed with a particular purpose in mind, reflecting the experiences of both Sam and the first author. Any meaning that was created from these experiences is based on the preconceptions, interests and research frames of Sam and the researcher (Wallace & Louden, 2000). While this information provided a unique detailed description and interpretation of one science learning journey, it cannot be considered a complete record of that journey. Similarly, other pre-service teachers will have different critical incidents from the same learning experiences, and therefore different stories to describe their science learning journeys.

The dual vision process provided a valuable tool for capturing, describing and interpreting the science learning experiences of pre-service primary teachers. This process allowed the researcher an opportunity to move into the reality of the pre-service teacher; the voice of the pre-service teacher and researcher to be heard; and a greater awareness of how pre-service teachers come to understand science and science teaching.

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EXPLAINING AND SUSTAINABILITY: EXPLORING IMPLICATIONS FOR EDUCATION AND BEYOND

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Abstract: This presentation will explore how current concepts of explanation implicate the possibility for generating explanations in science classrooms. Drawing from complexity-science based views of cognition-enactivism, I investigate how context-based, evolutionary views of explanation can inform the distinction between genesis of explanations and their validation in classrooms. More significantly, I will examine the implications for the current argumentative move in science education. I contend that argumentation, without attention to an enactive view of justification does not necessarily promote critical sustained learning in science. Although, focused at the secondary level, the issues presented are pertinent to science educators at most levels.

Objectives

Explaining has been considered as one of the most important, if not the central ways of getting to truth in science (Popper, 1983; Kitcher & Salmon, 1989). However, most philosophical exploration of scientific explanation separate the process of explaining—coming to the explanation—from the explanation itself. This assumption is manifest in science classrooms by attempts to produce explanations in line with contemporary scientific thought. Steinle (2006) proposes that this separation may be understood as a consequence of the distinction between contexts of discovery from those of justification.

In this paper I argue that the parallel between sustainability and explaining are both underwritten by this divisive discourse of process as distinct from product. Through comparing the process-product distinction, by considering the split between the genesis of knowledge and its justification, I propose how conversations on sustainability stand to gain from an enactivist view (Varela, Thompson & Rosch, 2001) that brings together knowing, doing and being. I will propose that issues of sustainability apply to our ability to consider how we know as much as to what we do in ways significant to the world system.

Significance

Choudhury and Korvin (2002) propose that conversations around sustainability, for the most part, are conducted in utilitarian, economic terms. They argue that separating the interactive elaboration that occurs in both, human systems and the physical world system (indicative of learning in both) render the concept of sustainability only to be relevant in the application of the knowledge produced in human systems and does not allow the implications of the dynamic of human-in-world as a learning system to be significantly productive to the discourse of sustainability. By locating humans back in an enacted world system, the question of sustainability is recast in much broader terms, allowing the feedback between knowledge producing human systems and the evolving environmental physical world system to become apparent without ceding to the assumption that the effect of knowledge production on the physical environment is secondary.

More specifically, explanations of phenomena as knowledge products, especially in scientific realms, are considered truth-heavy and therefore are not complicit in issues of sustainability. This position is underscored in science classrooms where students are introduced to currently accepted theories of science without emphasis on how the dynamic justification that takes place in the community fixes and allow such explanations to influence possible trajectories of action that become viable to the community. Further, although the sociology of science and the philosophy of science have been fields of research that have rather exclusively focused on genetic (descriptive) and justification (logical) processes respectively, adopting a more expansive view of enactivism allows both types of reconstructions to be understood as working simultaneously in the production of many consequences including the production of accepted knowledge that may be significant to issues of sustainability.

In addition, approaching the process of explaining in school science classrooms in this way, students may be invited to understand how their actions at any time are integral to the evolution of their own knowledge. In doing so they are encouraged to view any action of theirs as having a consequence, in knowledge producing contexts by virtue of impact on future possibilities to act (Osberg, 2004) and therefore the sustainability of the world system.

Theory

From an interpretation of cognition rooted in complexity science thinking, enactivism re-conceptualizes explanation as cutting across individual, social and physical dimensions of knowing, nested in increasingly elaborated organic systems (Maturana & Varela, 1987, Davis, Sumara & Luce-Kapler, 2000; Thompson, Varela & Rosch, 2001). It acknowledges that explanations emerge in the interactions of teachers and students (Coleman, 1998; Davis & Simmt, 2003; Meyer & Woodruff, 1997), constrained by the brute physicality of evidence (Maturana, 2000). Aspects of the physical world are imbued with meaning and brought forth as objects in language. The cognitive approach to understanding explanation as an epistemic consequence of the actions of some group of people highlights the implications of truth-making for sustainability.

Explaining when considered in action (Gordon-Calvert, 2001), is one that pays attention to the way in which a learning community defines itself. The explanations that emerge are a feature of the evolving knowledge system. It is in the moment-to-moment interactions, of the significances that are brought forth, that explanations arise, both as representation and in-action. An action oriented view of explanation brings together the genesis, justification as well as the application of knowledge with the anticipation that something changes in the moments that follow because of the preceding action. In the complex web of explanation-in-action (including expressed language) we start to see that individual actions impact collective ones, which in turn affect the environmental ones, each across different timescales, and therefore helps re-envision the question of sustainability in terms of the dynamic of the impacted system. Further, it emphasizes the dynamic boundaries of play (Gordon Calvert, 2001) as a function of the unceasing explanatory action that brings together the accepted criterion in the field on inquiry with contextual considerations in a constrained yet enabled way.

Design and procedure

The research design was an interpretive case study (Merriam, 1998) that was conducted in two Grade Eight physics classrooms over a one month period as the students were introduced to magnetism and electrostatics. The classroom interactions were observed, focusing on small groups in practical sessions. These observations were video and audio-taped and used for post-observation focus group conversations as well as for data analysis.

Data was transcribed and analyzed paying particular attention to the emerging explanations. The animate shape of the web of explanation-in-action was analyzed as it morphed, allowing certain interactions to be strengthened through maintained viability of those interactions in ensuing actions while other possibilities were surrendered consequence to time-sensitive, instantaneous, contextual constraints. The themes addressed in the findings emerged from the data in context of significant literature.

Findings

In this study, the development of explanations was significantly constrained and enabled by the moment-to-moment emergence of significance in community. Students drew on each others' and the teachers' actions and utterances, as well as the physical environment as energy rich sources that helped them collectively articulate why charged objects were being deflected. Significant ideas proposed by some members did not get incorporated into the emerging explanation until the evolving idea could sustain it. The ability draw on triggers was functionally dependent on their ability to remember these prompts.

Teacher interaction for the most part remained a constraining element. To a large extent, the interaction structure maintained by the teacher was authoritative (Lemke, 2000; Scott, Mortimer & Aquiar, 2006) and in line with cultural predispositions to teaching. Students however, used their mother tongue (Dhivehi) as opposed to the mandated language of learning and teaching (English) to sustain their own meaning making processes even as the dominant classroom discourse occurred. While the students were doubly disenfranchised by the language of instruction and the teacher interaction structure, they were able to use these structures to maintain interactions between themselves, alienating the teacher at times in the interest of supporting their own explaining.

The results indicate that students enacted modes of explanation in action that sustained their ability to continue to explain. While the teachers' outcomes were met on the surface, it was evident that students were adept players in the game of doing-the-lesson (Jiménez-Aleixandre et al, 2000). They also suggest that students manipulated the dynamic criterion of validation for constructing scientific explanations in classrooms, drawing on perceptual cues that were available. One implication of this study is that teachers may be able to build on students' sensibility of explanations as a function of the dynamic criteria of justification to empower student learning by engendering an attitude to meta-cognitive preparedness. Students may then be encouraged to leave cues for themselves as indicators of the dynamic boundaries of play so that they may be able to pay attention to how and why they ended up with certain explanations. In doing so students can be prompted to think of sustainability as being attentive to possibilities that may arise before they do, both in their learning and in terms of the world system.

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REFLECTIONS OF AN INDUSTRY – SCHOOL PARTNERSHIP UPON A TRADITIONAL SCIENCE EXPERIMENT.

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Abstract: In a world where the brightest minds aspire to medicine, law and electronic commerce, the commercialisation of students becomes increasingly important. Students with a traditional leaning for the classic sciences have been tantalised and seduced by the digital world. The classic sciences have traditionally built esteem with technical jargon, complex symbols and increasingly difficult university courses. Unfortunately students perceive classic science to be boring and not relevant to their world. Yet science itself is not complicated, boring or even square. It primarily is about observation and logical deduction. In essence, it is detective work and should be fun. So how can we reconnect these students? To this end, a partnership between industry and community school enabled a group of Year 9 students to participate in a real life sustainability based science experiment.

Objectives

Traditional science education appears to have lost a connection with the modern digital generation. Participation in classical sciences and mathematics in universities is widely reported in decline and there have been notable Universities closing their science departments. The question is, has the battle has been lost in our schools? Rennie et al (2001) stated "When students move to high school, many experience disappointment, because the science they are taught was neither relevant nor engaging and does not connect with their interests or experiences." It appears the classic sciences have been left behind in a world where students have been attracted to more commercialised and populist areas of science, such as forensics.

The purpose of this paper is to report and reflect on the effectiveness of a community school and industry partnership to enhance and motivate middle high school student interest in science. The students participated in a rich task that required them to research, design, conduct and evaluate an investigation with a sustainability theme. Student skills and attitudes were evaluated before participation, and then again after to see if their experience had any influence or effect on their cognitive, and more importantly on their affective perceptions on the relevance of science skills to their world.

Significance

The relative decrease of student numbers studying science in our schools is a worrying trend. What is needed is an integrated approach where scientific principles are used within a holistic approach to science education. There needs to be a reconnection to the use of science for solving everyday problems, to bring back logical deduction and evaluation. The collaboration of industry and the school is a valuable opportunity to reap the best of both worlds. The resources and support of industry combined with the educational facilitation of the teacher have the potential to bring real life opportunities and issues to students they could not otherwise access.

However not everyone wants to be a scientist. To engage and motivate as many students as possible, the rich task presented needs to appeal to those who may not have thought of science as being relevant to their own paradigm of the world.

Few issues appear to penetrate the mindset of the digital generation; however concern for the environment appears to be near universal. By presentation of a real world environmental problem and unpublished research into a potential solution, it is proposed that general science awareness could be raised back to a level of relevance and perhaps even fun. Through this approach, the application of the classical sciences, investigative skills and mathematics are 'discovered' and valued by the students.

Theory

It is believed that participation in real life problem solving will inspire students both into finding relevance for the scientific process within their lives, as well as opening many varied science based career paths.

This investigation is a truly 'Rich Task (2006)', where students show their understandings, knowledge and skills through performance on cross disciplinary activities that have an obvious connection to the wide world.

Students that have the opportunity to experience science at school in the form of rich tasks and science inquiry would then have the advantage of seeing science as a valuable means to solving real life problems, that impact on the community they live in. By cooperation with industry and government organisations, a community school has access to a host of potential resources ranging from provision of materials, through to access to equipment and more importantly highly motivated individuals.

Through such a partnership and the application of scientific process to a real life investigation, it was hoped that the "hands on approach" would penetrate the barriers to science of the digitally hardened.

Design and procedure

Within Western Australia, and specifically the Peel - Harvey estuary, traditional agriculture has relied upon the use of highly soluble fertiliser, upon some of the world's poorest soils. The sandy coastal soils of this region can effectively be considered a form of hydroponics. The result is massive nutrient pollution and associated algal blooms. Yet a simple solution could be at hand. Bauxite residue, a by-product of the alumina industry, has been used in conjunction with fertiliser in trials by the Department of Agriculture (Summers et al 2000). Results indicated that the combination of bauxite residue with fertiliser reduced leaching and increased plant yield.

A simple experiment was proposed. Do plant varieties (in this case, wheat cover for dust suppression) respond differently to this soil ameliorant? To answer this question, an

experimental design had to be put in place in collaboration with industry and with the assistance of the Department of Agriculture WA.
An interactive constructivist approach was used by the teacher to guide the students through their task. Problem solving exercises, statistics and reporting were all involved group discussion, consultation and trial and error.
The pre-experimental research was prepared by the students involved. After consultation with Alcoa rehabilitation experts, pot experiments were established with soil treated with fertiliser and soil wetting agent. Two levels of gypsum neutralised bauxite residue were added for soil amelioration, and a third set was left as the control. 10 plant samples from each group were harvested after 6 weeks, cleaned and dried for measurement of height and mass.

The theory, materials, experimental procedures and results were written up as a comprehensive report by the students. Discussions, conclusions and a series of recommendations were also prepared by group discussion. Their main findings included:

- Soil amelioration increased the mass of all varieties tested. Half the varieties tested also experienced increased plant height.
- The rate of use provided by Department of Agriculture WA was the most beneficial and appears to improve the early plant growth.

Findings
Establishing a partnership between industry, Government agencies and a community school required persistence and determination by those involved. An essential part of the process is to invest time to establishing relationships with those involved. While this partnership was established through student - parent – teacher relationships, other vehicles may be more applicable. Churach (2004) outlined a major step forward with a Centre for Sustainable Resource Processing educational program aimed at establishing ties between science teachers and industry (Particularly the minerals industry). It is hoped that such programs will aid partnerships.

From a teacher’s perspective, time constraints were the biggest obstacle. The first was in arranging the project. Co-ordination of school timetable, and industry needs was a significant difficulty. The need to be well prepared and to work well in advance is mandatory. Next years project is already being planned now.
Issues of working with industry are also a challenge, given the limited times the students are available to have visits. A new development is the requirement for criminal checks for working with children.

Of particular interest were the changing attitudes of the students. Did the real life experience reconnect science into their digitised world view? Anecdotally the answer is yes. An interesting observation was that the students quickly discovered real science is unlike science portrayed in TV. It involves commitment and perseverance, and is rewarded with the knowledge that part of a real problem has been solved.
All students in the group remarked the project was the most interesting science they had been involved in, and they had an increased awareness of how science is involved in solving real life problems. On the whole, attitudes became more positive towards the

process and the relevance of science was enhanced. However most importantly they had fun!

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HOW DOES THE SKILL OF OBSERVATION DEVELOP IN YOUNG CHILDREN?

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Abstract: This research paper is appropriate for teachers working in primary education and provides some answers to the following questions,
- What does the skill of observation look like in young children?
- How does the skill of observation influence other scientific skills?
- What pedagogical approaches support the development of the scientific skill of observation?

Preliminary analysis of the data indicates similar social and cognitive interactions in the different age groups, although at different levels of sophistication.

Objectives

The research aims to answer the following questions:

- What does the skill of observation look like in young children?
- How does the skill of observation influence other scientific skills?
- What pedagogical approaches support the development of the scientific skill of observation?

Significance

Young children's emergent science is very much misunderstood and yet it is a vital foundation for later scientific development. The scientific process is comprised of a number of very important skills. All of these skills are utilized in other areas of life and the curriculum, but together they form a unique process which is important to develop in young children if they are to progress in science, as skills support conceptual understanding. The skill of observation is arguably the most important skill in science and in the early years, leading to other process skills. However, there appears to be little understanding of what the skill of observation looks like in young children and how the skill of observation develops in young children.

Theory

Observation is an important initial skill in science, helping to recall details of an investigation and aiding problem-solving (Grambo, 1994) and is evident in very young children (Johnston, 2005). However, there is not common understanding of how it develops. One view is that as children develop, they begin to focus their observations, 'filtering out' those that are unimportant to the investigation they are engaged in (Harlen & Symington, 1985). This can give the impression that their skill is declining, although it may be more sophisticated (see Strauss, 1981) and be influenced by theories from teaching and their own expectations. Observation as a theory-dependant process is not a new idea (Hanson, 1956) and is evidenced by research into children's conceptual understanding (Driver, 1983), which indicates that intuitive observations have been replaced by *'instrument and theory-driven observations and the development of scientific explanations'* (Duschl, 2000: 191). Other research into children's ideas about astronomy (Kameza & Konstantinos, 2006) and features of plants, during a visit to a garden (Johnson & Tunnicliffe, 2000) indicate that it is not direct observation that leads to conceptual development, but metacognition and social construction (Shayer & Adey, 2002), influenced by previous ideas (Tompkins & Tunnicliffe, 2001). However, this is not always seen in practice in very young children and it is not necessarily the scientific theory but the child's intuitive theory that prevails (Johnston, 2005).

There is agreement (Harlen, 2000; Johnston, 2005; de Bóo, 2006) that the development of good observational skills need to be supported by focused and structured teaching, in order to develop thinking and linguistic skills (de Bóo, 2006) and creative thinking (Johnston, 2005a). Pedagogical factors affecting the quality of observational development are similar throughout early years and primary education (Harlen, 2000; Johnston, 2005) and include,

- time to observe and discuss observations, including the creation of conceptual conflicts (Hand, 1988), through debate and argument (Naylor et. al., 2004);
- the careful use of observational aids (as they can detract from the observations);
- encouragement and support from teachers, including questioning (Vygotsky, 1978);
- focus on patterns, sequences of events and interpretations;
- recording observations. Indeed, rapid sketching of detail has been found (Grambo, 1994) to improve observational skills by focusing on important features which are then remembered.

Without support children are likely to move from their limited unsophisticated creative and imaginative general observations (Dale Tunnicliffe & Litson, 2002) to unsophisticated particular observations, rather than improve their skills in both types of observation. Whilst young children can make very sophisticated and detailed observations, they can get distracted easily and may need support to refocus (Keogh & Naylor, 2003).

Like other process skills, observation is best developed through structured experience recognized in learning models in science, for example, Renner's (1982) 'experiences' provided by the teacher, Karplus's (1977) 'exploration' with minimal guidance, Erikson's (1979) 'experimental manoeuvres', Cosgrove and Osborne's (1985) 'generative learning' and a constructivist approach (Scott, 1987), popular in primary science education. It is likely that the introduction of structured primary strategies (DfEE, 1998 & 1999) and changes in primary practice have affected pedagogical practice (Cullingford, 1996) which has reduced the practical component of much science teaching (ASE, 1999) will have an adverse effect on observational as well as other scientific development.

Design and Procedure
The sample involved seven groups of children aged between 4 and 11 years of age.

Group	Number of Children	Age of Children

1. (Reception)	6 2	4 years 5 years
2. (Year 1)	8	5 years
3. (Year 2)	8	6 years
4. (Year 3)	6 2	7 years 8 years
5. (Year 4)	7 1	8 years 9 years
6. (Year 5)	8	9 years
7. (Year 6)	5 3	10 years 11 years

The children began by playing with a collection of small toys, including electrical, magnetic, wind-up, push and spinning toys for about 5 minutes. They were then asked to pick a toy and tell the group about it (what they noticed about it, how it worked). A few toys were also picked out for the children to observe and explain how they worked. Finally, the children were asked to sort the toys into groups.

Each group was videoed and the video tapes analysed in order to answer the research questions. Permission to use the children in the research was sought and although names of the children are used on the video, the school has not been acknowledged to maintain anonymity. Triangulation of analysis involved use other teacher and academic groups.

Findings

Preliminary analysis of the data indicates that initial observations were similar in all groups of children and included (in order of use),

- affective comments showing interest and motivation, such as *'Whee!', 'Cool!'* and *'Wicked!'*;
- functional comments on how the toys work, such as *'It's magnetic', It's jumping up'* and *'Listen it cheeps'*;
- social questions, such as, *'Can I look at this after you?'* ;
- exploratory questions such as, *'What do you do with these?'*.

This initial observation and exploration of the toys appeared to be a vital pre-requisite for all the children to motivate them, enable them to bring their previous knowledge to the observation and to share ideas within the group. During this period, there was no or little teacher interaction and no clear differences between the observational skills of the different groups of children.

In all cases, initial observation led to the use of other scientific process skills, such as classification, prediction, and some explanation (hypotheses and interpretations), dictated mainly by the type of activity and the teacher questioning. There was generally a greater sophistication in these skills with the age of the children and this appeared to be maily supported by the social interaction between the children but secondarily supported by teacher questioning. This social interaction was more sophisticated in the older groups than the younger ones and involved an increasing exchange of scientific ideas and scientific explanations. Although the teacher was asking questions at this stage in the activity, it appeared that the peer interaction was often a more important factor than the teacher/ child interaction, especially with older children.

The observations were followed by a teacher-led classification activity in which each group of children decided the classificatory groups and placed the toys within these. The youngest children chose mainly categoric criteria for classification, such as colour of the toy with the older groups choosing derived functional criteria, indicating what you had to do to the toy (push or pull) or what it did (spin, jump) and older children used more derived scientific criteria, explaining the scientific explanation for how the toy worked, (magnetic, electrical, air). There was a general increase in sophistication of classification, although the most complex classification, with interrelated groups was seen in the Year 2 group (6 year olds). During this stage of the activity, teacher questioning was the main factor supporting the classification with peer interaction a secondary factor.

It appears that a combination of individual, peer and teacher interaction is important in supporting the development of both observational and other scientific skills, although the nature and amount of this interaction is individual to different groups of children and cannot be predicted.

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PRE-SERVICE TEACHERS' ENVIRONMENTAL VALUES: AN INDICATOR FOR CURICULLUM REFORM TO ADDRESS EDUCATION FOR SUSTAINABLE DEVELOPMENT.

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Abstract: The years 2005-2014 have been declared the United Nations Decade of Education for Sustainable Development (the UNDESD). Education is seen as an essential tool for achieving sustainable development. One approach that could be adopted to attain this goal is through greening the chemistry curriculum with implementing green chemistry. This paper will present the findings from a survey aimed at assessing pre service teachers' environmental values as well as the concepts of green chemistry. An illustration on how green chemistry experiments can be integrated into chemistry curriculum will be provided.

Objectives

Environment and education are vital elements of life that can be utilized to enhance the quality of human existence on earth. The environment provides the space for man to interact with other people, infrastructures and the environment itself. Education is the process of teaching and learning through which values are imparted to the learners. Values are one of the most important considerations when trying to find solutions to environmental problems. Additionally, values central to the evolution of a suitable society not because they influence behaviour but also values form the base on how we live our lives.

In Malaysian Educational scenario environmental education is infused into conventional subjects. At the primary level EE is infused into subject such as 'Man and Environment' and 'Science and Local Studies'. In secondary level EE has been incorporated into all subjects taught with emphasis in Science and Geography. Furthermore, EE is also infused through co-curricular activities. Did these efforts by Ministry of Education succeed in establishing environmental values central to sustainable development among Malaysian students? This study was carried out to determine the environmental values of pre-service teachers who were engaged with chemistry teaching method course. Alternative approach of integrating EE by greening the existing chemistry curriculum to address EfSD will also be introduced. As such this study proposed to answer following research question: 1. Does the existing curriculum able to inspire environmental values that could derive behaviour change of the students? 2. How does the finding of this study relate to the curriculum development to address sustainability? 3. As an educator how do we give them the optimism and ability to imagine a better world and skills to at least imagine possible strategies to achieve that world?

Significance

Bonnoto (2006) stressed that values cannot be taught and learned in the same way as we learn and teach knowledge and abilities. Zoller (1996) argued that for the education to impart values it must enhance critical thinking ability, problem solving skills and the students should be empowered to choose and appreciate the environmental issue by value-driven learning. Anatas (2000) reported green chemistry experiments can be used as tool to enhance high quality education, it develops higher thinking skills capability such question-asking, critical thinking, decision making and problem solving. The aims of green chemistry experiments are to prevent pollution. Therefore it provides opportunities to reflect upon the effects of chemicals to the environment and health compared to the conventional way of conducting experiments. These experiments also provide a unique opportunity to highlight ethical considerations that may be encountered when addressing complex problems. Moreover green chemistry laboratory provides a platform for both teachers and students to discuss environmental issues. Through teaching sustainable chemistry, students could attain values, skills, behaviour and knowledge needed to meet the needs of the present without compromising the ability of future generations to meet their own needs. With the proclamation of the Decade of Education for Sustainable Development, it is perhaps the right time to integrate the green chemistry concept into chemistry curriculum. The significance of this research is that it will inform the teacher educators, policy-makers and curriculum develops the status of environmental values among pre-service that will ultimately call for educational reform in term pedagogical change and curriculum change. This study will also provide useful information about green chemistry as an alternative approach to facilitate an integrative and interdisciplinary learning experience.

Theory

Values influence behaviour that directly and indirectly impacts the environment (Stern, 2000a). Theory of reasoned action proposed by Ajzen and Fishbein (1980) indicates knowledge and values influence the behaviour. Therefore, the education provided must deliver appropriate knowledge and values in order to attain a particular behavioural change.

Values are the key factor in decision-making. Therefore, by focusing on values other barriers will come down in time. Right now human possesses culture that has a dominant value system of human superiority and mastery over nature (Leopold 1996). On the road to sustainability this must be change to value systems of human in harmony with nature (Oskamp, 2000). Merchant (1992) categorised environmental values as egocentric (less environment), homocentric and ecocentric (more environment). Theory of value change suggested by Rescher (1982) states that value change can be triggered through redeployment, rescaling of existing values or due to causal factors such information or ideological change. Accordingly, Palmer (1993) points out that some researchers' feel one of the biggest periods of value change occurs during the higher education process, when young people are exposed to many different experiences, new viewpoints and new information. This research suggesting by introducing green chemistry experiments as laboratory based pedagogy the values possessed by the pre-service teachers could transform from egocentric (less environment) to egocentric (more environment).

This research was set in a theoretical content based on the work of Ajzen and Fishbein (1980), Rescher (1982) and Palmer (1993). The research evaluates the environmental values of pre-service teachers and suggesting that values which ultimately influence the behaviour can be changed with implementation of appropriate pedagogy and curriculum such as green chemistry experiments.

Egocentric values tend to revolve around concern for personal well-being. Concern about how the environment will affect a person individually is an example of this type of value; for example, saying, "care about the environment because I don't want to breath polluted air" is an example of an egocentric value. People holding these values may be more concerned with pursuing an economically advantageous course of action in order to maximize personal success (Axelrod, 1994). They may also deny that humans have a negative effect on the environment (Stern, 2000a). Homocentric values revolve around concern for other human beings. For someone with these values, concern for the environment would be based on the costs or benefits for all people; some may be centered on economic benefit, human pleasure, human health and security, or other such utilitarian type values. People holding these values are more concerned about human society as a whole and may pursue a course of action which satisfies the needs of the maximum amount of people, whether it is the most environmentally friendly course of action or not (Axelrod, 1994). Ecocentric values revolve around concern for the whole ecosystem or biosphere. People who hold these values believe that the environment should be protected due to its intrinsic worth; it has value independent of its usefulness to humans. They place a high value on the earth and judge actions according to their effects on the biosphere (Kempton, Boster and Hartley, 1995). People holding these values will be most likely to pursue a course of action which protects the environment, even if it involves personal sacrifice (Axelrod, 1994).

Design and Procedure

The sample consisted of sixty pre-service teachers from Teacher Training Institute at Northern Region of Malaysia. These pre-service teachers were enrolled in Chemistry Teaching Method course. At the time of the research the pre-service teachers were at second year of four years Teacher Education Programme. The subjects were given a set of questionnaire to evaluate their environmental values prior to a lecture session on education for sustainable development. The subjects were given one hour and thirty minutes to complete the questionnaire. The questionnaire used in this research is the revised version of questionnaire on environmental values by Kempton, Boster and Hartley (1995). The scale used in this questionnaire is a six point Likert-type scale, which asks respondents to choose whether they strongly agreed, agreed, slightly agreed, disagreed, slightly disagreed or strongly disagreed with the statement. By not providing a neutral middle choice, respondents were forced to decide whether they agreed or disagreed with the items. Responses were coded so that numbers represent the answers as follows: 1 = strongly agree; 2 = agree; 3 = slightly agree; 4 = slightly disagree; 5 = disagree; 6 = strongly disagree. For example, for the statement, Species of plants and animals have intrinsic aesthetic and spiritual value, even if they are not of any use to humans, an answer of 2 means that the respondent agrees with this statement. If the mean response of the class for this statement is 2.4 that mean the average answer is somewhere between agree and slightly agree. A lower score on the post test means that their answer has become more environmental. For example, an answer of strongly agree, or 1 (a lower score), indicates a more environmental answer.

Questions that were reverse coded were represented as follows: 1 = strongly disagree; 2 = disagree; 3 = slightly disagree; 4 = slightly agree; 5 = agree; 6 = strongly agree. For example, for the statement, Global climate change has been blown out of proportion, an answer of 3 means that the respondent slightly agrees with the statement. If the mean response is 3.4 that means the average answer is somewhere between slightly disagree and slightly agree. A lower score on the post test again means that their answer has become more environmental. For example, if the answer becomes 1 (a lower score), that means they strongly disagree with the statement, which is a more environmental answer. The questionnaire employed in this research contains 37 items from egocentric, homocentric and ecocentric category. Question 1-11 evaluates the egocentric value, question 12-26 evaluates homocentric values and question 27-37 evaluates ecocentric values.

Findings

The overall mean value for the questionnaire is 2.71, mean value for egocentric is 2.50, mean value for homocentric is 2.57 and mean value for ecocentric is 2.60. Basically, the students appeared to show high level of environmental values. This could be due to the existence of curriculum which has the EE infused in it. The students were taught about the environment and the environmental problems through out their primary and secondary schooling. The role played by media to inform citizens the importance of conserving the environment also could lead to high level of environmental value formation. But then, the findings showed that the values seemed to be less ecocentric and more off egocentric and homocentric. Apparently, students with this kind of values would commit any economic activities that will benefit themselves and would satisfy the needs of the society. As the environmental impact from these activities is not immediate, the impact is taken for granted. This impact will be experienced by the future generations. Additionally, the high level of egocentric values among the pre service teachers could be due to the EE which was infused into the curriculum was not effectively imparted to them. The method used to deliver EE failed to derive the value which finally will enhance behavior change. The dominance of reproductive role of curriculum over constructing civil society could be another reason for this phenomenon. Whereby, reproductive curriculum was developed to serve the economic needs of the country. This has resulted in education systems which privilege literacy, mathematics and abstract science, teacher-centered processes of teaching and learning and competitive assessment that favors the social differentiation. The findings from this study suggest for a review of the curriculum and pedagogy used and the need to integrate instruction that would enhance the development of ecocentric values. One approach that could facilitate the formation of ecocentric values is through laboratory based pedagogy involving green chemistry experiments.

Green chemistry experiments can be used as a tool to enhance high quality education. Green chemistry experiments have been found to enhance students' high order cognitive learning skill such as question asking, critical thinking, decision-making and problem solving. The aims of green chemistry experiments are to prevent pollution. Therefore it provides opportunities to reflect on the effects of the chemicals to the environment and health compared to the conventional way of conducting the experiments. Moreover, green chemistry laboratory provides a platform for both students and teachers to discuss environmental issues. Haack, (2005) suggested the interdisciplinary nature of green chemistry and its important role in pollution prevention provide educators with a variety of opportunities to incorporate green chemistry principles throughout the curriculum. In addition, educators and students at all levels will feel empowered to explore the connections between green chemistry and local environment.

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HOW TO COUNTERACT DISTORTING EFFECTS OF THE INSTRUCTIONAL LANGUAGE ON SCIENCE EDUCATION IN NON-WESTERN NATION-SATES

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Abstract: Significance of metalanguage in science education is discussed from the viewpoint of non-Western nation-states, which prize respective national languages and science education simultaneously. Because metalanguage conveys the same meanings irrespective of a language expressing the metalanguage, an issue of choosing an instructional language becomes less significant on the following condition: science educators always draw pupils' attention to differences between the scientific and pupils' indigenous worldviews. Then, pupils will be able to develop correct understandings of science and to foster their sound national identity. In this perspective, the Malaysia challenge in science education is briefly discussed.

Addressing the problem

This paper proposes an application of metalanguage in order to counteract distorting effects on science education, especially the teaching of Western modern science; in the following, the term "Western modern science" is abbreviated to "W-science." The problem of distorting effects arises when science education is conducted by means of a non-SAE language[1)]. Having a responsibility to conduct science education regardless of their own cultural traditions, non-Western nation-states encounter the problem the present paper addresses. There, people cannot identify themselves with the legitimate successor to the Greco-Roman civilization, the cradle of W-science, which entails thinking about the world in the Greek way (Burnet, 1975, v).

As a rule, the formation of nation-states, into which nationalism "acts to organize all peoples" (Kohn, 1973), gave rise to science education as a social phenomenon. Each nation-state highly prizes its national language, and regards science education as vital at the same time.

> [Thus] nationalism is closely linked ……, with the introduction of modern science and technology in the service of the nation, with the exaltation of the national language and traditions above the formerly frequent use of universal languages (in Europe Latin and later French) and universal traditions (Christianity and Islam). (Kohn, 1973)

In the foregoing, "modern science" should be replaced by "W-science" according to the present context. As pointed out here, many non-Western nation-states deliver science education through the medium of their respective national languages. In doing so, these science educators implicitly accept the supposed universality of W-science, and also usually accept the following language setting for science education: W-science is taught by means of non-SAE languages. This leads these science educators to the supposition that science education is independent of the instructional language.

Language and worldview

However, science education depends primarily on the instructional language, because a language inevitably entails a worldview innate in the language (Whorf, 1959; Suzuki, 1993). In other words, using a specific language is accepting the worldview entailed by the language. Taking this into consideration, Kawasaki (1996; 2002) has revealed that science education in Japan is under the influence of the Japanese worldview entailed by the Japanese language as the instructional language. For example, the Japanese term "shizen" is supposed to be the Japanese counterpart of "nature" in science education in Japan; however, this Japanese term usually refers to the supernatural in the Japanese language. Therefore, whenever science teachers utter "shizen," pupils recollect the supernatural even in the science classroom. Such conceptual confusions cause distorting effects owing to linguistic incommensurability. To put it strongly, in the Japanese science classroom the Japanese worldview is described in terms of W-science.

Thus, the linguistic incommensurability between W-science as an SAE language and the Japanese language introduces confusion about W-scientific concepts in pupils' minds: the distorting effects caused by the instructional language. In order to draw science educators' attention to the distorting effects, Kawasaki (2002) proposed the notion "linguistic mode of science education," for example, the Japanese language mode of science education. This notion illuminates differences between an SAE language mode of science education and a non-SAE language mode. Drawing a distinction between these modes of science education is based on differences between the worldviews concerned.

The axiomatics model of science education

A paradigm, which shows how linguistic modes of science education can be produced, is definitely necessary for comparative studies of language modes of science education. The paradigm and linguistic modes form a genus-species relationship, which makes it possible for science educators to carry out comparative studies. The axiomatics model of science education (Kawasaki, 2006) works as the paradigm, and distinguishes among the axiom, the postulate and the theorem stages of cognition in the same way as in geometry.

At the axiom stage, a system of axioms is established. Each axiom has indefinable terms and logical terms that form a relationship between the indefinable terms. Every indefinable term has nil intension and unlimited extension. A possible axiomatics model of science education is:

[SCIENCE] is a system of [KNOWLEDGE] about [NATURE] (A1)
[SCIENCE EDUCATION] is a system of teaching [SCIENCE]. (A2)

In the foregoing, indefinable terms are expressed in capital letters and put into square brackets. Sharing the indefinable term [SCIENCE], the axioms (A1) and (A2) form an axiom system. The extension of [SCIENCE], for example, encompasses not only W-science but all indigenous knowledge systems about [NATURE]; the indefinable term [NATURE] expresses the world as such, the world that is not yet interpreted by any language. The other indefinable terms should be understood similarly (see Kawasaki, 2006 for details).

At the postulate stage, an innate worldview is unwittingly chosen according to the instructional language. In accordance with the worldview, the language mode of science education is born at the theorem stage. For instance, the Japanese mode of science education is a result of the combination of the axioms and the traditional worldview inherent in the Japanese language. If the W-scientific worldview inherent in SAE-languages is combined with the axioms, such language modes of science education are free from distorting effects. The W-scientific worldview is commensurate with the worldviews pupils are expected to acquire in their communities.

Metalanguage in science education

An issue that needs to be discussed in non-SAE language modes of science education is how to counteract the distorting effects. The necessary condition is that science educators become aware of the distorting effects. By using the axiomatics model, science educators will draw their attention to the differences between the W-scientific worldview and the worldview pupils are expected to acquire in their non-SAE communities. In science educators' explanation of the differences, the language they use can be properly called metalanguage.

Usually, metalanguage is defined as: the expressions used for describing or referring to language. This definition needs revising according to the present context in which a language entails a worldview innate in the language. The revised definition is: metalanguage is an explanation of worldview. The present definition assures science educators that the instructional language as metalanguage can go beyond the worldview entailed by the instructional language as such.

Imagine a non-SAE language-culture community, where people share a non-SAE language entailing a worldview different from the W-scientific worldview. There, the non-SAE language is the instructional language, as in Japan. In this non-SAE language mode of science education, pupils are confronted with two worldviews different from each other: the W-scientific and the non-SAE worldviews. From science educators' viewpoint, they have to deal with these two worldviews by using the single instructional language, the non-SAE language. Consequently, science educators explain the W-scientific worldview by using the non-SAE language as a metalanguage. Thus, worldview education is non-SAE language modes of science education where science educators are always conscious of the differences in worldview (Kawasaki, 2006).

Science education as foreign language education

In worldview education, science educators have to understand the differences between these two worldviews in concrete ways, as Kawasaki (2002) showed in the Japanese language mode of science education. Worldview education is entirely based on metalanguage expressed by the non-SAE language. This linguistic situation science educators encounter is essentially similar to what happens to foreign language educators, because both types of educators have to cope with two worldviews (or value systems) contradictory to each other. Clearly, foreign language educators use metalanguage when they explain the foreign language grammar in pupils' first language.

However, there is a dissimilarity between the two types of education. In foreign language education, pupils are always conscious that they are confronted with the two languages, worldviews or value systems. They do not lose consciousness of their dealing with the two languages. Their consciousness prevents them from conceptual confusion. Furthermore, only those pupils who learn a foreign language can realize their first language: *Those who know nothing of foreign languages know nothing of their own*. This maxim is attributed to Goethe as is well-known.

By contrast, as a result of the supposed universality of W-science, science educators do not realize that they have to deal with two worldviews. This is an essential reason why science educators encourage pupils to replace their worldview by the W-scientific worldview. It should be emphasized that these science educators undermine non-Western nation-states by means of science education. However, worldview education will make it possible for pupils to develop correct understandings of W-science <u>and</u> to foster their sound national identity at the same time, because of their willing to pay attention to worldview differences. This must be supported by a paraphrase of the maxim above: *Those who know nothing of the W-scientific worldview know nothing of their own*. Thus, science education should be associated with foreign language education. Such science education is worldview education, where metalanguage plays a critical role. This is the way to counteract the distorting effects of the non-SAE instructional language.

The Malaysia challenge

In addition, it should be noticed that metalanguage conveys the same meanings whatever language is used for expressing the metalanguage. As a result, the issue concerning the instructional language becomes less significant in worldview education. This perspective can justify science education being delivered by means of an SAE language (e.g., the English language), even in a non-Western nation-sate. If the non-Western nation-state consists of plural language-culture communities, the merits of linguistic equity may lie in a science education delivered by means of the SAE language. In this sense, the Malaysia challenge to conduct science and mathematics education in the English language is justified if educators and their pupils have enough ability to handle the English language.

This linguistically challenging science education has the following two advantages, but only on condition that science educators always draw pupils' attention to the differences between the worldviews concerned. First, with the aid of the metalanguage given in the science classroom, pupils will be able to readily distinguish the W-scientific worldview from the worldviews inherent in their respective communities. Then, being able to make this distinction between worldviews will protect pupils from conceptual confusion about W-scientific concepts, and will make it possible for them to foster the sound national identity they are expected to establish.

Second, using the English language liberates pupils from conceptual confusion about W-scientific concepts because the English language entails a worldview commensurate with the W-scientific worldview. In successful worldview education, science educators will never encourage pupils to replace their inherent worldviews by the W-scientific one, because science educators naturally have a relativistic view of W-science. Hence, the Malaysia challenge in science education provides a constructive perspective in the field of science education research in a non-Western nation-state consisting of multi-cultural communities.

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Notes

1) "SAE" is an abbreviation for "Standard Average European" coined by Whorf (1959), a US linguist. English, German, French are examples of "SAE." The notion "SAE" divides the world into two: Western and non-Western nation states.

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TOPICS OF INTEREST TO STUDENTS AND TEACHERS OF BIOTECHNOLOGY EDUCATION

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Abstract: This research highlights the differences between biotechnology interests of Year 11 Biology students and their teachers. 500 students and 15 teachers were surveyed and a sample interviewed. This paper will explore the findings of a six scale survey, and interviews. The findings indicate that students and teachers are not interested in the same topics. For example, students want to learn about cloning, and conduct DNA extraction activities, however teachers do not want to teach cloning, nor do they want to conduct DNA extraction practicals. In some cases, teachers agree to teach certain topics "on paper" but in reality, do not teach them at all.

Objectives

Biotechnology is increasingly playing a role in the daily lives of citizens and so of foremost importance is public participation in this new technology. This participation cannot occur without a sound and comprehensive biotechnology education. If people are not educated in issues of science and technology, they cannot have a meaningful participation in the public debates concerning these issues. A biotechnology education requires that students, and thus future citizens, are well informed so they are able to effectively engage in public debate. In a contemporary science education, foundation knowledge of biotechnology principals and the related ethical issues are essential for effective engagement in public debate concerning biotechnology. The teaching of biotechnology therefore must provide for a sound understanding of its scientific basis. In addition, there needs to be opportunities for students to develop critical thinking and decision-making skills regarding the ethical use of biotechnology. The purpose of the research presented in this paper was to investigate which biotechnology topics students would find interesting to learn about and which biotechnology topics teachers would be interested in teaching. In order to do this, students and teachers of Year 11 biology were surveyed and interviewed. The students' and teachers' biotechnology topics of interest for inclusion in biology lesions were investigated. More specifically the research questions were: 1) what biotechnology topics are of interest to Year 11 students of biology? 2) What biotechnology topics are of interest to Year 11 teachers of biology? And 3) what are the similarities and differences in teachers' and students' biotechnology topics are of interest?

Significance

The Australian government and private sector interests strongly support the concept of biotechnology education as biotechnology is regarded as a very important development for both scientific and economic progress. The national science framework also recognizes the need for science students to be made aware of biotechnology in the Australian science curriculum. Curriculum planners and educators are therefore encouraged to incorporate biotechnology into science curriculum; however the level of biotechnology education occurring in Australian schools is minimal and lags well behind the levels taught in both the United Kingdom and the United States of America.

The teaching of biotechnology within a science education presents teachers with many challenges. The vast volume of information rapidly being disseminated in biotechnology leads to a number of practical problems in teaching it to science students. Concern initially relates to teacher discipline knowledge, and how teachers will access new scientific knowledge. Following on from this, and assuming a discipline knowledge base from the teachers, the teachers are faced with questions about what knowledge is attainable by the students, and what ethical issues relating to biotechnology could be taught. Teachers need to address how these topics can be taught effectively. Biotechnology presents broader philosophical questions to the teacher and their students. Some aspects of biotechnology, for example, confront questions concerning the origin of life, and how life itself is defined.

Suggested biotechnology topics that could be taught in a general biology curriculum include: bioethics in biotechnology, biotechnology in agriculture, medicine, environmental science and industry, defining biotechnology, molecular biology of cancer, organismal biochemistry, microbiology, genetic engineering, human genetics and genomic library, molecular biology as a discipline, and DNA fingerprinting. However, teaching all of these topics is not practical. Planning can assist in deciding which topics could be included in the teaching of biotechnology. A mandate already exists in the Queensland biological science curriculum to allow teachers in Queensland to use their professional judgement in making decisions on what materials are taught in view of their specific student circumstances (Queensland Studies Authority, 2004). To date, no formal planning has occurred in relation to determining the particular attitudes and interests of the key stakeholders – the students and teachers. This study aims to determine the baseline information in relation to biotechnology interests of Queensland students and their teachers.

Theory

Shulman and Tamir (1973) placed the affective outcomes of a science education as equal to the cognitive outcomes. The affective domain of science has been a substantive feature of the science education community for the past 30-40 years (Osborne, Simon & Collins, 2003) and has been "characterised by a variety of constructs, such as attitudes, preferences, and interests" (Trumper, 2006, p. 32). A link has been shown to exist between attitude and interest: "Generally a negative attitude to a subject leads to a lack of interest …. Furthermore, a positive attitude to science leads to a positive commitment to science that influences lifelong interest and learning in Science" (Trumper, 2006, p.32). Osborne, Simon and Collins (2003) outline how attitudes towards science consist of a large number of sub constructs which include the value of science, motivation towards science, and the enjoyment of science. Each of these is linked to interest in science. Through an exploration of how a student expresses their preferences and feeling towards an object, Osborne, Simon and Collins give an example of how a person may be interested in science but avoid publicly demonstrating this interest amongst their peers as this "is not the done thing". Therefore there is a need to incorporate intention and behaviour into attitudinal and interest studies. Ajzen and Fishbein (1980) argued that behaviour is determined by intention, and intention is a shared outcome of attitude and a belief of how other people view that behaviour.

This research is grounded in that of Ajzen and Fishbein (1980) where the interests of students and teachers are explored. Teacher intention and behaviour in relation to biotechnology education is considered.

Design and procedure

A series of surveys (Biotechnology Education Learning/Biotechnology Education Teaching Survey - BELBETS) were used with 508 15-16 year old students of senior biological science and their 15 teachers from eight secondary schools scattered throughout Queensland, Australia. All Year 11 biology students and their teachers present on the days the surveys were administered completed the survey. Eight student surveys were discarded. Of these, six students did not complete the survey in any meaningful fashion (they answered 'Strongly Agree' or 'Strongly Disagree' to all statements or made no attempt to respond to any statement at all); whilst the remaining two students left major sections of many scales blank.

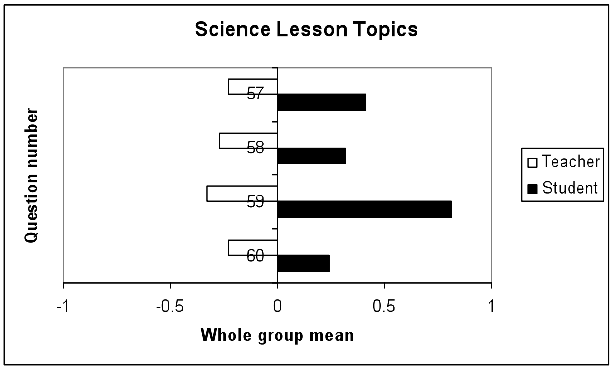
The administration of the BELBETS survey is continuing in Queensland schools; however this paper reports the initial findings of the 500 students and their 15 teachers. The surveys use a five point Likert scale (Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree) with items adapted from Dawson and Schibeci (2003) and Chen and Raffan (1999) and Biotechnology Online (2001). Additional items were created based upon general readings and Internet coverage. The student and teacher surveys vary slightly. The statements differ in that a student may read a statement written in the following way: *I would be interested in learning about cloning.* Whereas, a teacher would read the same statement as: *I would be interested in teaching about cloning.*

The results of the surveys were coded, and analysed using the Statistical Package for the Social *Sciences* (SPSS). To facilitate comparisons between the student and teacher responses a mean score was calculated for each item statement using responses of the whole group by scoring 'Strongly Agree' responses as 1.0, 'Agree' as 0.5, 'Neutral' as 0, 'Disagree' as -0.5 and 'Strongly Disagree' as -1.0. As the mean approaches a value of 1 it indicates affirmation of the statement, and as the whole group mean approaches -1 it indicates rejection of the statement (Skamp, Boyes & Stanisstreet, 2004). By plotting the 'Whole Group Mean' in a horizontal bar graph, a visual impression of the relationships between student and teacher responses is possible.

Interviews were held with 60 students and three teachers (from three geographically different schools) who had responded to the survey. The interviews were to establish reasons for which the students and teachers gave their particular responses.

Findings

The statistical analyses (Cronbach alpha, Pearson Chi-square) of the 70 survey statements allow the validation of six scales. One scale is presented in this synopsis; however additional scales are given in the full paper. To facilitate a comparison between student and teacher responses, it is convenient to compare the whole group mean. For example, student item 60 (teacher item 80) *(Human cloning and the issues associated with it should be discussed in science lessons)* shows the student whole group mean of 0.24 which indicates a moderate agreement with the statement. Compare this to the teacher whole group mean of -0.23 which indicates a moderate disagreement with the statement. Figure 1 clearly shows this difference graphically.



Note: As the mean approaches a value of 1 it indicates affirmation of the statement, and as the mean approaches -1 it indicates rejection of the statement.

Figure 1. Whole group mean scores for science lesson topics concerning biotechnology

The students indicate they are interested in discussions concerning human cloning, yet teachers are not so interested. This difference in interests is more apparent with the remaining statement items especially statement 59 (79) *(Birth control and the issues associated with it should be discussed in science lessons)*.

Interviews with the teachers provided another form of verification of the scales and survey. The interview comments align with the likert scale responses. As one teacher indicated in response to statement 57 (77) *(Bioethics education should be discussed in science lessons)*: “I don’t want to cover such things. There is a possibility that someone may be offended by another’s views, discussions could become a debate, and it is the English teacher’s job to do debates, not mine. They tell us we have to do it, we say no, then ‘Oh ok’, but then I don’t do it. I just say I did do it on paper to get the panel off my back.” (Mr H, School 2). Similar patterns can be found in the responses to statement 58 (78) relating to prenatal testing. The majority of teachers do not want to teach prenatal testing. As Mrs P (School 3) said:

> I don’t like the idea of a woman knowing her unborn child has a problem, and then her choosing a termination. What if the father didn’t want to terminate? We then have a problem. No, ethically I don’t like it. I don’t think the students should have to explore such things. It isn’t really relevant to them at the moment. Besides, it isn’t in our text book I don’t think.

An examination of the Whole Group Mean data in Figure 1 indicates that the students and teachers surveyed have very different ideas of what topics are of interest for inclusion into biology lessons. This opposition of interests is responsible for at least 1 student reconsidering his enrolment in the subject:

> This subject is boring. If I had known we would not be doing cool stuff like CSI, I wouldn't have done biology. I am going to drop it next term and do something else. All the teacher does is text book stuff like study questions and stuff. We do an experiment once in a while if we are good, but sometimes they don't work out like they should. (Paul, School 1, Teacher G).

It is well known that students are not selecting the sciences in post compulsory schooling, and this has had a flow-on effect into tertiary studies. There have been a number of explanations posited for this demise in science interests; however, very few if any have explored the link between teacher and student interests. It is obvious from these scales, that the students and teachers have opposing interests. The teachers are not interested in providing lessons on the same topics students are interested in learning about.

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USING STUDENT PERCEPTIONS FOR IMPROVED SCIENCE ASSESSMENTS

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Aim: The overall aim of the study was to investigate relationships among students' perceptions of their assessment tasks, classroom learning environments, academic efficacy and attitude to science from year eight, nine and ten.

Objectives

1. to identify exemplary teachers on the basis of students perceptions of their assessment tasks; and
2. to describe the form and design of assessment tasks used by exemplary science teachers.

Significance

Despite the growth in emancipatory conceptualizations of classrooms that embrace a constructivist epistemology, little contemporary evidence exists to support the view that students are genuinely involved in decision-making about their assessment tasks. That is, forms of Assessment and specific assessment tasks employed in schools are overwhelmingly decided by teachers and administrators. Furthermore, even though reports like *The Status and Quality of Teaching and Learning in Australia* (Goodrum, Hackling, & Rennie, 2001) have asserted that assessment is a key component of the teaching and learning process, teachers tend to utilize a very narrow range of assessment strategies on which to base feedback to parents and students. In practice, there is little evidence that teachers actually use diagnostic or formative assessment strategies to inform planning and teaching (Randnor, 1996). Teachers feel that they need to 'sacrifice learning with understanding for the goal of drilling students in the things for which they will be held accountable' (Hobden, 1998).

Historically, teachers have received substantial levels of advice on assessment practices. Harlen (1998) advises teachers that both oral and written questions should be used in assessing student's learning. The inclusion of alternative assessment strategies, such as teacher observation, personal communication, and student performances, demonstrations, and portfolios, have been offered by experts as having greater usefulness for evaluating students and informing classroom instruction (Dorr-Bremme & Herman, 1986; Stiggins, 1994). Tobin (1998) asserted that assessment can be used to provide opportunities for students to show what they know. Reynolds, Doran, Allers & Agruso (1995) argued that for effective learning to occur, congruence must exist between instruction, assessment and outcomes. This paper represents context-specific investigation of this congruence.

An effective assessment process should involve a two-way communication system between teachers and their students. Historically, teachers have used testing instruments to transmit to the student and their parents what is really important for the student to now and do. While this reporting tends to be in the form of a grade, the form and design of the assessment can send subtle messages on what is important. There has been a substantial amount of research into types of assessment but very little research into students' perceptions of assessment (Black & Wiliam, 1998; Crooks, 1998; Plake, 1993, Popham, 1997).

Use of Student Perceptual Data Until the late 1960s. a very strong tradition of trained observers coding teacher and student behaviors dominated classroom research. Indeed, it was a key recommendation of Dunkin and Biddle (1974) that instruments for research on teaching processes, where possible, should deal with the objective characteristics of classroom events. Clearly, this low-inference approach to research which often involved trained observers coding teacher and student behaviors was consistent with the behaviorism of the 1960s. The study of classroom psychological environments broke this tradition and used student perceptual data in late 1960s. Since then, the strong trend in classroom environment research has been towards this high-inference approach with data collected teachers and students. Walberg (1976) supports this methodological approach where student learning involves student perceptions acting as mediators in the learning process. Walberg (1976) also advocates the use of student perception to assess environments because students seemed quite able to perceive and weigh stimuli and to render predictively valid judgments of the social environments of their classes.

Classroom Learning Environment Recent reviews (e.g. Fraser, 1998, 1994) show that science education researchers have led the world in the field of classroom environment research over the last three decades, and that this field has contributed much to understanding and improving science education. For example, classroom assessments provide a means of monitoring, evaluating and science teaching and curriculum. A key to improving student achievement and attitudes is to create learning environments that emphasize those characteristics that have been found to be linked empirically with student outcomes.

Academic Efficacy Over the past two decades the broad psychological concept of self-efficacy has been the subject of interest (Bandura, 1997; Schunk, 1995) Within this field, one particular strong area of interest is that of academic efficacy, which refers to personal judgments of one's capabilities to organize and execute courses of action to attain designated types of educational performances (Zimmerman, 1995). Research studies have provided consistent, convincing evidence that academic efficacy is positively related to academic motivation (e.g. Schunk & Hanson, 1985), persistence (Lyman, Pretice-Dunn, Wilson & Bonfilio, 1984), memory performance (Berry, 1987), and academic performance (Schunk, 1989).

Instruments and Procedure Used:

The study was carried over in phases over a period of three years using multi-method research approach:

1. In first phase *Perceptions of Assessment Tasks (PAT)* a six-scale instrument of 48 items from a 55 item questionnaire developed by Schaffner, Burry, Cho, Boney & Hamilton (2000) was administered on 470 students from grades eight, nine and ten in 20 science classrooms in three Western Australian schools. Close ended interviews were conducted with 40 students to look at student perceptions of their assessment tasks.

2. In second phase based on internal consistency reliability data and exploratory factor analysis, refinement decisions resulted in a five-scale instrument that was named the *Student Perceptions of Assessment Questionnaire* (SPAQ). The SPAQ was used with five scales of the *What is Happening in this Class* (WIHIC) questionnaire, an attitude scale, and a self-efficacy scale. This survey was administered to a larger sample of nearly 1,000 students from 41 science classes from the same grades as in the first stage.
3. In the final stage of the study five teachers identified on the basis of students showing most positive assessment perceptions were interviewed and their teaching observed. Informal interviews were also conducted with students from the classes identified.

Findings and analysis

Quantitative data The validity and reliability information of the instrument developed in this study was determined by the degree to which items in the same scale measure the same aspects of students' perceptions of assessment tasks, classroom learning environment, attitude to science and academic self efficacy, a measure of internal consistency, the Cronbach alpha reliability coefficient (Cronbach, 1951)was used. For the scales of SPAQ the highest alpha reliability of .83 for the scale of Authenticity, and the lowest of .63 for the scale of Diversity. The scale of student attitudes to science has alpha reliability score of .85 and scale of Academic Efficacy of .9. Since all the reliabilities are above .63 the instrument developed is valid for use.

High mean scores ranging from 2.16 for the scale of Student Consultation to 3.17 for the scale of Congruence with Planned Learning on a four point Likert type scale confirm that students generally have a very positive perception of their assessment tasks. Scale of Student Consultation having the lowest scores confirms that students generally do not have a say in their assessment tasks.

Significant correlations ($p < 0.01$) were found among all the scales used in the instrument, for example, Congruence with Planned Learning was positively related to and was positively associated with all the other scales of SPAQ.

Qualitative data Based on the findings of the quantitative data five exemplary teachers were identified and their teaching observed and informal interviews conducted. (Denzin & Lincolin, 1994) *bricolage* method influenced me while interpreting the information, which was collected using a variety of research methods. This approach enabled to draw on a variety of paradigms to inform their interpretation in a bid to explain the positive student perception of assessment tasks. The main themes, which emerged from the qualitative data, are:

- Very through in their teaching
- Giving student enough time to prepare for an assessment
- Giving students freedom to choose from a variety of assessments
- Flexibility in teaching and assessment

Contributions to teaching and learning of science

In this study a new instrument, the Students' Perception of Assessment Questionnaire (SPAQ) was used in conjunction with already established classroom learning environment scales. This study demonstrates that scales of learning environment can be used in complex studies where many interrelated variables are assessed. The schools interested in adopting emancipatory approach to their assessment will find the results of this study very interesting.

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BEGINNING PRIMARY TEACHERS' BELIEFS ABOUT, UNDERSTANDINGS OF AND INTENETIONS TO ACT TO REDUCE GREENHOUS GAS EMISSIONS AND GLOBAL WARMING

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Objectives

Greenhouse gas emissions enhance the greenhouse effect (GHE), causing global warming (GW), climate changes and an increased incidence of natural disasters such as droughts, bushfires and floods, and hotter summers and cooler winters (IPCC, 2001). Science education can contribute to more enlightened decision-making (Earth Summit, 2002) in relation to environmental issues like the GHE and GW. It is crucial that people should be scientifically literate and be committed to acting in ways that reduce greenhouse gas emissions and GW. GW is accelerated by human activities such as industrialization, deforestation, farming and increased energy consumption through transportation and use of air conditioners (IPCC, 2001; Ponting, 1993).

The United Nations Environmental Programme (UNEP, 2001) documents and Intergovernmental Panel for Climatic Change (IPCC) reports indicate the extent of human impacts on the enhanced GHE. Further these reports provide suggestions for education about the causes, mechanism, importance and impacts of the GHE and ways by which greenhouse gases emissions can be reduced. The purpose of this research is to identify future primary teachers' beliefs, understandings and intention to act regarding the GHE and GW. More specifically the research questions were: 1. What do second year BEd students need to know to understand the GHE and GW, understand reports in the media and to make decisions about the issue in their lives? 2. What do second year BEd students knows and understands about the effect of greenhouse gas emissions on GW? 3. What beliefs do second year BEd students hold about the reality, importance and likely impact of the GHE and GW? 4. What actions have students taken in relation to reduce greenhouse emissions to reduce GW and what actions do they believe the government should take in Australia?

Significance

In democratic societies the importance of education lies in making it easier for governments to promote policies that will help alleviate the problem (United Nations, 1992). Informed decision-making is considered to be an important outcome of science education (Bybee, 1993; Fensham, 1988; Yager 1993). It is important to provide opportunities for students to act as responsible citizens particularly towards environmental issues. The inclusion of opportunities to develop problem solving and decision-making in science curricula has been argued by many authors (Aleixandre & Munoz, 2002; Dillon, 2002; Gayford, 2002; Gough, 2002; Hart, 2002; Weelie & Wals, 2002; NRC, 1999).

A scientifically literate public would improve the quality of public decision-making and actions. Decisions and actions made in the light of an adequate understanding of the issues are likely to be better than decisions and actions taken in the absence of such understanding. Greater familiarity with the nature and findings of science will also help the individual to question pseudo-scientific information (Royal Society, 1985). Cross (1999) argued that citizens will, in one way or other, need to be involved in lifelong learning if they are to participate in the ongoing debate about changes occurring in society. An understanding of the GHE and GW are important aspects of scientific literacy. Scientific literacy and public understanding of environmental issues developed in science classrooms can provide a foundation for informed decision-making about socio-scientific issues like greenhouse gas emissions and empower communities to take appropriate actions for a sustainable, green and clean environment (Bamford, 1999; Hart, 2002; Olson et al, 1999).

The GHE and GW are frequently discussed within communities and the impact of these phenomena is affecting the quality of our lives. However, it appears that insufficient focus has been given to this issue within science education at all levels for individuals to develop understandings and concerns about the GHE and GW, to take decisions and to act responsibly regarding this issue in daily life. Research by Lucas (1988) revealed that people are not able to understand and cope successfully with science and technology issues using their scientific knowledge even though they were unable to provide scientifically correct answers to apparently simple questions. Kurup, Hackling & Garnett (2005) revealed that high school students have only a minimal understanding about the GHE and that limits their ability to take informed decisions regarding the reduction of greenhouse gases through their personal actions. These studies indicate the need to develop strategies that develop lifelong learning and informed decision-making ability for appropriate environmental actions and particularly in the case of reducing greenhouse gas emissions. Future teachers of science should have sufficient understanding of environmental issues to help their students become scientifically literate about the GHE and GW.

Design and Procedure

This study was conducted among 203 BEd (Primary) second year university students in Australia. The questionnaire used in the research (Kurup, 2003) was based on the theory of reasoned action (Ajzen & Fishbein, 1980). The questionnaire is similar in structure to ones used in predicting behaviours and intentions in family planning, marketing research, voting behaviour, and in a case of nuclear safety that were based on the theory of reasoned action (Ajzen & Fishbein, 1980).

The questionnaire had five parts. The first part identified concerns and beliefs about the issue, including the relative importance of the issue compared to other issues in daily life. The second part probed understanding of the GHE. The third part asked about actions taken regarding 10 easy ways of reducing greenhouse gas emissions. The fourth part probed reactions to a proposal to reduce car use. The fifth part dealt with the sources of information about the GHE, and expectations about government actions.

Findings

Second year BEd students' beliefs regarding the GHE's relative importance in daily life, its reality, its effects like global warming and climatic changes, and the importance of personal and governmental actions were studied. The following aspects of students' beliefs were identified:

- The GHE is not an important social issue and ranked six among seven important social issues.
- They strongly believe that the GHE is real and affecting our climate at present and will do so in the future
- They do not believe that what they do has an effect on the GHE and strongly believe that the government should conduct programmes to raise awareness of the GHE and enact strict laws to reduce greenhouse gas emission.

The following aspects of students' understandings about the GHE were identified:

- The majority did not understand that the GHE is keeping our planet habitable, causes GW, and could not explain how or why the enhancement of the GHE causes GW.
- Hardly any one could provide a complete or nearly complete and scientifically accurate explanation of the mechanism of the GHE and have only either an inaccurate understanding or misconception.

This understanding of the GHE is inadequate to make informed decisions and take appropriate environmental actions as a scientifically literate member of society. The majority of second year BEd students and their families are already taking or considering taking action regarding 10 accepted ways to reduce greenhouse gas emissions by household activities (e.g. turning off lights), however, they are not prepared to sacrifice their personal comforts or convenience and they have strong reasons for that. They very strongly suggested that the governments should enact strict laws to reduce greenhouse gas emissions and sign the Kyoto Protocol.

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SUSTAINABILITY AND TECHNOLOGY EDUCATION

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Abstract: The new 2006 draft curriculum for New Zealand (Ministry of Education, 2006 p.7) expects "each school will design and implement its own curriculum in ways that will engage and motivate its particular students"(Ministry of Education, 2006 p. 26). It states that significant themes such as sustainability, citizenship, enterprise, globalisation and critical literacies "offer schools opportunities for engaging students and integrating learning across the key competencies and the different learning areas"(Ministry of Education, 2006 p. 26). This paper outlines ways this can be achieved within the new technology curriculum. It will also explore notions of stakeholders and triple bottom line theory.

Objectives

The objective of this paper is to explore the links between, and the relevance of, sustainability, triple bottom line theory and stakeholders within a wide range of technology education programmes. This paper intends to raise awareness and encourage discussion on ways that sustainability can become a more integral part of technology education courses.

Significance

In 2006 the New Zealand Ministry of Education published a new draft curriculum (Ministry of Education, 2006) . This curriculum has a much stronger and obvious focus on sustainability than the previous curricula. The first twelve pages underpin curriculum decision making whilst pages 26 – 33 discuss a number of considerations for designing a school curriculum with the remaining pages focusing on descriptions and the achievement objectives for each learning area. Unless drawn to their attention, teachers may not see the strong links between the initial guiding pages and those relating specifically to the learning areas. The term sustainability was rarely used in the 1995 technology Curriculum (Ministry of Education, 1995), whilst the 2006 document outlines students' actions when considering sustainability (Ministry of Education, 2006 p.26).

Theory

The global emphasis on sustainability began approximately twenty years ago when the report titled 'Our Common Future' was published by the World Commission on Environment and Development (WCED). The Brundtland Report (WCED, 1987) as it became known, was a reference document for the following Earth Summit in Rio de Janeiro (International Institute for Sustainable Development, 2006b). At this summit many OECD nations developed a 'global partnership' in sustainable development by adopting the 27 principles of Agenda 21 (International Institute for Sustainable Development, 2006a). These principles emphasize how important education is for awakening environmental awareness. Many countries have been quick to establish laws and policies to support sustainable development, these countries include Great Britain, (Green, 2001; Parliamentary Commissioner for the Environment, 2002;) Australia (Newman, 2005), The Netherlands and China (Osada 2003 as cited in Smith, 2004).

It is important for teachers, society and governments to clearly recognize the difference between environmentalism and sustainable development. The former can be defined as activism to protect nature from the economy whilst the latter focuses on redesigning the economy itself. In other words “environmentalism can be considered a movement against pollution, degradation and serious loss of nature while sustainable development can be considered a movement towards new action and behaviours” (Parliamentary Commissioner for the Environment, 2002 p. 7). When teachers are focusing of sustainability they need to be looking at whether an idea or project is sustainable over time, economically, socially and for the wider environment. Figure 1 below demonstrates "the integration of environmental, social and economic dimensions of sustainable development" (Parliamentary Commissioner for the Environment, 2002 p. 7). “The model recognizes that the economy is a sub-set of society (i.e. It only exists in the context of a society), and that many aspects of society do not involve economic activity" (Parliamentary Commissioner for the Environment, 2002 p. 35).

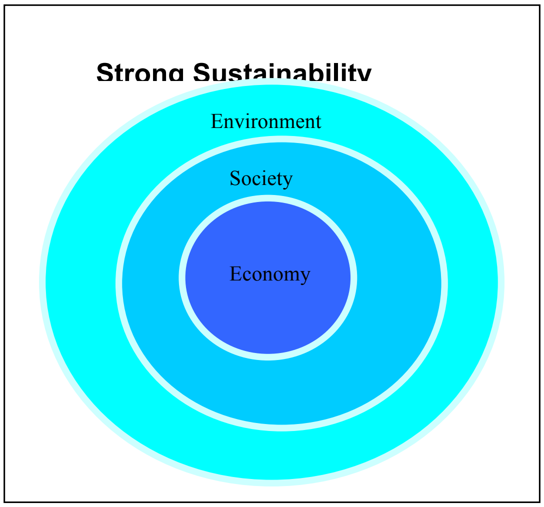

Figure 1: The Commissioner for the Environment's model of sustainability (Parliamentary Commissioner for the Environment, 2004 p. 15).

Triple bottom line is a term which was coined by John Elkington in 1994 (Henriques & Richardson, 2004). Elkington believes “sustainable development involves the simultaneous pursuit of economic prosperity, environmental quality and social equity" (Elkington, 1997 p. 397). The triple bottom line (TBL) focuses on “the three pillars of sustainable development, which have often been referred by economists as economic, social and environmental capitals (Richardson, 2004 p. 34). Those technology teachers following the TBL principles will encourage children to assess the viability of an idea or design on all three aspects. Although an idea may be less cost effective it may provide other benefits which can be weighed against a financial bottom line. For example a new product may be slightly more expensive to make but the may be less smelly or dirty to produce and hence the children making the product, and those in the class next door are given a better environment. The debate then occurs as to whose needs have the priorities- the children making the product, those wanting a cheap bargain/product or the investors wanting to get a good return on their initial outlay. This debate is the formation of stakeholder theory.

> The "key tenant of Triple Bottom Line (TBL) reporting is that organizations will improve their performance if they engage, in a meaningful way, with the people who affect them or who are affected by what they can do. These people or organizations who affect or who are affected… can be referred to as our stakeholders" (Ministry for the Environment, 2003 p. ix).

There have been numerous papers written about who is and who is not a stakeholder (Hendry, 2001; Mitchell, Agle, & Wood, 1997; Mongoven, 2003). Stakeholders are more than just stockholders (US) or shareholders (UK) (Carroll, 1993; Carson, 1993). They are people who "have something at stake in relation to the activities of the business" (Kaler, 2002 p. 93). Teachers need to ensure that all the needs and wants of major stakeholders are identified and that the students' designs reflect that these views have been considered. For many students considering views other than the client may be a challenge (Burns, 1997). It is important however that "technological outcomes are judged in terms of their effectiveness from different points of view" (Burns, 1991 p. 23).

Design and procedure

Research has shown there is a "dearth of professional development opportunities to dialogue both within technology education departments and wider professional circles concerning sustainability issues and their relationship to technology education" (Elshof, 2005 p. 179). Currently teachers in New Zealand are undertaking one-day workshop sessions in which the finer points of the curriculum are evaluated. Unless professional development opportunities occur, where the issues of sustainability can be discussed, the conceptualization and links to sustainability, TBL theory and stakeholders will be left to chance.

Findings

In the 2006 draft New Zealand curriculum (Ministry of Education, 2006) the term stakeholder has been used for the first time with reference to the New Zealand technology curriculum. The 1995 technology curriculum (Ministry of Education, 1995) uses the terms society, community, consumers and people instead of the all encompassing term of stakeholder. For this reason it is important teachers realize who these people are. As there is no definition in the curriculum this term is, unfortunately, open for interpretation.

In order for the true broad definition of sustainability, rather than the narrow version of environmentalism to be achieved, teachers need to be aware that sustainability includes considering economic, social and environment factors. If the vision of the new curriculum is to be achieved, students will follow the triple bottom line philosophy and be actively involved "contributors to the well-being of New Zealand – social, economic and environmental" (Ministry of Education, 2006 p. 8). Teachers will encourage children to identify views and perspectives from stakeholders from all three groups (those affected economically, socially and environmentally). By evaluating these views, and ensuring the subsequent product or solution designs demonstrate these have been considered, a truly sustainable solution will eventuate rather than one which is just environmentally friendly or profitable. With our students constantly evaluating their innovations on the TBL principles, many aspects of the World Summit Agenda 21 principles would be being met and New Zealand would be able to say it was definitely developing an environment which was truly sustainable.

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A LONGITUDINAL STUDY OF THE INFLUENCE OF A PRESERVICE TEACHER PROGRAM OVER TEACHER BELIEFS AND PRACTICES

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Abstract: The *No Child Left Behind Act* (2001) requires that every classroom in America be taught by a highly qualified teacher. It is essential to closely examine how teacher beliefs and practices are influenced and shaped by a preparation program with a strong emphasis on student-centered instruction. In this longitudinal study, from student teaching through the first three years of teaching, qualitative and quantitative data were frequently compared and triangulated to lend strength to the results. This paper will be relevant to K-12 teachers as well as all individual involved with teacher preparation.

Objectives

Given that teachers are considered central figures in improving school science, it follows that how teacher beliefs and practices are shaped by a teacher preparation program with a focus on student-centered classrooms should be the object of close examination. This paper is part of a larger study (Lew, 2001) concerning the development of constructivist behaviors from one of nine science teacher preparation programs across the United States (Salish I, 1997). Lew (2001) traced the changes in teacher classroom practices and teacher thinking across four years: from student-teaching to their third year of teaching. This paper reports the range of constructivist behaviors that emerged via the triangulation of qualitative data (from teaching videotapes and individual interviews) as well as quantitative data (from rubrics for quantifying teaching videotapes and interviews) from the perspective of "What Students should be doing in the classroom', "What teachers should be doing in the classroom", and "Teacher understanding of process and content" in accordance to the United State National Science Education Standards (NRC, 1996).

Significance

The *No Child Left Behind Act* (2001) requires that every classroom in America be taught by a highly qualified teacher. A survey of 600 science teachers nationwide by the National Science Teachers Association (2004) found 70% indicated their school district was experiencing difficulty in finding and hiring qualified science teachers and 48% said the problem is increasing. Three overarching goals for the US education system were established by the National Commission on Mathematics & Science Teaching for the 21st Century (2000):

1) Establish an ongoing system to improve the quality of mathematics and science teaching in grades K-12;
2) Increase significantly the number of mathematics and science teachers and improve the quality of their preparation; and
3) Improve the working environment and make the teaching profession more attractive for K-12 mathematics and science teachers.

Past research has produced little information about how individuals become science teachers, focused too narrowly on the problems of science teacher preparation, and offered few, if any, useful solutions (Anderson & Mitchener, 1994). An urgent need exists to better understand how these programs and practices ultimately influence science teachers' beliefs, classroom performances, and K-12 student learning outcomes. Only a handful of recent studies (e.g. Salish I Research Project, 1997) have specifically examined the links between science teacher preparation experiences and new teacher performance in the classroom. These studies were largely exploratory, focused only on beginning teachers, and made only modest attempts to examine 7-12 grade student learning outcomes**.** A longitudinal study of the impact of preservice science teacher education programs is needed that follows teachers into the real world.

Theory

The literature indicates widespread disagreement about the overall impact of science teacher preparation programs on preservice teachers. On the one hand, there are reports suggesting that teacher education program fail to achieve their goals (Hewson, et al., 1992); fail to impact preservice teacher beliefs (Zeicher & Gore, 1990) and that the overall university teacher education experience may be inconsequential when teaching in real classrooms. On the other hand, other studies indicate that beginning teachers are often significantly influenced by their preservice teacher education program (Hand & Peterson, 1995). Similarly, studies have shown the strong influence that teachers' beliefs play in shaping their knowledge, understandings and practices (Richardson, 1996). In contrast, SALISH I (1997) indicated a clear disconnect between the student-centered beliefs held by the subjects and the teacher-centered classroom practices they exhibited.

The area in greatest need for further research involves studies that combine descriptions of teachers' beliefs about effective teaching with observations of the teachers' performance in the classroom and their impact on students' conceptual understanding (Richardson, 1996). The study was developed upon the premise that if certain teacher preparation program features could be linked to effective practices in new teachers and successful student outcomes, then recommendations could be made for restructuring education (Brunkhorst, et al., 1993). Voluminous literature indicates research and instructional programs using "constructivist instructional strategies" in different parts of the world which may lead to improved science learning – producing students able to think critically and to use their scientific knowledge in new situations (Yager & Weld, 1997). Almost all constructivist classrooms focus on engagement of students and reflect the importance of students' prior knowledge in the learning process. Hence, according to constructivist tenets, schools must provide pupils with ample opportunities to build upon what they already know as they become active learners. In this study, constructivist behaviors, namely, constructivist teaching practices, beliefs and knowledge, are guided by the twelve descriptors offered by Brooks & Brooks (1993).

Design and Procedure

Salish I was a collaborative effort on the part of nine U.S. universities from 1993-1996 to investigate the influence of preservice programs on new teachers in their first 1-3 years of teaching. The sample for this study consisted of four new graduate teachers who took part in the Salish I (1997) study for a period of three years and for whom complete sets of database existed including "Best Effort" videotapes from student teaching. It is important to realize that the sample for this study has been ultimately determined by the information available, not by a prior statistical specification. The research design is a combination of qualitative and quantitative methods. This paper reports Constructivist behaviors investigated from two main instruments:

1. Actual classroom practices as viewed from 37 videotaped lessons and quantified using the Expert Science Teacher Educational Evaluation Model (ESTEEM, Burry-Stock & Oxford, 1993).
2. Teacher beliefs about teaching and learning as gained from interview questions ("Philosophy of Teaching and Learning" or PTL interview, Lew, 2001).

Videotape transcripts and interview transcripts provide the basis for qualitative descriptions and direct quotations regarding the new teachers' actual classroom practices and beliefs. The ESTEEM measures four sub-categories of constructivist teaching strategies; namely, Facilitating the learning process, Pedagogy related to student understanding, Context-specific pedagogy, and Knowledge of subject matter. The PTL interview used in this study consisted of 8 interview questions that were part of the Teacher's Pedagogical Philosophy Interview (TPPI, Richardson and Simmons, 1994) used in the Salish I Research Project. Interview transcripts in this study were quantified by means of a Scoring Guide that is a modified and expanded version of the scoring guide used in the Salish I Research Project. A panel of six science educationists familiar with the TPPI validated the Scoring Guide of the PTL. The PTL measures teacher beliefs for three sub-categories which correspond to the National Science Education Standards (NSES, 1996) pertaining to; what students should do in the classrooms (Student Actions or SA), what teacher should do in the classrooms (Teacher Actions or TA), and teacher understanding of process and content (Teacher and Content or T/C). Frequent triangulations via comparison of qualitative and quantitative data were carried out during data analyses in order to lend strength to the results. Comparing level of teacher expertise with regards to constructivist behavior (beginner, transition, early, and expert constructivists) substantiated statistical analysis (Lew, 2001). This paper focuses on the constructivist behaviors of the four new teaches from the perspectives of SA, TA, and T/C.

Findings

The major finding of the study is that the program is successful in preparing new teachers who are generally student-centered. They put into practice their research frameworks, are aware of the National Science Education Standards, and present evidence that they are early constructivist teachers. Quantitative and qualitative data indicate great congruence between teachers' actual classroom practices and espoused beliefs. The following are some shared constructivist behaviors of the four new teachers.

A. What Students Should be Doing in the Classroom (Student Actions or SA)

Three categories of constructivist practices with regards to what students should be doing in the classroom in accordance to National Science Education Standards (NRC, 1996) emerged from triangulation of qualitative and quantitative data:

1. Students share the responsibility of learning with the teacher
2. Student engagement in activities and experiences

3. Students who are motivated to learn

B. What Teachers Should be Doing in the Classroom (Teacher Actions or TA)

Under the constructivist tenets, teachers are not the center of learning but are mediators of students and their environment; teachers are not simply givers of information but ones who help students to search rather than follow (Brooks & Brooks, 1993). As such, a constructivist teacher modifies his/her pedagogy to the context of the students and ties the teaching of content to situations which relate it to student understanding. Five categories of new teachers' constructivist teaching with regards to what a teacher should be doing in the classroom as specified in under the National Science Education Standards (NRC, 1996) emerged from triangulation of quantitative and qualitative data.

1. Variation of teaching approaches and varied assessments
2. Teaching that focuses on student relevance
3. Teaching that incorporates higher order thinking skills and the use of scientific knowledge and ideas
4. Adjustments in strategies based on interactions with the students
5. Establishing a friendly and respectful learning environment.

C. Teacher Understanding of Process and Content (Teacher and Content or T/C)

Under the constructivist tenets, it is very important for teachers to understand what constitutes real learning as compared to superficial memorization and regurgitation of information. "Teachers must have theoretical and practical knowledge and abilities about science, learning, and science teaching" (NRC, 1996). To become a successful constructivist science teacher, the teachers need to know and understand what is science and the processes involved in the generation of what constitute scientific knowledge. Three categories emerged from triangulation of qualitative and quantitative data that demonstrate the four new teachers' understanding of the process and content of science knowledge in accordance to the National Science Education Standards (NRC, 1996).

1. Teacher understanding of subject matter and the integration of content and process skills.
2. Teacher understanding of the science that student encounters in everyday life, the science in natural phenomena and science-related social/controversial issues
3. Teacher as intellectual reflective practitioner.

The four new teachers were differently affected by their different experiences in different contexts. Each new teacher offered varied focuses and each exhibited unique patterns of change in their constructivist behaviors across time in their actions and their thinking or philosophies about teaching and learning, as well as the extent they perceived that they used constructivist teaching practices. Yet, they shared many similar constructivist beliefs and perceptions about teaching and learning which they successfully translated into classroom practices across their first three years of teaching.

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THE ECOCRISIS: EMBRACING ECOPEDAGOGY AND ECOLITERACY

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Abstract: For over forty years, the world's leading scientists have warned that expanding rates of global industrialisation are not sustainable. Major economies and their educational institutions have fostered pedagogical experiences, which reinforce a consumer-centred perspective. Much of the industrialised world has become abstracted away from the life and living processes. In order to avoid an ecological crisis in the twenty first century, humanity's collective survival is dependent upon accommodating an educational shift towards a global *ecoliteracy* premised upon ecosphere inclusiveness in diverse disciplines. In addition, world governments need to endorse an *ecopedagogy*, to steer the agenda of global politics; economics; science and technology, within a framework of ecosphere sustainability.

Objectives

The purpose of this paper is to examine the underlying philosophical assumptions driving the pending global ecological crisis explained by the Stern Review (2006). The paper is critical of the lack of response by world governments and corporate interests to take ecopedagogy and ecoliteracy seriously. Specifically, five key propositions are reinforced in this paper. Firstly, is the fact that the human physio-neurological and cultural realm is dependent upon healthy diverse ecosphere and not separate to the ecosphere. Secondly, the human realm is but an evolutionary outcome of other organic systems. Thirdly, the continuation of human existence is dependent upon securing a more authentic and sustainable engagement within a biologically diverse ecosphere. Fourthly, the future of a sustainable co-evolution on Earth depends upon the cultural transmission of values that repositions ecology centrally in human pedagogy and polity. Finally, ecoliteracy requires the development of an ecopedagogy premised upon systems intelligence. This approach is based upon a full commitment to an interdisciplinary understanding of core values and key scientific principles that foster sustainability. In addition, this paper briefly offers a local focus, covering ways teachers may interpret the Curriculum Council of Western Australia (1998), Curriculum Framework, to develop an ecopedagogy that enhances ecoliteracy within a constructivist philosophy.

Significance

For over forty years, prominent international scientists, such the late Rachel Carson (1962), have warned the international community of a pending ecological crisis. Ehrlich & Ehrlich (1983) estimated that during the next hundred years, more than fifty percent of all species would disappear, a loss of biodiversity unprecedented since the extinction of the dinosaurs. The international scientific community underscores research critical of unsustainable rates of material reproduction. Ehrlich & Ehrlich (1996, pp. 246 -250) noted that: *" ... 1,670 scientists, including 104 Nobel laureates ... claim unequivocally that the planet is at serious risk."* Serious global risks include cancer due to ozone depletion through to social and economic tensions leading to war, due to unsustainable, industrial, financial, corporate and government policies and practices. Scientific reports from the United Nations and OECD countries continually reinforce the seriousness of the ecosphere destruction. For example, (Stockholm Sweden 1972, (Rio de Janeiro Brazil, 1992) and (Kyoto Japan, 1997). The most damming analysis of the neglect by polity and corporations is found in the *Stern Review on the Economics of Climate Change* (October 30, 2006). The Review is emphatic about the seriousness of the impact caused by greenhouse gases as a direct outcome of human activities now the highest levels for 650,000 years. Climate models indicate a *" doubling of pre-industrial levels of greenhouse gases…to commit the Earth to a rise of between 2 - 5° in global mean temperatures…reached between 2030 and 2060…far outside the experience of human civilization…"(*P. 1, ¶1-2). Estimates of the global cost of this upheaval in the planetary equilibration are in trillions of US dollars and exceeding the total cost of the destruction caused by the First and Second World Wars. Researchers warn not only of exhaustive economic collapse, but generational costs to hundreds of millions of people including: radical increases in viral diseases, psychological trauma, and loss of intrinsic cultural icons caused by rising sea levels and extreme weather patterns. Finally, the major problem facing structural educational change and the initiation of an ecopedagogy, can be found in way institutions tend to support the status quo. Down (1993) maintains that the purpose of any educational process or initiative is primarily aimed at the socialisation of students to assimilate the interests of hegemony.

Theory

This paper favours a *Critical Theory* approach fostering the traditions of Habermas and the broad traditions of what is referred to as the *Frankfurt School of Social Science*. This is an approach, directed to towards critiquing and changing society's as a whole, specifically with regards humanity's relationship with the ecosphere. The concepts of ecoliteracy and ecopedagogy have been directed at the totality of global society and late-capitalism in its historical specificity from the 1960s to the early twenty first century. The writer sees the ecocrisis as a crisis of pedagogy. This paper touches on many macro-dimensions of global society, such as economics, political science, science, psychology and education. The overall epistemological stance in this paper sees critical knowledge as a construction of knowledge (Habermas cited in Dews 1993), which enables individuals to liberate themselves from forms of domination economic agendas by means of critical self-reflection and/or psychoanalysis. Therefore, issues pertaining extent global systems theory, ecological philosophy, social ecology, and education theory merge to accommodate an understanding and means to reduce the personal level subservience towards contemporary global economic systems of domination and/or dependence. Habermas (1993) sees the role of this epistemological approach as one, which can expand autonomy and help reduce the extent of domination. In addition, the writer advocates a pedagogical approach that supports a constructivist paradigm as associated with the research of Piaget's cognitive development as well as Vygotsky's insights into social linguistic development. (Goodrum, Hackling & Rennie 2001) (Skamp 2004) (Australian Academy of Science 2006)

Design and procedure

The design and style of this paper relates to an extensive literature view associated the writer's doctoral studies during the 1990s covering environmental ethics and *ecophilosophy*. The writer has selected particular references to underscore the philosophical assumptions driving the pending ecological crisis. The writer's literature review indicates that the demarcation between philosophy, politics, economics, environmentalism and environmental education is considerably blurred. The writer links his personal critique of the issues in context to the *Stern Review on the Economics of Climate Change* (October 30, 2006.

Findings

Through expansion of the international monetary-bureaucratic complexes, late-capitalism has extended its ability to rationalise people and the ecosphere for its own motives. Ontologically, global markets have penetrated areas that redefine human relationships in terms of consumption, or by bureaucratising the conditions of the human life. At best, industrialised countries and the corporations they support, offer only *shallow* acknowledgment of the finitude of the ecospheres. Governments so often provide the rhetoric of innovation, creativity and enterprise, yet act like fundamentalists as they try to eliminate legitimate critics, or bend the rules to accommodate invested interests. This is demonstrated by delays in reaching significant agreement on global environmental initiatives such as the Kyoto protocol by the USA and Australia. Western democratic governments have failed to see the need for ecosphere solidary (Lummis 2004), let alone a need for ecoliteracy. As Popper (1972) noted, the greatest risk to the humanity and the ecosphere can be found in the values and philosophies, which underpin human activities. A plethora of international reports and reviews, reinforce that greenhouse emissions and exploitation of natural systems have pushed *autopoiesis* to unchartered territory. Reasoned conclusions continue to reinforce that for humanity to avoid a major economic and ecological collapse, the international community needs to link global economic activities to agreed core eco-values and guidelines supported by scientific research, to accommodate sustainability. (Stern 2006) Therefore, an ecopedagogy needs to be central to all levels of formal education, to ensure that future leader have the appropriate ecoliteracy to tackle complex problems. Finally, science educators from industrial societies are important participants in informing the interests of late-capitalism, because collectively through their students and programs, they have the capacity to influence social and pedagogical processes, and literacy associated with the ecosphere.

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BRIGHT GIRLS CHOOSING PHYSICS AND CHEMISTRY: THE IMPORTANCE OF SELF-CONFIDENCE AND SELF-EFFICACY

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Objectives

This paper reports the findings of an investigation into the decisions of high achieving, or ‘science proficient’ boys and girls about whether to enrol in physical science courses. This continues to be a significant issue given the considerable gender variation in participation rates in these courses, and the lack of satisfactory explanations for this variation. The results are also timely given the recent OECD resolution to encourage more young women into science (OECD, 2006).

In brief, the study found firstly that science proficient Year 10 (15-16 year old) girls choosing physical science courses perceived themselves to have lower levels of academic ability in science than did science proficient boys choosing these courses. Second, girls and boys believed their science teachers held similar views to their own with regard to ability in science. Third, there were substantial differences in the ways girls and boys went about choosing their science courses. The girls who eventually chose physical science courses tended to consult more widely, and to consult their mothers and senior students to a greater extent, than did boys choosing these courses. They also relied more on the advice of their fathers than did science proficient girls choosing biology or no science courses.

Significance

It has been a common and persistent pattern in many countries that girls are less willing than boys to choose physical science courses. For example, in Australia girls make up only about 45% of chemistry students and 25% of physics students (Fullarton et al., 2003). The reluctance to choose physical science, and physics in particular, has been attributed to a range of factors, including cognitive preferences, the gendering of these subjects as male, the influence of peers, and societal and parental expectations. This paper suggests that this reluctance may also relate to the perceived incongruence between the anticipated difficulty of physical science courses and the lower levels of self-efficacy expressed by adolescent girls. While this is not a new contention, the findings in this case are supported by statistical evidence showing that relative to boys, even high achieving girls often lack the confidence to undertake physical science courses. This paper also contends that the more extensive consultations undertaken by girls choosing physical science courses, and their greater reliance on the advice of senior students and parents, are consistent with their need to bolster self-efficacy by gaining external reassurance of their ability to cope with the anticipated demand of these courses. Finally, the paper provides evidence of a strong relationship between willingness to choose physical science courses, self-efficacy and the quality of social capital inhering in relationships with significant family members.

Theory

Gender differences in students' participation in school science have been the subject of considerable research. The research foci have included investigations of enrolment differences (e.g. Johnston & Spooner, 1992), the apparent role of physiological differences or cognitive preferences (reviewed in Sjøberg & Imsen, 1988), the gendering of science as male (Jones, Howe & Rua, 2000), the influence of peers (Astin & Astin, 1992) and different parental expectations of sons and daughters (Eccles, 1989). One of the most widely supported arguments in that science is gendered, both as a school subject and as a profession (Hegarty-Hazel, 1997), and that such gendering is a social construct which requires reconfiguration before science can be equally appealing to boys and girls.

An alternative but not inconsistent view is that self-efficacy is a critical hurdle for girls contemplating science courses or careers (Murphy & Whitelegg, 2006; Osborne & Collins, 2001). The self-efficacy may relate to the common perception that physical science courses are difficult relative to others on offer. However, cognitive difficulty alone does not provide a convincing argument, given the higher participation rates of girls in other cognitively demanding courses, such as foreign languages or advanced history.

Design and procedure

The findings emerged from analyses of responses from 169 science proficient students to a survey about their enrolment deliberations and subsequent senior science choices (Lyons, 2003). The Year 10 (15-16 year old) students had recently chosen courses for their final two years of high school. Eighty of the students (38M, 42F) had chosen physical science courses, 50 (14M, 36F) chose biology or a general science course only, and 39 (7M, 32F) chose no science courses. The study defined 'science proficient' as having achieved a grade 'A' (excellent achievement) or 'B' (high achievement) in their Year 10 school certificate science examination. The focus on science proficient students was prompted by research showing that earlier school achievement is one of the strongest predictors of the physical science choice (Fullarton et al., 2003). In restricting the study population to students who had already demonstrated the potential to successfully undertake physical science courses, this research was able to look for influences beyond academic ability.

The survey asked students to indicate to what extent they had relied on the advice of six sources in making their course choices. These included best friends, senior students, Year10 science teachers, careers counsellors, mothers and fathers. Respondents' indicated degrees of 'reliance' on a five point Likert-like scale ranging from relied 'very much' to 'not at all'. They were also asked to rate their own academic abilities in science compared with other Year 10 students, and their perceptions of their science teacher's view of their ability. Both ratings were made on a five-point scale from 'well above average' to 'well below average'.

Differences in the rating patterns of boys and girls were investigated using cross-tabulations of sex and ratings. The significance of differences in adjusted residuals was determined with reference to Pearson and Likelihood ratio chi-square tests. Associations were considered to be significant at the $p<0.05$ level. The survey responses were further investigated through in-depth interviews with 37 of the students, allowing a richer and more meaningful interpretation of patterns in the quantitative findings.

Findings

Self-efficacy and enrolment decision

In terms of self-efficacy ratings, girls choosing physical science rated their academic abilities significantly ($p<0.01$) lower than did boys choosing these courses. Figure 1 highlights the extent of the gender difference in self-rating. Even among Grade 'A' physical science students (n=54), girls tended to rate their own academic abilities significantly lower than did boys. Students' perceptions of their teachers' views followed an almost identical pattern, suggesting that students felt their own views were reasonably 'objective' assessments of their academic ability.

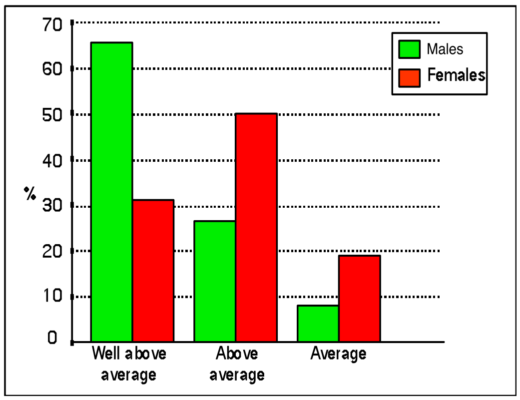

Figure 1. Physical science students' self-ratings on their academic ability in science (n=80). [No student rated his or her ability below average].

Consultation patterns

There were significant differences between boys and girls in terms of the approaches taken to seeking advice on courses. Evidence from both the student survey and the interviews show that girls choosing physical science tended to consult more widely than boys, and to rely more upon the advice of siblings and senior students. For example, 33% of girls and only 8% of boys choosing physical science courses reported seeking advice from sources other than the six nominated above, particularly older siblings. Further, girls choosing physical sciences rated their reliance on the advice of senior students significantly higher ($p<0.01$) than did physical science boys, suggesting a greater need for assurance from senior students about choosing these difficult courses. While it might be argued that girls tend to consult and communicate more widely than boys in general, it should be noted that there were no significant rating differences between boys and girls choosing biology or no science courses.

Girls choosing physical sciences tended to rely significantly more on the advice of fathers than did girls in other choice categories, especially those choosing no science. In addition, girls choosing physical science courses rated their reliance on the advice of mothers significantly higher than did physical science boys. Again, these differences were only significant among the physical science students.

The influence of social capital

The interviews highlighted the perceived difficulty associated with the choice of physical science courses, and physics in particular. The narratives of girls supported the hypothesis that the wider consultation process was associated with doubts about their self-efficacy with respect to these courses. By comparison, the boys appeared less concerned about coping and displayed greater confidence. Among interviewees choosing physical science there was greater evidence that the higher levels of social capital (Coleman, 1988) in supportive family environments enhanced their self-efficacy. This narrative evidence, in concert with the quantitative findings regarding consultation patterns and self-efficacy ratings suggests that self-efficacy was a more important issue for girls choosing physical science than for girls making other choices, or for boys in all categories. Although the girls choosing physical science courses often did so independently of their peers, their decisions were associated with the qualities of family relationships as a foundation for their overall confidence and self-efficacy.

The contribution of this study to the literature is in demonstrating that self-efficacy is not simply a concern of girls of average academic ability, or of those who are ambivalent about school science, or those who may be seen by teachers as not having a 'scientific bent'. Rather, there is evidence that even among girls achieving at the highest level in Year 10 science there is a crucial need to feel confident and reassured of their capacity to successfully undertake physical science courses. In terms of encouraging more girls to participate in these courses, it is important that the significance of self-efficacy be appreciated by teachers and advisors.

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COOK BOOK OR NON-COOK BOOK LABORATORY ACTIVITIES

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Abstract: This paper will present the findings of a study that investigated functional abilities of students in handling laboratory equipment in electricity experiments at the University of the Witwatersrand, South Africa. Data was obtained through a questionnaire to students, observations during laboratory activities, a semi-structured interview with demonstrators of laboratory activities and diagnostic questions in a written practical test. This study as reflected in all the instruments used, revealed that students lacked the required functional abilities. Therefore it was concluded that there was need to move away from 'cook book' experiments to appropriate non-traditional laboratory activities. This information would suit designers and evaluators of introductory physics programmes.

Objectives

The central theme concerning discussions and analyses involving cookbook or non-cookbook laboratory activities should be the display of functional abilities among learners. Functional abilities refer to the psychomotor skills that emanate from concepts learnt, and information gathered, in a particular discipline. Some of the examples of these skills are reaction time, manual dexterity, rate of movement and spatial relations (Shuell, 1990). Shuell (1990) mentions that a series of factor analytic studies by Fleishman and Hempel (1954, 1955) revealed systematic changes in the particular combination of psychomotor abilities most important for performance as learning progressed. These are operational skills and modes exhibited by students in handling laboratory equipment to enhance conceptual learning: in this instance electrical components such as voltmeters, ammeters, rheostats, switches and resistors. In some literature, functional abilities are extrapolated to include procedural understanding (Shuell, 1990; Buffler *et al*., 1998). In this study, the term procedural understanding was adapted from suggestions made by Gott & Duggan (1996) and summarised by Allie *et al*. (1998: 448), in terms of the perceptions of the reliability of experimental data as it influences the design of a practical investigation, the ways the data is collected, the ways the data is reported and the ways the data is interpreted

The purpose of the research presented in this paper was to identify the 'functional abilities of students in a number of electrical experiments done during the third quarter. Further this research was expected to establish quantitatively the extent of the problem and qualitatively the reasons for poor functional experimental abilities. In order to do this a study was carried out on three first year experiments in electricity done during the first year of physics course for medical students at the university of the Witwatersrand, South Africa. More specifically the research questions were: 1. How do students perceive circuit diagrams? Are they able to recognise that a circuit diagram represents only electrical elements and connections, not physical or spatial relations? 2. Do students understand the differences between ammeters and voltmeters, and how these differences relate to their connections into a circuit diagram? e.g. their difference in internal resistances 3. Are students able to recognise the difference between series and parallel connections?

Significance

Prior to 1988 paper review of 82 research papers based on the role of laboratory work were not conclusive on the question of what laboratories could accomplish (Blosser, 1988). However, critical analyses of the mentioned studies revealed that they had methodological defectects (Blosser, 1988). Nevertheless, since the early 1990s, there have been systematic efforts to assess the effectiveness of laboratory instruction and demonstrations (McDermott & Redish, 1999) resulting into the design of research based instructional materials in laboratories (Lubben & Millar, 1996; Séré *et al*., 1993; Allie *et al*., 1998; McDermott & Redish, 1996 & 1999; Millar and Beh, 1993; Carter *et al.* 1999; Aho *et al.* 1993; Toh and Woolnough, 1993; Gangoli & Gurumurthy, 1995; Junkin & Cox, 1997; Laws, 1991 & 1997; Clerk *et al.,* 1996; Beichner *et al.,* 1999; University of Minnesota Research Group, 1996; Sokoloff & Thornton, 1997; Etkina et al., 1999).

Practical work has been used in high schools and tertiary institutions for various reasons and purposes. In general two sorts of rationale for practical work are to facilitate the learning and understanding of science concepts and to develop competence in the skills and procedures of scientific inquiry (Millar, 1991). These may be regarded as two distinct aspects of science performance. Despite the limitations of practical work expressed in some literature (Blosser, 1988), these two rationales remain what is generally expected of practical work.

Klainin (1988) suggests that students should learn science by doing what scientists do. However, this action must be coupled with the cognitive framework of the learner. While scientists carry out experiments in their laboratories or appropriate places in order to verify existing laws, investigate observed events and to formulate new laws, learners may go through the same procedures to gain conceptual understanding of phenomenon. Carin and Sund (1980), quoting John Dewey, the father of progressive education, mention that we learn by doing, and reflecting on what we do: there is evidence from psychology, and other sources, indicating that learning is not a passive process.

Practical work must involve the learner actively because practical work studies phenomena rather than concepts. However, examining phenomena develops concepts (Kapteijn, 1988; p191). Furthermore, Lunetta (1988:169) summarises practical skills as involving planning and designing, performance, analysis and interpretation, and application.

Theory

Carter *et al.* (1999) describe the construction of knowledge through a Vygotskian perspective. In this perpective technical tools (science equipment) are used to regulate the external or physical world in order to mediate learning. If technical tools are outside the zones of proximal development of the students, conceptual progress may be hindered (Carter *et al.,* 1999).

At different levels of education, practical work may take different forms, such as inquiry, discovery or guided learning, but it is imperative that practical work consists of investigations, exercises and experiences (Woolnough, 1991) in order to study phenomena. In this way practical work is done to enhance students' understanding of the theories of science and to develop the ability to do practical problem solving (Woolnough, 1991). Olsen et al. *(1996), state that the learning cycle has phases of exploration, conceptual invention, and expansion of concepts. Thus the inform-verify-practice (IVP) of traditional teaching is only suitable for the presentation of information (Olsen* et al., *1996).*

Practical work involves practical skills, which may be divided into three categories (Millar, 1991), namely general cognitive processes, practical techniques and inquiry techniques. General cognitive processes include observing, classifying, hypothesising, inferring and predicting. Practical techniques include measuring, experimental procedures, recording and displaying data. Inquiry techniques include repeating measurements to improve reliability and validity, drawing graphs to see trends, and identifying variables that need to be altered, measured or controlled.

It must be noted here that general cognitive processes <u>*can not*</u> *be taught (Millar, 1991): they can only be sharpened with the use of practical work in institutions of learning. As for practical and inquiry techniques, these* <u>*can*</u> *be taught to the learners.*

However, much of the 'practical work' being performed in various educational institutions does not meet the above criteria and ideals. Roychoudhury and Roth (1996) claim that current science teaching rests on an inappropriate epistemology and collaboration methods are not used in science laboratories. Experiments are described in detail ('cookbook' instructions). Learners can go through the steps without even thinking about what they are doing and why they are doing them. With experience in laboratory outcomes, some learners even change their results to suit the desired outcome (pre-ordained knowledge); referred to as 'rigging' or 'stage-managing'. Practical work must involve much more than this mindless following of directions if useful learning is to occur during laboratory sessions (White, 1991:78). Woolnough (1991: 181) expresses a similar perception:

> "There is still much practice of standard exercises, with students being expected to follow 'cookbook' instructions. The evidence is that such practical work does little to enhance students' understanding of the concepts of science and nothing to enhance their appreciation of the methods of science."

Design and procedure

A questionnaire was administered and to be used as a base-line survey. The questionnaire had three parts. In part A students filled in their personal information. In part B students filled in information about their previous laboratory experience. In part C students answered diagnostic questions on circuit diagrams. The circuit diagrams used in part C were adopted from Rockford *et al*. (1991: 90) and they were also used by Joshua (1984: 273). In addition the questions in part C included generative questions. Such questions are asked in order to gain students' underlying thinking. According to Vosniadou (1994), generative questions are questions that require explanations of phenomena not directly observed and they have a greater potential to reveal underlying conceptual structures than factual questions.

Students were observed during laboratory sessions in the following experiments: Experiment E1 - The relationship between current and voltage, Experiment E2 - The EMF and internal resistance of a source, and Experiment E3 - The determination of resistance and resistivity. Field notes were obtained during these observations. The researcher walked around the laboratory as students were carrying out their laboratory activities: sometimes asking students to find out if they followed the experiments, and sometimes helping the students who had difficulties. Meanwhile a close watch was kept on how students handled the equipment used in the various experiments.

Two laboratory demonstrators were interviewed separately to find out how they rated the students and how they interacted during the laboratory sessions. Diagnostic questions based on Experiments E1, E2 and E3 were set and included in the practical test paper. The questions in this test were also of a generative type. The skills assessed in this paper included: describing in simple terms how they would carry out practical procedure, explaining and/or commenting critically on described procedures or points of practical detail, following instructions for drawing diagrams, drawing, completing and labelling diagrams of circuits, processing data as required, deriving equations for presenting data graphically, using suitable axes, explaining how to determine and use a gradient and intercept (or interception on a graph) appropriately, drawing and reporting a conclusion or result clearly and identifying and /or selecting, with reasons, items or apparatus to be used for carrying out practical procedures.

Findings

85 (97%) students in the sample that responded to the questionnaire did physical science for their matriculation. Only 3 (3%) did not do physical science. 32 (36%) students were male and 56 (64%) were female. 85 out of the 88 students who responded to this questionnaire came from South Africa. Only 3 came from Zimbabwe.

All students except one claimed they read through the laboratory manual prior to coming to a laboratory session: some a day before the laboratory experiment, some the night before, some fifteen minutes before. Just one student indicated dependence on the pre-laboratory tutorial only. Students who indicated that they depended on the laboratory manual gave the reason that the theory of the experiments they were to perform was not yet covered in lectures. This meant that students would go for the laboratory session without the required cognitive preparation. The most popular method of preparation was reading through the laboratory manual only.

52 (59%) students had laboratory experience before coming to Wits while 36 (41%) students did not. Some students did practical work in their schools; others watched demonstrations and others did more chemistry experiments than physics experiments.

50% of the students were not able to recognise that circuit diagrams represent only electrical elements and connections, not physical or spatial relations. About half of the students were not able to recognise the relationship between the features of a diagram and the electrical elements and wires that comprise the physical system. Many students did not understand the differences between ammeters and voltmeters. Although 40% of the students stated that the resistance of an ammeter is very small and that of a voltmeter is very large, they did not relate this information to the functions of the meters. During laboratory observations, it was found out that most students had difficulties in recognizing series and parallel connections. Some students had difficulties identifying and stating the use of circuit components such as a potential divider, reversing switch, rectifier, standard cell, ammeters and voltmeters. Many students did not wire circuits easily. Most students did not understand the need for repeated measurements, and other methods of minimising errors, such as the use of the best-fit line on straight-line graphs.

Most of the students in the sample did not develop the type of functional understanding that enables them to apply basic electrical concepts. Though there was some degree of observed improvements as the quarter progressed, it was still evident that most students still had serious conceptual reasoning and practical difficulties even at the end of the year. The difference between students observed before covering electricity in lectures and those observed after covering electricity was not significant. This is an indication that these difficulties were not addressed by the standard presentation of material in the traditional lecture and laboratory format. Most importantly students had great difficulty in handling the equipment and wiring it into the required circuit. Therefore there is need to move away from the traditional 'cook book' experiments to appropriate non – cook book experiments.

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TEACHING PRIMARY TEACHER EDUCATION STUDENTS HOW TO TEACH SCIENCE

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Abstract: This paper describes a problem-based pedagogical approach adopted in a compulsory science and technology curriculum subject within a Bachelor Education (Primary) degree. Students demonstrate their content knowledge, collaborative skills and pedagogical content knowledge within a criterion referenced assessment framework. A quasi-experimental pre/post-test design is used to assess students' developing content knowledge, scientific conceptions and complexity of their reasoning. In addition, ongoing feedback and evaluation procedures are built into the subject, which has allowed tutors to make continual improvements to the subject.

Objectives

The context for the pedagogical approach described here is a compulsory science and technology curriculum subject within a Bachelor of Education (Primary) degree that tackles the complex integrated skills required by pre-service teachers, to address problems identified in various national and international research reports related to the teaching of science (e.g. AAAS, 1990; Goodrum, Hackling & Rennie, 2000; Harris, Jensz & Baldwin, 2005; Millar & Osborne, 1998). The common problems identified include the lack of time devoted to science in the primary classroom, the lack of content knowledge possessed by teachers and, the lack of resources. This subject was designed to address these problems.

Significance

The research reported here demonstrates the dramatic improvements in both content and pedagogical content knowledge (PCK) that can be achieved by primary pre-service teachers if they learn how to teach science through being immersed in a collaborative, problem-based learning environment. The team teaching illustrated how collaborative models of teaching and learning that involved the planning and implementation of authentic learning experiences both for themselves and for their future pupils could generate a challenging, enjoyable, and deeply satisfying classroom climate.

Theory

The pedagogical approach is informed by current research in science education and is theoretically underpinned by social constructivism. Social constructivist philosophy holds that students are active throughout the learning process in constructing their own understandings of scientific phenomena (Schwandt, 2003). In constructing these, students are likely to develop alternative conceptions of the phenomena in question. The instructor's role in such a classroom is to challenge students' emerging conceptions by asking questions that expose their thinking and to direct attention to other, more scientifically correct, possibilities that emerge from the practical activities designed to challenge any initial alternative conceptions they may have held (Schwandt, 2003).

Equally important as part of the theoretical framework, was a commitment to the development of students' pedagogical content knowledge (PCK). Shulman (1986), describes PCK as a form of knowledge that is specific to a particular teaching/learning situation. That is to say, the PCK of science is distinct from the PCK of mathematics. Grossman (1990) identified four central components of PCK: knowledge of, and beliefs about, purpose; knowledge of students' conceptions, curricular knowledge; and, knowledge of instructional strategies. Other researchers have extended this definition to include aspects of assessment, content knowledge and demonstrated the interrelationships amongst the components (e.g., Appleton, 2002).

Given that the pre-service teachers we encounter had generally finished their studies of science at the end of the compulsory years of secondary school, their content knowledge was problematic. Despite the fact that their conception of the subject was to learn how to *teach* science, they did not *know* the science content they had to teach nor the processes of science. Consequently, a problem-based learning approach was adopted to teach one component of the primary science syllabus: astronomy. Problem-based learning has been shown to be effective in such diverse contexts as medicine (e.g., Albanese & Mitchell, 1993), civil engineering (e.g., Johnson, 1999) and education (e.g., Hmelo-Silver, 2004).

Cooperative learning has also been shown by research to be effective in engaging students in tasks (e.g., Johnson, Johnson & Stanne, 2000; Slavin, 1990). Moreover, if appropriately scaffolded, collaborative approaches can reduce the workload for an individual while the group collectively works on the larger task. The adoption of such strategies seemed appropriate given the time constraints of the university timetable and of the teacher education course.

Design and procedure

A quasi-experimental pre/post-test design is used to assess students' developing content knowledge, scientific conceptions and complexity of their reasoning. The decision to focus on the content strand that involved astronomy was, in part, based on many observations of primary classrooms during practicum visits to schools where *the content* was taught using a project based approach where pupils undertook research to produce posters on a topic that was included in the syllabus.

The team-teaching approach to the delivery of the subject involved a minimum of two tutors teaching in each tutorial. This approach enabled the team to demonstrate explicitly, through modelled practice, collaborative approaches to problem-solving and analytical and critical thinking skills that the pre-service teachers could then apply both within their cooperative learning groups and, later, in the context of the primary classroom and schools in which they will teach. Ongoing feedback and evaluation procedures were built into the subject through the use of one-minute Harvard Papers. These allowed the tutors to make continual improvements to the subject *in situ* and cater for the needs of students.

Creation of the Problem-based learning environment

The Astronomy Diagnostic Test (ADT) (CAER, 2004) was administered at the first meeting of the subject. Immediate marking of the ADT gave students feedback concerning their prior knowledge, lack of content knowledge and the alternative scientific conceptions they held. Confronted by their appalling results, students clearly understood that there was *a problem*. For example, one student articulated in class that *[I]f I don't know the content then how will I know how to teach it?*

Various cooperative learning strategies were employed (think-pair-share; roundtable; numbered-heads-together and jigsaw) to analyse research literature on alternative scientific conceptions held both by primary pupils and their teachers.. Students realised that they first had to address their own alternative conceptions so that they would not pass these on to their students. Comments made by them during one tutorial included: *There are many misconceptions among students, adults and teachers; Misconceptions are easily passed on;* and summatively*, I learnt lots of new things from the research papers and saw the collaborative approaches as a valuable teaching tool.*

Constructing curriculum and the learning environment

In their groups, students constructed a curriculum to meet the content-knowledge deficits identified by the ADT. This gave them a real purpose and motivation for the learning that was to take place. Each of the constructed curricula was unique because each group had specific content-knowledge requirements to be met and alternative conceptions to be redressed in order for them to be able to teach the content of the Earth and its Surroundings strand of the NSW Science and Technology K-6 syllabus in valid ways.

Resources for their learning were supplied. A compendium of 31 astronomy related projects and required equipment such as basketballs, tennis balls, tape measures globes, polystyrene balls, modelling clay etc. Any hints on how to teach the content had been carefully removed from the projects in the compendium so that students could begin to construct for themselves the PCK necessary to teach the material, first to their peers in the group and, later after reflection, to pupils in their classes.

A criterion-referenced assessment framework was employed where students were provided with a set of clearly specified performance outcomes on a number of criteria for each assessment item. Each of the assessment items had both an individual and a collaborative component. The feedback provided to the student was both formative and summative.

Findings

Evidence shows that the pre-service teachers who have experienced this approach are engaged and motivated by the transformed subject. Engaging in authentic science during tutorials has challenged their alternative scientific conceptions and required them to reconceptualise their current understandings of scientific concepts. In doing so, students are enacting the processes essential in teaching the scientific concepts to primary-age students and concurrently developing their PCK.

The emerging PCK became evident in one face-to-face interaction with a group when one student said *[B]ut I wouldn't teach it this way*. When asked why, the group responded in ways that reflected an early stage of understanding of the pedagogical issues. They made comments about the need to break the task into *manageable chunks* over a series of shorter lessons in order to *scaffold the learning of their future primary students*.

Consistent with collaborative learning principles, the task of acquiring the content knowledge was too great for any one individual to execute on their own in the time available. The approach motivated individuals to engage with their content both as students and as teachers and facilitated the following: face-to-face promotive interaction; positive interdependence; individual accountability and personal responsibility; interpersonal and collaborative skills; and the development of critical reflection of both their own, and their group's, performance (Johnson & Johnson, 1990).

Individualised programs tailored to the individual group's needs required everyone in their different roles to be involved and working at different levels: students as teachers, students as learners, and the members of the tutorial team as facilitators and mentors.

Sessions that followed were almost chaotic, but nonetheless were characterised by continuously high levels of task orientation. Student comments relating to the collaborative approaches used include: *I loved the Jigsaw activities – everyone brought something different; Cooperative learning is great and useful; and, We had a cooperative day where we got together and did it.*

In terms of learning outcomes, the success of the approach is demonstrated for this most difficult of primary science content areas by the fact that analysis of the post-treatment Astronomy Diagnostic Test (MANOVA) revealed that their content knowledge significantly improved (effect size=**1.99** (Cohen's d)). In addition, their alternative conceptions significantly reduced (effect size=**0.688**) and they acquired a significantly increased ability to explain the astronomical phenomena they will be required to teach in primary science (effect size=**1.33**).

Evidence from the analysis of the feedback questionnaires completed by students at the end of a subject indicated that, where previously they had been afraid of teaching science, did not know the content, could not explain the reasons for certain scientific phenomena or were simply bored by the subject, they were now enthused, motivated and committed to improving their content knowledge. They now had a much deeper knowledge of how to address their own and their future pupils' alternative conceptions. More importantly, they are acquiring the skills on how to teach science content in interesting and engaging ways.

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CONSERVATION SCIENCE – THE INTERFACE BETWEEN SCIENCE AND ART

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Abstract: Materials science involves the study of the relationships between the processing, microstructure and properties of materials. Consider then the scientific challenge presented by historic artefacts in museum collections and archives. Often we have little or no information about the 'recipe' used, the provenance of the raw materials is often unknown and the environmental history undocumented. In this paper I will describe how science can inform art and art can inform science in the technical examination and conservation of historic artefacts. This paper raises issues of interest to all age groups and their educators, exploring the interfaces between art, science and ethics.

Objectives

The application of scientific methods to the preservation of our cultural heritage is an important example of '<u>science and art</u>' and in this paper I will discuss the fascinating range of issues we meet when using science to assist in the conservation of artworks. I will show how the latest generation of high resolution and high sensitivity scientific tools can be used to better understand the processes of decay and deterioration in art-works; processes such as corrosion, oxidation and diffusion that can take place very slowly (at rates of less than one nanometre per day). The primary example I will use is the corrosion of glass. The experimental procedures I will describe are also transferable to other areas, and can for example be used to predict the likely degradation kinetics of the glass and ceramic media proposed for the long term storage of radioactive waste.

Significance

The conservation of our cultural heritage brings together the scientific community, the arts community and the public, helping them to better understand each other, and breaking down the barriers of jargon that get in the way of communication. The vast range of artefacts held in museums and other collections around the world give us tantalising insights into societies long gone and techniques long forgotten. These collections are of great cultural significance and are a source of enormous fascination to the public who visit them. It seems that curiosity about the past is a human trait that spans all cultures and communities. Furthermore, and in a spirit of optimism, we might hope that by gaining deeper understanding of the origins of our various cultures (and their commonalities) that we might better understand our shared humanity. We are also curious about the future and keen to ensure that the do not create problems for future generations. By studying how materials have interacted with their environment in the past we can make predictions about their future behaviour, thus ensuring as best we can that these materials are fit for purpose.

The historic objects we see in museum collections must be *de facto* <u>relatively</u> stable, but appearances can be deceptive and all materials are subject to degradation, the issue is simply one of kinetics. The main agents usually associated with the decay are water vapour and other gases such as oxygen and sulphur dioxide together with temperature and light.

The role of conservation science is to preserve the objects for as long as possible and there are two aspects to this:

(a) **Passive conservation**: This involves selection of the best environmental conditions for storage and display with humidity, temperature and level of illumination being key issues.
(b) **Active conservation**: This involves the application of treatments to reduce the rate of decay.

Conservation science is relatively young and guidelines and ethics are being developed to inform best practise. Conservation guidelines may be found in many forms and a listing is provided at (http://palimpsest.stanford.edu/bytopic/ethics/). Some of the key points have been listed by Jonathan Ashley-Smith (ref. 1):

1 All treatment should be adequately documented.
2 Structural and decorative falsification should be avoided.
3 It should be possible to return the artefact to its original condition even after long periods of time (the principle of reversibility of process).
4 As far as is possible decayed parts of an object should be conserved and not replaced.
5 The consequences of ageing should not be disguised or removed.

It is clear that the guidelines place extras constraints on the scientific approach especially apropos sampling.

Theory

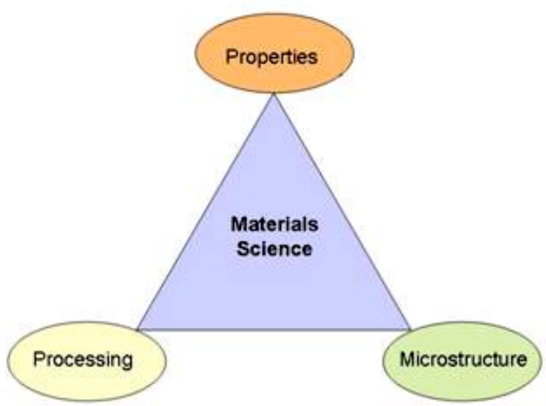


Figure 1. *Materials science is the relationship between the processing, properties and microstructure of a material.*

Materials science is central to the scientific endeavour in conservation and involves the study of the relationships between the processing, microstructure and properties of materials (Figure 1). Historic artefacts in museum collections and archives provide us with great scientific challenges as the materials are more complex than modern materials. Often we will have little or no information about the ‘recipe’ used; furthermore the provenance of the raw materials will often be unknown and the environmental history undocumented. The materials will often be a complex mixture of crystalline and glassy phases and will contain many impurities. Often the materials are porous and the surfaces rough, porous and cracked. Occasionally durability will have been sacrificed for the sake of an enhanced appearance. The situation may be contrasted to that of a modern silicon wafer where we have almost complete knowledge of all aspects of the starting materials (which will be ultra-pure), the processing and the properties.

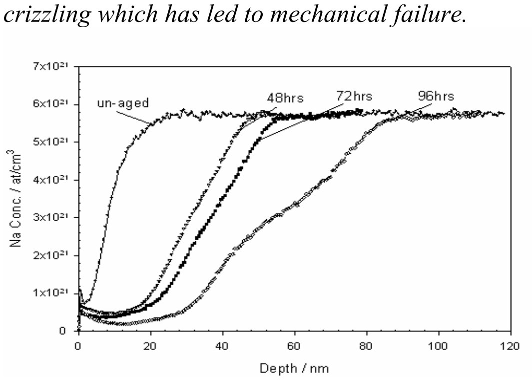
Design and procedure

Vessel glass decay

The example chosen here to illustrate the development of a scientific methodology appropriate for art-works is the study of the decay of vessel glass. There is a common misperception that glass is a stable and durable material, but in fact the stability is strongly dependent upon the relative amounts of network former, stabiliser and modifier. Many glass objects in museum collections from many different geographical locations and periods of time are unstable to varying degrees (ref. 2). These glasses are characterised by insufficient stabiliser (CaO, MgO, Al_2O_3) and an excess of alkali (Na_2O, K_2O). Over a period of time water vapour penetrates the object and alkali ions migrate to the surface reacting with atmospheric gases to form salts. A gel type hydrated layer is formed in the near-surface which shrinks or expands depending on the environmental conditions. The surface develops a fine network of cracks (crizzling) and eventually layers of the surface fall away and mechanical stability is lost (Figure 2). Advanced surface analysis techniques can be used to monitor this process in real-time, without the need for accelerated ageing. This is important as accelerated ageing is a contentious procedure and many believe it can introduce new processes into the material that may invalidate the predictions. In the case of the high-soda low-lime Venetian goblet shown in Figure 2

the approach we took was to measure the composition of a fragment of the glass that had spalled away using electron-probe micro analysis (EPMA). We then made up a batch of the glass using contemporary raw materials (Analar grade powders) and conducted a series of ageing experiments on this analogue material (ref. 3). Samples were left to age in a number of environments including a display panel at the V&A museum and then we measured the sodium distribution using a surface analysis technique called secondary ion mass spectrometry (SIMS) which can measure the sodium distribution in the near surface to a precision of less than one nanometre. Interestingly this technique, along with many others, was developed primarily for the semiconductor industry but it has now been realised that its high depth resolution and sensitivity can be used in many other areas of materials science (ref. 4). The results of the SIMS depth profiles of some samples aged under different conditions are shown below **(Figure 3)**. The key point is that the analytical technique can accurately detect differences in the near-surface chemistry as a result of exposure of the glass to water vapour for different periods of time.

Figure 2. *An example of Vessel glass decay in an 18C Venetian goblet. The glass is too rich in soda rendering it unstable to moisture. The frosty appearance is the result of crizzling which has led to mechanical failure.*



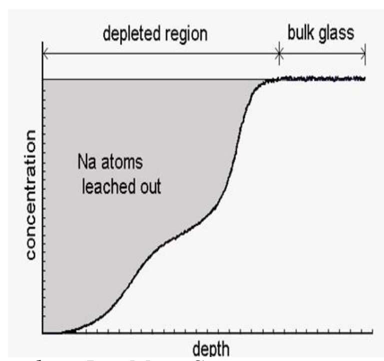


Figure 3. *The left hand figure shows the results of Secondary Ion Mass Spectrometry (SIMS) depth profiling of four glass samples aged at 55% relative humidity at room temperature for different periods of time. The number of sodium atoms leached out of the glass (in atoms/cm^2) is indicated by the area shaded in the schematic in the right hand figure.*

The precision of the measurement is less than one nanometre so that it is possible to measure corrosion rates of the order of one nanometre per day (1nm/day) corresponding to one millimetre every three thousand years. Thus it is possible using the latest generation of advanced surface analysis tools to measure ultra-slow corrosion rates and to avoid the need for accelerated ageing in producing a measurable effect. Armed with this experimental protocol we can measure the rate of corrosion of glass as a function of temperature and relative humidity and it turns out that low temperatures and a relative humidity of ~38% are the best conditions to minimise the glass corrosion (ref. 5). We can also use the protocol described above to measure the effectiveness of various chemical treatments, designed to stabilise the glass surfaces.

This study illustrates that:

- Conservation science is a discipline sitting at the intersection between science and art.
- The materials science of historic artefacts is complex and fascinating, indeed in many ways more challenging than that of modern materials.
- The only direct experimental evidence of how materials interact with their environments over long periods of time comes from the study of historic artefacts.
- All materials are ultimately unstable and all but the slowest of decay processes are now measurable with the modern scientific tools that can measure processes proceeding at rates of less than one nanometre per day (corresponding to one millimetre in three millennia).
- We can use the same analytical procedures to test the stability of materials proposed for the long term storage of radioactive waste.

In conclusion conservation science is an important example of 'science and art' showing how scientists and artists can work together and of how scientists can reach out to the public, showing them the relevance of science in a very direct way.

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CREATIVE EXPLORATION: ENHANCING CHILDREN'S INQUIRY AND UNDERSTANDING IN PRIMARY SCIENCE EDUCATION

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Abstract: This workshop, suitable for primary science educators and teachers will inform participants about a teaching and learning approach that focuses on the development of explanations arising from aesthetic experiences of natural phenomena. Participant's involvement in practical activities will provide the focus for differentiating between investigating for exploration and investigating for explanation. Samples of children's work will be used to explore how aspects of the nature of science and communicating of understanding in science have been taught.

Objectives

This synopses identifies the rationale for developing Creative Explorations, a constructivist teaching learning approach for primary science that addresses issues associated with the decline primary students attitudes towards science, and the need for all students to develop a level of scientific literacy. Theoretical positions associated with the interrelationships between aesthetic experiences, exploration and the explanation of natural phenomena when developing and communicating science understanding are explored.

Significance

The status of science teaching and learning in a crowded curriculum and the decline in students' attitudes towards further learning in science education are two areas of challenge to primary science educators. Despite the availability of many quality teaching and learning resources, science as a curriculum area in primary schools is generally percieved of as low priority. As well as the lost status of science amongst teachers there is also concern that the decline in secondary school students interest in being involved in further science is becoming increasingly evident in students in primary school (Crooks & Flockton, 2003). The challenge for primary school science teachers and educators is to develop a teaching and learning approach that presents science education in such a manner that will firstly appeal to teachers as being significant and worthwhile and secondly counter the decline in attitudes towards science being expressed by children.

Theory
Introducing the model

Creative Exploration		
Explore	a problem, situation, phenomenon, artefact, model, event, story.	**Wonder**
Observe	What is happening? What changes happened? What materials are involved? What are the main parts? What are the key aspects? What do these parts/structure do?	**Wonder about**
Identify evidence	What is the cause and effect of changes? What is the function? What parts are interacting with other parts? What are the outcomes of these interactions?	
Create explanations	Personal explanations supported by evidence are created and processes to test them are planned	**Wonder at**
Investigate	Find out, measure, compare, verify, test, clarify identify	
Evaluation	A self evaluation of these investigations may lead to, new or modified explanations, doubts about existing ideas or tentative conclusions. These tentative explanations can be communicated to others for peer evaluation	**Wonder whether**
Further investigation	Evaluated explanations can lead to: re-exploration, seeking further explanation, leading to further investigation	

Table 1 Sequential elements of Creative Exploration model for developing personal understanding in primary science

Theoretical justification of the teaching and learning model

Creative Exploration evolved as a teaching and learning approach through the development of the science assessment exemplars (Ministry of Education, 2004). The exemplars identified the demonstration of awe, wonder and interest in science as a key indicator of the goal of "developing interest and relating science learning to the wider world" (Arcus, 2003; Ministry of Education, 2004). The Creative Exploration approach has similar features to the Primary Connections learning model (Hackling & Prain, 2005) that elaborates on the 5 E's model developed by Bybee (1997)of engage, explore, explain, elaborate and evaluate. In particular, Creative Exploration as an approach places an emphasis on the exploration of aesthetic experiences and the subsequent desire by the learners to make sense of, or explain, the natural phenomena involved. The underpinning philosophy of the approach is also strongly influenced by the interactive approach (Biddulph & Osborne, 1984) that resulted from the Learning in Science Project, and the notion of children's science (Osborne & Freyberg's, 1985).

Children's science

If science can be defined as the current acceptable explanation of natural phenomena and the process by which the evidence underpinning this explanation is generated then children's science can be defined in much the same way. Children's thinking can be classified as being scientific if their explanations of phenomena and change includes the identification of the evidence they used when constructing their explanations. Children generating new thinking to explain the phenomena they are exploring are being creative. Creativity is defined by the National Advisory Committee on Creativity and Culture in Education as "imaginative activity fashioned so as to produce outcomes that are both original and of value, (NACCCE, 1999, p. 29 cited in Feasey 2006)" A person acting creatively is "thinking or behaving imaginatively in the process of trying to solve a problem or answer a question, (Feasy, 2005 p.6)" Children creating, communicating and evaluating their own and others' explanations for the phenomena they experience are significant components of this constructivist teaching and learning approach.

Taking children's ideas seriously in science was identified by Harlen (2001) as one of the two most significant developments in the past 100 years of primary science education. She suggests that any explanation that is supported by a positive response to the question, What made you think that? must be considered as having an impact on further learning. The significance of intuitive ideas on further learning in science was recognised by the learning in science project (LISP) conducted at University of Waikato during the 1980's and further explored during the Space project in the UK (Harlen, 2001). Explanations developed by children as they interact with natural phenomena become the foundation blocks on which further and more sophisticated explanations are developed. A knowledge of these ideas and how they were constructed is vital for a teacher when facilitating deeper understanding and guiding the children's learning in science. Creative Exploration as an approach to teaching draws heavily on the assumptions underpinning the interactive approach, in particular, the exploratory stage and the need to negotiate common understandings of the language used when communicating about the phenomena being explored. It is important that teachers use active listening when teaching in an interactive style. An interaction can be described as an interchange of communications in a context where there is a genuine desire by the facilitator to understand the student's point of view (Rivers, 1987) The valuing of children's thinking by the teachers involved can substantially influenced the students attitudes towards further engagement and learning in science.

Importance of affective attitudes on developing explanations.

The decline in attitudes towards being involved in learning in science has resulted in the call by some science educators to promote the development of affective attitudes like curiosity, awe, wonder and interest as an essential goal of science education (Millar & Osborne, 1998; Arcus, 2003). Similarly others Dahlin, (2001) and Girod and Wong (2002) claim that a more phenomenological - aesthetic approach is required. That is an approach to teaching and learning in science that stresses the importance of aesthetic experiences of natural phenomena that leads to the development of a sense of fascination by the learners involved. Girod and Wong (2002) contend that Dewey's notion of educated experiences, or fulfilled experiences of phenomena over time, could be described as aesthetic experiences, that can have a significant influence on learning in elementary school science. Similarly, Dahlin (2001) also contends that there needs to be a greater "emphasis on the aesthetic dimension of knowledge formation" (p. 130). He defines aesthetic as "a point of view which cultivates a careful and exact attention to all the qualities inherent in sense experience …. an approach to natural phenomena would not merely be to appreciate their beauty but also understand them" (p. 130). Learners involved in aesthetic experiences of nature can develop a sense of fascination (Godlovitch, 1998) that can generate a sense of anticipation which can in turn lead them to a depth of engagement and learning (Girod & Wong, 2002). A feature of Creative Exploration is the inclusion of exploratory activities that, with teacher direction and input, provide aesthetic experiences that will promote a desire for understanding and explanation for the learners involved.

Teachers' actions in promoting engagement and learning.

The quality of teachers' actions and responses when interacting with students can have a significant formative influence on students' attitudes towards science (Osborne and Collins, 2000). The quality of these behaviours is dependent on the attributes, skills, and dispositions that the teacher brings to his or her work with learners. Osborne and Freyberg (1985) identified five aspects of the motivational role that the teacher must play if they are to capitalize on the pupil's intrinsic control over their attention to the learning activity in hand. They suggest that the teacher must;

- "explicitly state the intent of the lesson or activity so that pupils can reconstruct for themselves the problems to be solved or the learning task"
- "encourage pupils to ask themselves, and each other questions which will focus attention and initiate generative learning,
- encourage pupils to take responsibility for, and to direct, their own learning,
- choose situations of demonstrable interest to the pupils whenever possible,
- and encourage pupils to reflect on their own ideas and ideas of others" (p. 92)

These aspects presented by Osborne and Freyberg could be described as a set of guiding principles that teachers could apply to their interactions with the learners they are working with as they explore, seek and create explanations. They focus the attention on the learners and the control individuals have on their learning.

Summary

Although Creative Exploration is still in a developmental stage, it does identify significant practices that could be beneficial for teachers when reviewing their practices. It stresses the importance of making the learner realise that exploration is part of science and, through close observation and wondering, patterns and trends can be identified. The testing and further investigation of these tentative observations and evidence through systematic inquiry can lead to validated explanations that are able to be communicated to others. In short they are using scientific processes to create explanations that are new to the individuals involved. They are doing science.

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SIGNIFICANT FACTORS TO INCREASE PUBLIC AWARENESS OF SCIENCE: HOW CAN A SCIENCE MUSEUM PROMOTE LONG-TERM PARTICIPATION IN AN EXTRAMURAL COURSE FOR ADULTS?

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Abstract: Science museums have played a role to promote science communication in our society. This study will consider essential factors to develop a practical program in a museum which links the promotion of science awareness for adults with a focus on an adult course carried out by the Museum of Nature and Human Activities, Hyogo in Japan. Especially, "Instructor Training Course of Chirping Insects" is the focus of this study. There are two main points of the investigation: (a) What kind of content and instruction are supplied? (b) What does the curator invent to attract people to the course continuously? These issues are examined on the basis of participant observation and interviews with the curator and participants.

Objectives

Recently in Japan, the problem of moving away from science arises not only among young people but also among adult. It is suggested that the problem occurs because most people lose to have a chance to learn science just as they graduate from school, while science subject is provided in school curriculum. In fact, the statistic in *the FY2005 White Paper on Education, Culture, Sports, Science and Technology* shows that the number of people who are interested in science has gradually declined (MEXT Japan, 2006). Thereupon, the government pointed out that experience and hands-on activities for wide range of people would encourage people to have interest on natural phenomenon or natural environment, which is a basic approach to science (MEXT Japan, 2005). In brief, to encourage public awareness of science for people is now quite important issue in Japan.

Thus far, several educational programs for younger people and school students in science museums or centres were focused on and reported. For example, Howarth & Slingsby (2006) explained a practical case study of outdoor biology in science field centres for school students. Nakayama et al.(2003) developed a practical program for secondary students to understand ecosystem in tidal flats under cooperation with a museum. Lucas (2000) reported an example of a science centre that showed how primary school teachers and their students were involved and how the teachers and students interacted with each other and with exhibits during the visit. Ogawa (2003) examined characteristics of single-visit educational activities in a science museum for school groups. On the other hand, there was little research on programs for adults carried out by the museum or centres. As far as the recent movement of public awareness of science for the public in Japan is concerned, it should be essential to develop practical programs for adults. For that purpose, what kind of contents and guidance are appropriate for practical programs for adults? What kind of ideas should be evolved to encourage people to have continuous interest for attending practical program held by science centres or museums? In this study, essential factors to develop a practical program in a museum which links to promote science awareness for adults will be discussed with focusing on an adult course carried out by the Museum of Nature and Human Activities, Hyogo in Japan.

Significance

Research on science museums has been discussed in terms of promoting informal education. Rennie (2001) examined effectiveness of science education in the museums from the viewpoint of visitor studies including profile of visitors, behaviour during the visit, and impact on the environment. It was also reviewed contents or human resources to provide practical programs in the museums (e.g. Ogawa, 2002). In sum, focusing on activities in museums is a sort of major trend to investigate how to promote science awareness for people. Dillon et al (2006) noted that a continuous program rather an one day activity is more effective to encourage understanding on environmental problem and awareness of nature. However, most of activities in museums are carried out in only couple of hours in a day (Ogawa, 2003). The way of how to delivering practical activities for adults is a matter that demands an immediate solution in Japan. In this regard, it would be necessary to explore some implications to promote science awareness and to consider factors to deliver practical activities continuously for adults.

Theory

There is a research field of "science communication", which is defined as including four topics, such as 1) communication among experts and professionals, 2) communication history, 3) communication of scientific information to other professionals, and 4) communication to audiences outside technical communities [(1)]. The objective of this study will link to the topic 4) , and will suggest some factors to develop a practical program for the general public in science centres or museums, that is quite serious problem in Japan. Obviously, the process that science infiltrates into society is called "institutionalisation of science" (Kuhn, 1977; Hiroshige, 1987). The research of science communication will investigate exactly the way of institutionalisation of science. Because science communication "discourse crosses national, cultural, and economic boundaries on issues such as health care policy, educational reform, international development, and environmental risk" [(2)] by considering how science influences on custom or practice in people's daily life.

The trend of science communication, which promotes awareness of science for general public, began in 1980's. For example, the Australian National University has undertaken to develop science communicators under the relationship with - the National Science and Technology Centre (Bryant, 2001). In addition to an example in Australia, the National Science Museum, Tokyo, Japan has undertaken several projects in relation to science communication, such as setting workshops for the researches and the public and designing science communicator fostering programmes. Especially, the Museum of Nature and Human Activities, Hyogo in Japan strived to develop a sort of academic courses for the general public. These facts show that science museums have played a role to produce science communication movement in our society. In this regard, taking notice of museum activities should be significant to consider issues of science communication.

Design and procedure

(1) Method

In this study, essential factors to develop a program which links to promote science awareness for adults will be discussed with a case study of an adult program carried out by the Museum of Nature and Human Activities, Hyogo in Japan. Especially, "Instructor Training Course of Chirping Insects" will be focused on. There are mainly two points to investigate.

(a)What kind of contents and instruction are supplied?

(b)What does the curator invent to attract people to the course continuously?

These issues will be examined on the basis of participant observation and interviews with the curator and participants.

(2) Outline of Instructor Training Course of Chirping Insects in the Museum of Nature and Human Activities, Hyogo

The training course of chirping insects has two classes, one is a beginners' class for non-experienced persons and the other is an advanced class for the persons who once took beginners' class. In both classes, participants are expected to identify 15 different kinds of sounds of chirping insects. There is also an amateurs group composed by the persons who finished the advanced class. In 2006, the beginners' class and the advanced class were held on the following date.

*Beginners' class: 10 June, 8 July, 2 September

*Advanced class: 12 August, 9 September, 30 September, 14 October

In the course in each day, a lecture and fieldwork run from 17:00 to 21:00. The end of the day, homework was given for the participants. Participants should make presentation on their homework at the next course date. For the participants of the advanced class, they were asked to plan and carried out a trial seminar course of chirping insects' identification for other people, who had no experience to identify the insects, at the final date of the course. In brief, people once take the beginners' class, they can learn to identify various kinds of chirping insects over a few months and they can continue to participate in higher-level course after the following year. What is more, the amateur group is formed and people can join it, if they hope to learn more about insects. As has been seen, this course would make it possible to encourage people's interest on a certain subject and help to keep acquiring special knowledge and skills.

(3) Examples of interviews for the instructor and the participants

***To the curator (an instructor of the course)**

Q. Why are the courses arranged to develop trainers of chirping insects?

A. In general, people think they have to improve practical skills to instruct other person. What I would like to hope to the participants is that they can sharpen their listening sense if they are conscious of the sound, because it must be difficult for them to identify the sound of the insect among background noise. On the other hand, I don't ask scientific accurateness for them. I only advise the way to collect better data to compare with others.

***To the participants**

Q. Why do you take the course?

A. (P1) There is several similar courses in other museums. However most of them finish in a day. The course in the Museum of Nature and Human Activities, Hyogo is unique

because it continues during a summer, and we can acquire basic skill to identify the sounds of several insects. (a participant of the Beginners' Course)
(P2) I like to study natural history, for example, I enjoy bird watching every weekend. In summer, we can hear variety of sounds of insects. So I am interested in identifying the sound. In future, I want to tell someone else like my children or grandchildren, how to identify the sound and share enjoyable time. So I think I need to develop useful skill to identify the sound. (a participant of the Advanced Course)
(P3) Chirping insects, especially crickets, appears in classical poetry. We Japanese feel warm affection for the insects. I believe that my life becomes richer if I can identify the sound of the insects in the season. (a participant of the Advanced Course)

Findings
Regarding two points to discuss essential factors to develop a practical program in a museum which links to promote science awareness for adults, several contents and interviews in the above section are summarized as follows.
(a) What kinds of contents and instruction are supplied?
Four factors are obtained as characteristics of the course. First, the subject is quite popular for the participants; namely, people can watch and feel everywhere it in their daily life, e.g. chirping insects in this case. Second, the period of the course covers a couple of months throughout a season, especially summer or autumn. Third, people can learn basic skill to identify various kinds of sounds of chirping insects. Fourth, the curator, who is a scientist of the museum, doesn't ask scientific accurateness for the participants, but aims to sharpen sense of hearing. This means that the course the curator wishes to adopt positive attitude for the participants to lead to science world in future.
(b) What does the curator invent to attract people to the course continuously?
The most significant point to note is that the way of setting the term of the course. One of the participants mentioned that majority of similar courses held in other museums are offered in only a day. However the course in the Museum of Nature and Human Activities, Hyogo covers nearly one season. This may be a factor to involve the participants into the activity continuously. Besides, the participants can join a higher-level course in the following year. This device may promote the participants awareness to learn more by taking the course. It should also be important that the experienced persons of the advanced course founded an amateur group. This will suggest that the participants are able to keep learning with the persons who have the same interest each other.

As we have seen, there are several devices to encourage people's interest in an adult course in the Museum of Nature and Human Activities, Hyogo. The following issues are suggested as essential factors to develop a practical program for adult to promote awareness of science and nature.
*To deal with popular or familiar subjects for adults and the general public.
*To encourage sharpening sense which people do not feel in their daily life.
*To develop programs and groups that people can join continuously.

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Note

(1) From the explanation of the journal of "science communication" published by the SAGE Publications (http://www.sagepub.com/ journalsProdDesc.nav?contribId =514045& prodId =Journal200892)
(2) Ibid.

MINING AND MINERAL PROCESSING INDUSTRIES PROFESSIONAL DEVELOPMENT PROGRAMS – DETERMINING HOW EFFECTIVE THEY ARE FOR SCIENCE TEACHERS.

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Abstract: Science teachers need to respond to the changing educational climate in a positive and confident way. Greater demands are being placed upon science teachers and these challenges require them to have an in-depth content knowledge and diverse pedagogical skills to enable them to teach a greater range of diverse learners. A need was identified by science teachers for up-to-date content knowledge about the mining and mineral processing industries. This paper traces the interaction of teachers involved in content-rich professional development events based around the mining and mineral processing industries and identifies any change in attitude of the participating teachers to the mining and mineral processing industries, after the professional development events have occurred.

Purpose of the Study

Science teachers need to respond to the changing educational climate in a positive and confident way. Greater demands are being placed upon science teachers and these challenges require them to have an in-depth content knowledge and diverse pedagogical skills to enable them to teach a greater range of diverse learners.

Significance of Research

A need has been identified by science teachers for up-to-date content knowledge about the mining and mineral processing industries. This study traces the interaction of teachers involved in content-rich professional development events based around the mining and mineral processing industries and to identify any change in attitude of teachers to the mining and mineral processing industries after the professional development events. Using government and industry funding, science teachers participated in a range of professional development events targeting different mining and mineral processing industries that exposed teachers to the high-tech nature and career possibilities of those industries for their students.

Background

At a time when fewer students choose to study physical sciences at the secondary level, the Australian mining and mineral processing sector has an increasingly greater demand for bright, qualified young people seeking research and leadership career tracts within these industries. The need for improving science education has been identified, and governments throughout Australia are making commitments to ensure students have access to high quality science education. This includes exposing students to complex, real-world problems in both industry and research institutions (Spotlight on Science, 2003). So, government and industry funded professional development events provided for science teachers could result in the teachers providing their students with a realistic view of mining and mineral processing industries.

The Australian mining and minerals processing industries have expanded at an increasing rate over the last few years and this trend is expected to continue due to the growing demand from China for Australian raw materials. Simultaneously the supply of young science graduates gaining the academic credentials and in science, technology, engineering and mathematics needed to maintain a qualified workforce, continues to dwindle. This problem has been well documented, but no easy solution has become apparent (Nicol & Woffenden, 2002, Bartier, Tuckwell & Way, 2003, Churach, 2004a).

The Australian Cooperative Research Centre (CRC) which conducts research in the mining and mineral processing industries has viewed this issue with particular concern. The Centre for Sustainable Resource Processing (CSRP) wanted to raise community awareness of the mining and mineral processing industries. Operating under the assumption that there can be no research without researchers (or no employer without employees), the CSRP sort a method to involve the minerals processing and energy industry with the community at large. The question arises as to the most effective method of reaching the community and in particular, young people who may be interested in the mining and mineral processing industries as a career choice needed to receive correct and up-to-date information in an efficient and cost effective manner.

The answer to this question can be answered in terms of where young people receive their inputs and who they turn to when they are looking for information. The Western Australian Government's Youth Survey (2003) surveyed 7,919 young people aged 12-25 years across all socio-economic backgrounds and educational circumstances. The study showed that teachers are held in high regard and that they have influence over their lives. Teachers are well positioned to positively influence their students' attitudes towards science and encourage them to consider careers in science and industry (Churach, 2006).

In a sense, these findings support the old notion that "the best salesperson is word of mouth". Why does word of mouth carry such weight? Simply put, most people place a stronger value of influence on input from those whom they know best and with whom they have a longstanding relationship. That parents and friends rank 1 and 2 as the most influential on opinions is easily predictable. In the same sense one can understand the high ranking of teachers as opinion influences. For the most part, young people spend their "working days" in the company of teachers and in many cases, interact with some teachers for more hours per week than they would normally interact with a parent. If all things are be equal, the target audience to be reached would be parents and friends though in terms of numbers, there is little leverage to be gained in attempting to reach (for example) 20,000 parents in order tin influence 30,000 of their children. We can say with great confidence that the teacher-student relationship is real and that these relationships already exit.

But how far does this influence go beyond the classroom? A study looking at what motivational factors affects career choice in the minerals resource and energy sector employed a questionnaire exploring career drivers (Churach & Rickards, 2003). The results showed 46% of these researchers, managers and scientists took time to volunteer the positive effect that one or more of their teachers had on their career choice and wrote comments like "My high school science teacher always encouraged me and challenged me to ask why…". However, 16% of those in this sample spoke of teachers having a negative effect with comments like "I wanted to prove that I could do it even though my high school chemistry teacher said I never could". These data seem to indicate that at least for people who have chosen careers within the mineral and energy sector, science teachers are often heroes.

Design and Procedures

The CSRP-Murdoch project places the emphasis on the on-going nature of the program based on the idea that in order to have long term effects on student perception of the industry, participating teachers need to undergo a variety of experiences involved with resource processing. Ideally, teachers would gain the greatest benefit from being exposed to a variety of both academic experiences ie., hands-on laboratory work and lecture-type offerings, and industry experiences ie., plant and mine tours and work experiences, over a period of time. This would allow the teachers involved to develop relationships with scientists and industrialists to a point where they feel comfortable in asking questions and sharing experiences (Churach, 2004b). Over an extended period (a few years) it would seem natural for teachers to gradually integrate their newfound content knowledge into their lessons and to have positive impacts on their students' perceptions of the industry. There is support for this approach in the literature. One project conducted in Alberta, Canada indicated more positive outcomes when career options became infused into the curriculum and not taught as separate items (Millar, 1995).

The CSRP-Murdoch professional development events were provided to a group of over 200 teachers in Western Australia and an additional 40 teachers in Queensland. These activities included:

- short courses and workshops (The Chemistry and Physics of Extractive Metallurgy", "Advanced Extractive Metallurgy", "Online Interactive Learning – Providing a Minerals Industry context for Secondary student Learning Workshop", and "Geology and Mineralogy in the Resource Sector"),
- research facility and industry tours (atomic force microscopy, CSIRO Minerals research Centre tour, gold mine tour, bauxite mine tour and alumina processing tour),
- a variety of resource processing lectures, and
- several sixty to ninety minute mini-sessions run for teachers.

The number of teachers involved in the professional development events varied from six to thirty depending on the activity. Teachers were encouraged to remain networked via e-mail and in most cases participants were involved in more than one activity. In some cases individual teachers took part in five to six separate events.

A questionnaire for teachers was developed using items designed to assess a series of attitudes secondary science teachers hold about the mineral resource industry and how the professional development program may affect these attitudes. The survey was reviewed by the academic staff at Murdoch University Extractive Metallurgy and at the Science and Mathematics Education Centre at Curtin University of Technology. Respondents answered numerically on a 5-point Likert Scale with 1 being “Strongly Disagree” and 5 being “Strongly Agree”. Participants were asked to respond to each of the 16 items from their point of view before their first professional development and then again from the point of view after undergoing whatever number of professional development events they completed within the program. Follow-up interviews were conducted with a sample of participants.

Examples from the total 16 questions included:

- My overall knowledge of the Mining and Mineral Resource industry is very extensive?
- I believe an excellent way to solve environmental problems can be found through Mining and Mineral Resource research.
- Professional development events that offer a maximum amount of science content-oriented material make me a better classroom teacher.

Results

Results of all the surveys were tallied to find the average response for each question both before and after the respondents participated in any Professional development events. Though actual values of responses can not be taken as a meaningful reflection on the PD program, the shift in average response can be interpreted as a change in teacher attitude towards the industry. A positive shift in score is interpreted as a positive shift in teacher attitude towards the industry and a negative shift in score is viewed as a negative shift in teacher attitude towards the industry.

A two tailed t-Test for paired samples was run on each of the 16 question sets in the survey and in every case the change was found to be statistically significant ($p<0.01$). This can be interpreted as indicating that the changes in attitudes shown by teachers were much more likely to have been associated with the PD work they had done than with any kind of chance occurrence. The follow-up interviews support this finding.

It is interesting to note that the two greatest shifts in response where with the teachers' overall knowledge of the industry (Likert shift = 1.40) and teachers getting to know and network with scientists (1.28). Other notable shifts in teacher attitudes were in teacher willingness to provide career information to students (1.05) and to use mining and mineral processing examples in class (1.00). Standard deviations are also listed for each scale indicating the spread of responses. In the four attitude shifts mentioned here, small standard deviations implies that participants showed similarly large changes in responses, exactly what would be anticipated if a strong association existed between teacher professional development events and attitude changes.

Findings

The authors of this paper state unequivocally that they do not support any professional development activities to merely be a public relations campaign for any industry. That said, it is apparent to these researchers that much of what goes on within the mineral and energy sector in Australia is never seen by the community at large. The professional development activities undertaken in this research allowed a group of several hundred teachers to gain an insight to the high-tech nature of the mineral and energy industry today. It also resulted in teachers acquiring a newfound appreciation for the application of the theoretical chemistry and physics they teach within the school curriculum. There is also strong evidence that a better understanding of the diversity and availability of career paths within this industry. There is an association between teacher participation in this professional development program and a changing attitude towards the industry in a positive way. And finally, an unintended outcome of this project has become apparent in that secondary science teachers participating in these professional development activities have welcomed the chance to network with other teachers, with academics and with industrial scientists.

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EVALUATION OF GENETICS EDUCATIONAL TECHNOLOGIES USED BY AUSTRALIAN SECONDARY SCHOOL SCIENCE TEACHERS

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Abstract; Genetics is a rapidly-evolving subject that can be difficult to understand and requires up-to-date resources. Genetics educational technologies may be useful for teachers as they can be updated and overcome some difficulties in learning genetics. However there is little current literature about their use. This doctoral project investigates the use of these technologies by Australian teachers. Popular resources will be identified and evaluated via classroom case studies looking at how technology is incorporated into the classroom and whether resources accommodate a range of teaching and learning styles. Guidelines will be produced on how to select and use genetics educational technologies.

Objectives

Genetics is a rapidly-evolving subject that can be difficult to understand and requires up-to-date resources. In addition, the explosion of information and communication technologies has dramatically expanded the number of multimedia teaching and learning resources available. Genetics educational technologies may be useful for teachers as the technologies may have capacity to be updated and could overcome some difficulties in teaching and learning genetics. However it is not clear who the technologies should be tailored to – the teacher or the learner – and there is a lack of explicit guidelines relating to their use in the classroom. This study aims to: a) ascertain whether educational technologies can accommodate different teaching and learning preferences in science classrooms; b) determine current use of these technologies in Australian schools; c) investigate the fit between learning designs of specific resources and the overall learning design of science classes; d) determine practical factors that enhance or diminish use of these technologies; and e) develop evidence-based guidelines to for teachers, learners and the wider community on how to appropriately select and use genetics educational technologies.

Significance

The wide range of websites and resources available to teachers and learners can be quite overwhelming and evaluating the quality, merit and value of these resources is often not possible in busy teaching and learning schedules. How can teachers and learners determine which educational technologies are useful, with appropriate educational content, particularly in a technology-driven and rapidly-evolving area such as genetics? There is limited literature regarding use or evaluation of genetics educational technologies. A review of audiovisual genetics education resources in 1978 produced a set of 'best practice' guidelines which have not since been updated (Carter et al., 1978). More recently, two Australian studies did not reach consensus on whether genetics educational technologies are better than traditional classroom genetics instruction (Gason et al., 2004; Tsui & Treagust, 2003). Few studies include both theoretical and practical evaluations of the use of genetics educational technologies.

The outcome of this research will be evidence-based guidelines to assist teachers in using educational technologies to accommodate the different approaches to learning within one learning environment. Guidelines for practitioner use of genetics educational technologies have not been updated since the late 1970s so this project represents a significant contribution to this area. The findings regarding the ways in which educational technologies are used in this sample may have broader implications for the use of educational technologies in general secondary and tertiary education settings, as small group and tutorial learning is an increasing component of higher education. It is also expected that the guidelines that emerge from this research may be applicable to practitioners wishing to design, develop or use educational technologies more effectively, such as those within the science and technology education community.

Theory

The focus of this project is the interplay between teaching and learning when using educational technologies to teach genetics. Research has established that learners have different preferred learning styles or approaches to learning, which can be affected by the learning environment (Biggs, 1993; Marton et al., 1984; Prosser & Trigwell, 1999). In addition, teachers bring to classroom context their own prior knowledge and pedagogical principles and preferences. The structure of teaching and learning activities in the classroom, including the resources used in it, are critical to students' learning experiences (Ames, 1992). However research shows that teachers often choose tasks that are "poorly matched to learner abilities and skill levels" (Blumenfeld, 1992, p.273). Thus there is a clear potential for an inconsistency between the preferred style of learners and the methods of instruction adopted by a teacher. So who should educational technologies be tailored to – the teacher, the learner or both? Or can the design of educational technologies be flexible enough to accommodate both learning and teaching styles?

Design and procedure

To determine if genetics educational technologies are being tailored to the teacher or the learner, it is necessary to determine which technologies are currently being used. Phase 1 in this study involves auditing the current practice of Australian science teachers when teaching genetics. Phase 2 involves case studies of classroom observations while an educational technology is used to teach genetics. Triangulation of data from questionnaires, observations and focus groups will determine the students' approaches to learning, the teaching styles, the learning design of preferred activities and any practical barriers or facilitators to use of educational technologies in the classroom. Phase 3 involves drafting and validating guidelines for teachers on how to select and use genetics educational technologies.

This paper reports on the first phase of the study. An audit questionnaire was drafted to investigate genetics educational technologies currently used by secondary school science teachers. Two preliminary focus groups with Victorian science teachers provided information to guide the study and validate the questionnaire. The questionnaire was distributed via the Science Teachers Association of Victoria newsletter (~1100 members) and at the 2005 annual conference of the Australian Science Teachers Association (~200 delegates). The questionnaire gathered data on the demographics of the teachers and educational technologies used. Data were entered into SPSS and analysed using descriptive and inferential statistics.

Findings
The preliminary focus groups revealed that there is large variation in access to educational technologies, teachers like to use a variety of media but need 'back up' plans due to equipment failure, the currency of information is important but not crucial and searching for educational technologies is time consuming.

> *Genetics in particular lends itself to videos and websites because quite often text stuff is not completely up to date and it doesn't provide you with those animations that are useful or… with interviews with real people who have that condition (Sam, Year 10 teacher)*

The response rate for the questionnaire was 17.2% (224 returned). Of these, 187 were completed by Australian secondary school genetics teachers and included in analysis. The mean age of respondents was 43.6 ± 10.1 years and mean teaching experience of 17.7 ± 10.4 years. 59.7% of respondents were female. Respondents taught at mainly government schools (54.0%), with 89.3% in metropolitan or inner regional areas, and 79.4% from either Victoria or New South Wales.

Respondents cited using 127 different genetics educational technologies. Figure 1 shows how many resources are used by each teacher. 16% do not use any while 35.9% use one or two resources. Table 1 shows what types of educational technologies are used and why teachers use them. Websites are the most popular type of educational technology, with over half of all citations being websites and over a third of respondents using them to both prepare and teach class. Videos account for a third of all resources cited with over a fifth of teachers using them. Teachers use websites and CD-ROMs to prepare for class and all four types of resource in the classroom.

Figure 1: Genetics educational technologies used by Australian secondary school science teachers.

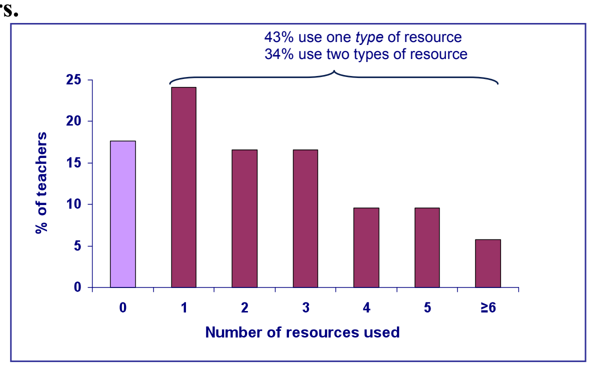

Table 1: Different types of genetics educational technologies used by Australian secondary school science teachers and why they are used

	Website	Video	CD-ROM	Software
Proportion				
Of all resources	52.0%	33.1%	9.4%	3.1%
Of teachers who used that type of resource	35.3%	22.5%	6.4%	2.1%
Why the resource is used				
To prepare for class	✓	×	✓	×
To teach class	✓	✓	✓	✓

Despite focus group data that revealed teachers like to use a variety of media, the largest group of teachers (43%) used one only type of resource (Figure 1). The questionnaire did not ask teachers why they used a specific resource, or type of resource, and this question will become the focus of interviews following the classroom observations in Phase 2 of the study.

To determine whether any specific resources are used more frequently than others, the 127 resources were ranked according to how many citations they received. This revealed that five educational technologies account for 32.6% of all reported usage: the Biotechnology Online website (Biotechnology Australia, 2005), the DNA Interactive CD-ROM (Dolan Laboratories, 2003), Drosophila Genetics Lab software (Newbyte, 2006), the Genetic Science Learning Center website (University of Utah, 2006) and the website version of DNA Interactive (Dolan Laboratories, 2003). Three of these 'Top 5' popular resources are websites, one is a CD-ROM and one is a simulation software program. The resources have different delivery mechanisms and learning designs. The DNA Interactive and Genetic Science Learning Center resources cover a broad range of genetics topics and include lesson plans and student activities, both on screen and printable worksheets. These resources can be used by students or teachers in an exploratory, self-directed or didactic manner. The content of the Biotechnology Online website is in accordance with the curricula of each state in Australia and aims to integrate genetics with non-science subjects by highlighting genetics technologies and ethics using problem-based learning via case studies. Alternatively, the Drosophila Genetics Lab is a simulation program that has no genetics educational content as such but is used to illustrate inheritance quickly and cheaply in the classroom. Given the different learning designs of the popular resources currently used by Australian science teachers, they may be able to accommodate different teaching styles and student approaches to learning. This will be investigated in the next phase of the study.

Teachers are aware of the many genetics educational technologies available but find it time consuming to select the most appropriate resource for their circumstances. Focus group data revealed that Victorian teachers prefer to use a variety of media and don't like to rely on just one resource in case it fails during class. In reality, however, Australian teachers reported using mainly one type of resource. Websites and videos are the most popular types of resource used and there are several 'popular' resources.

In conclusion, now that the genetics educational technologies that are currently being used have been identified, the next phase of the research will investigate the complex interplay between student approaches to learning and teaching styles via classroom case studies. The correspondence between the theoretical design of the resource and its practical use will also be examined. Evaluation criteria for genetics educational technologies and learning designs have been developed from current literature. These criteria will be applied to the popular resources to allow a theoretical evaluation before the resources are observed in the classroom. The practical factors that enhance or diminish teachers' and learners' experiences will be identified and the degree to which educational technologies can accommodate a range of teaching and learning styles will be determined.

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SCIENCE TEACHER POLICY, SUPPLY AND DEMAND: PERSPECTIVES FROM NIGERIA

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Abstract: With a population of over 140 million, Nigeria (fondly referred to as "the heartbeat of Africa"), is oil rich and the most populous black nation. This paper is organised in five sections. The first section reports on the organisation of science education after which a review of policy on science teacher education in Nigeria is provided. Next is a report on the demand and supply of science teachers and fourth is an examination of the quality of teachers who are engaged in science teaching. The concluding section provides some recommendations for improving the policy and practice of science teacher training and continued professional development of science teachers in Nigeria and other developing countries.

The Context

With a population of over 140 million, Nigeria (fondly referred to as "the heartbeat of Africa"), is oil rich and the most populous black nation. Science education in the geographical area now known as Nigeria began in 1843. That year, the Church Missionary Society (C.M.S) established a primary school in Badagry where nature study was taught. In 1914 when the Northern and Southern Protectorates were amalgamated and Nigeria emerged as a nation under British colonial rule, there were 2908 primary schools and 123 secondary schools were science was offered as elective. Independence was in 1960. From 1960 to date, there have been significant transformations in the provision of science education in Nigeria as a response to changing societal needs. Science teacher education has also been subjected to changes occasioned by policy formulations at the federal and state levels especially since 1999.

Nigeria operates a 6-3-3-4 educational system recently re-named 9-3-4 system. The first two levels - primary and junior secondary, make up the core of the basic education programme. The next two are the 3 - year senior secondary and the 4-year higher education components. Today, science education is delivered in the nation's 70,415 basic education schools enrolling over 26 million children; over 23,000 public and private secondary schools with a total enrolment of 11.4 million and about 200 (consolidated) higher institutions with a combined enrolment of about 1.5 million students.

Science Teacher Education Policy

The Nigerian policy on science teacher education is a subset of the National Policy on Education and the National Policy on Science and Technology. The goals of teacher education are given in the policy document as:

(a) produce highly motivated, conscientious and efficient classroom teachers for all levels of our educational system;
(b) encourage further the spirit of enquiry and creativity in teachers;

(c) help teachers to fit into social life of the community and the society at large and enhance their commitment to national goals;
(d) provide teachers with the intellectual and professional background adequate for their assignment and make them adaptable to changing situations;
(e) enhance teachers' commitment to the teaching profession.

As Borishade (2001) notes, while no specific provision is made for science teacher education in the policy, an indirect reference is made to the importance of science and technology education in the document. This in turn, impacts significantly on science teacher education. The national policy prescribes that every institution of higher learning should apply the 60:40 science to arts enrolment ratio. This implies that many more students will be enrolled for science hence many more teachers will be needed to teach science.

The policy gap on science teacher education is filled by science teacher specific policies at the primary, secondary and higher education levels. At the primary level, such policies are established by the Universal Basic Education Commission (UBEC). A strand of the policy requires that teachers at the basic education level should have basic training in the content and methodology for delivering good quality primary science education. This provision allows for generalist teachers at the junior basic level who are able to teach science along with other subjects including mathematics, social studies, and English language.

At the secondary level, three levels of authority enact policies for science teacher education. These are the federal, state and local government. This is in accord with the concurrent legislative status of education. At the federal level, the primary and secondary education department and the department of technology and vocational education (to a lesser extent) form the arrowhead of such policy stimulus. The Office of the Honourable Minister of Education coordinates and packages policy submissions from the departments. For the States, the Ministries of Education attend to policy on science teacher education while the Local Government Education Authorities have responsibility for initiating policies.

Policies enacted at each level are enforced only at that level. For a policy to have national application, the approval of the National Council on Education (NCE) must be secured. NCE is the higher policy-making body on education in Nigeria. The work of the Council is facilitated by reference and plenary meetings of the Joint Consultative Committee on Education. With regard to science teacher education, NCE set policy guidelines on such matters as science teacher training, curricula development for science teachers, science teacher welfare, establishment of specific science schools and science textbook development.

The state ministries of education have policies that guide the orderly development of science education within their catchment. These include the duration and content of science teacher training, special allowances for science teachers as well as their continued professional development.

Science teacher education policies at the higher education level are formulated by three agencies. These are the National Commission for Colleges of Education (NCCE), National Board for Technical Education (NBTE) and National Universities Commission (NUC). While NCCE takes responsibility for science teacher education policies in the colleges of education, NBTE plays similar role for technical and vocational teacher education in Polytechnics. NUC on the other hand is concerned with policies on training of teachers in universities faculties and institutes of education. Together, the three agencies formulate policies that guide the setting of philosophy and objectives of the science, technical and vocational teacher education programme. They also make prescriptions on admission, content courses to be offered, pedagogic courses to be offered, duration of teaching practice, contact hours for graduation, quality of staff, minimum level of facilities, and mode of assessment. These policy guidelines ensure some measure of uniformity in the minimum standards applied in each institution. There is a consolidation arrangement to bring NUC, NBTE and NCCE under the aegis of a new organization- the Tertiary Education Regulatory Commission (TERC).

Demand and Supply Gaps

Science teacher supply is undertaken at three levels. The National Teachers Institute and Colleges of Education are the major providers of teachers for the primary level. Secondary level teachers are supplied by the Colleges of Education and the University faculties/Institutes of Education.

Annually, the colleges of education produce an average of 15,000 science teachers while the universities have an average output of about 12,000 for the secondary school system. This output outstrips demand, leading to a surplus. This surplus is exemplified by the pool of unemployed graduate and Nigeria Certificate in Education (NCE) science teachers said to be “roaming the streets”.

It is a paradox that in many States, vacancy positions for science teachers are not filled - not on account of non-availability of such teachers. The inability of such States to pay for the services of teachers has turned out to be the hindering factor. The paradox is further stretched by the claim of these States to pursue a policy which encourages science and technology development. How such a policy can be achieved is rather doubtful. It is gladdening to note however that the Obasanjo administration is implementing the National Teachers Corps Scheme which will assure a more even geographical spread of science teachers with enough numbers in all schools. The Teachers Registration Council (TRC) is also taking steps to engender professionalism.

Quality of Science Teachers

This section describes the quality of science teachers in Nigeria by level, and by the depth of their knowledge bases. Three knowledge bases are of interest. These are content knowledge – knowledge of the subject matter of science; pedagogic knowledge – knowledge of the art of teaching and its associated skills; and pedagogic content knowledge, that is skills in the teaching of scientific subject matter.

Reports from various studies (e.g. Okebukola, 2002) including those conducted under the auspices of the Science Teachers Association of Nigeria (STAN) and reported in a number of its position papers and annual conference proceedings confirm that at the primary level, teachers have strength in pedagogic knowledge but weak in content knowledge of science. Primary science is poorly taught because of the shallow knowledge of teachers in primary science content. While teachers demonstrated superb ability in teaching skills, they were unable to present science to children as an exploratory activity. Content errors in teaching are characteristic of many primary science classrooms. The teachers have the medium but lacked the massage.

At the secondary level, the strength of the teacher is in pedagogic content knowledge. The weakness as it is the case of the primary level is content knowledge. The large dose of courses in education during teacher training relative to courses in the cognate science subjects largely accounts for this. The curriculum of teacher trainees in the colleges of education and universities loads unduly on education courses. This was not the case in the past where a full grounding in the teaching subject was the norm. At the higher education level, the pattern shifts in the opposite direction. Here the teachers are well grounded in content knowledge. However, many demonstrate weak pedagogic content knowledge. It is often a marvel to students in the faculties of Education where the lecturers are expected to be exemplars in the art of teaching that only a few of the lecturers practice what they preach with regard to teaching methods.

In spite of the deficiencies reported above, Nigerian science teachers are still highly rated in the Africa region. The demand for Nigerian science teachers by many African countries influenced in part, the setting up of the Technical Aid Corps scheme. Every year, science teachers from Nigeria under the platform of the scheme are deployed to selected African countries. Assessment reports from these countries confirm the good quality of the teachers. Again, these reports do not form a firm basis for generalisation about the good quality of Nigerian science teachers. It is clear from national assessments that a lot of ground still needs to be covered in improving the quality of teachers.

Conclusions and Recommendations

A review of the science teacher education policy was undertaken in this paper. The review indicates that the policy in force has tremendous strength for delivering good quality science education in Nigeria if implementation is approached with a greater degree of seriousness. Policy gaps were also identified in the areas of training, benchmarking and standards setting, monitoring and assessment and continued professional development.

The supply and demand sides of science teachers were also examined where significant gaps were noted. A trend towards over-supply in some subjects and in some states were highlighted. The positive trend since 1999 in the direction of closing the gap was noted. On the quality side, we observed weaknesses in primary and secondary science teachers in content knowledge of science. This in turn, is affecting pupil performance in primary science. The strength of higher education teachers in content knowledge and weakness in pedagogic knowledge were also observed. Recent reforms (especially from 2002 to April

2007) by the Obasanjo Administration are noteworthy. These are in the areas of science curriculum improvement by the Nigerian Educational Research and Development Council (NERDC), standards setting and science programme accreditation by NUC, NBTE and NCCE, provision of instructional materials for science teaching at all levels, "Adopt-a-School Programme", implementation of the National Economic Empowerment and Development Strategy (NNEDS) with a slant towards improving science teaching, pursuit of the science education related components of the Millennium Development Goals (MDGs) and Education for All (EFA).

It is evident from the foregoing that noteworthy changes would need to be made to policy prescriptions and implementation to assure the delivery of good quality science education in the country. The following recommendations would appear appropriate:

- Faithful implementation of the science teacher education component of the Ten-Year Education Plan (Okebukola, 2007).
- Enactment of a comprehensive science education policy embedding policies on science teacher education that would address such issues as:
    - curriculum for science teacher education;
    - benchmarks for preparation of science teachers;
    - greater rigour in the accreditation of science teacher preparation institution;
    - monitoring and evaluation of practice; and
    - licensing and re-licensing of science teachers.
- Strengthening of the Science Teachers Association of Nigeria (STAN) in offering in-service training for science teachers especially through its annual national and State-level workshops and conferences. (The *STAN Place* is being set up to facilitate such training)
- The on-going Education Sector Analysis (ESA) should conduct periodic demand and supply analysis of science teachers with a view to ensuring a match between what is needed in the field and what the colleges, faculties and institutes are producing.
- The Open and Distance Learning Programmes should be well funded and managed so to support the training of a large number of science teachers required for the UBE, MDG and EFA initiatives.

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MAPPING AFFECT PROJECT (MAP): PROMOTING JUDGEMENT OF LEARNING AND COGNITION IN LEARNING CHEMISTRY IN TAIWAN

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Abstract: Developing a self-awareness of achievement and progress is an essential part of promoting sound personal Judgment of Learning for self-regulated learning. Based on Bloom's Taxonomy of values, criteria were designed for student self-assessment of a variety of affective characteristics of learning, including social behaviour, judgement of cognitive learning, and values towards learning. The project aimed to test the validity and reliability of the instrument against these students. We note variation in the ability of these students to make reliable self-assessments, explained partly by the use of novel criteria. We conclude that self-assessment may not be as reliable as we expected.

Significance

Many chemistry courses proclaim a set of aims that espouse lofty ideals about developing lifelong interest in learning, self-supported motivation to learn, and the development of a reflective approach towards individual progress and target-setting. However, it seems to be rare that learners are directed to engage their thinking and actions towards these aspects of learning, with most focussing only on cognitive development. In this project, we decided to take these claims seriously and to establish a theory-based framework for rigorous and systematic criterion-based self-assessment of a range of aspects of learning. The range included learner values towards the learning process, their own judgment of learning, learner feelings about working in a social context, and confidence in their learning. We wish to emphasise that we have focused entirely on affective characteristics of learning, since we believe that this area has been under-represented in research.

Theory

The value of developing metacognition has been well explained by Gunstone and Mitchell (1998), and by Gunstone and Northfield (1992). Bandura ((1991 & 1997) provides strong evidence for a causal link between motivation, self-efficacy and achievement. Cao and Nietfield (2005) studied accuracy of learning in a psychology course. They concluded that:

> 'As a key component in self-regulated learning, the ability to accurately judge the status of learning enables students to become strategic and effective in the learning process. Weekly monitoring exercises were used to improve college students' accuracy of judgment of learning over a 14-week educational psychology course. A time series design was used to assess the within-subject differences in judgment of learning (JOL), confidence, monitoring accuracy, and performance. Results show that the monitoring exercises have a positive effect: JOL, confidence, monitoring accuracy, and performance all increased over the semester. Four metacognitive judgments have been used to operationalize the concept of monitoring to reflect the

> ongoing process-related metacognitive activities that one may engage in when performing a task. These judgments include: (a) task difficulty or ease of learning judgment (EOL), (b) learning and comprehension monitoring or judgment of learning (JOL), (c) feeling of knowing (FOK), and (d) confidence judgments.'

We focus on what we have termed here Judgment of Learning as one strategy in developing metacognitive awareness. We distinguish between Learning and Judgment of Learning. Learning is often assessed through specific questions or tasks designed to test understanding of explicit learning objectives. Success in responding to the tasks or questions is translated into an assessment of learning. Judgment of Learning is a self-assessment activity in which the learner makes their own judgment of their success in meeting learning objectives.

Our interest is in the assurance of quality of learning. This is in line with recent attention to Assessment for Learning which attends not only to specific learning achievements and providing feedback to the learner, but makes suggestions on the next steps to be taken by both learner and teacher. We see self-assessment of Judgement of Learning and other affect as a major component of self-regulation of personal quality of learning.

There is relatively little previous work on record in this area, particularly for chemistry students. Self-assessment is more often directed at generic statements of learning (very good, good, average, poor), or other Likert type scales. As such, they are often of little use for Assessment for Learning.

The criteria were designed to match the values criteria developed from the Krathwol *et al* framework. They were chosen to reflect persistent features of learning, i.e. those features where it is likely that some progression would take place over the research period. We are aware that we have focused on these features in a way that is unusual in chemistry learning, a novel aspect of this research.

Design and procedure

Research questions:

1. Can we construct a valid and reliable method for assessing feelings about knowing and values of learning of students in a chemistry course?
2. What aspects of learning are persistent features from session to session that enable progress in higher level skills to be monitored?
3. How do self-assessments of feelings about knowing change during the course?

We designed a set of criteria based on Krathwol, *et al* (1985) to guide student self-assessment of aspects of affect. This series of values has been well characterised in the references provided and so was chosen as a template from which the other features of affective learning were derived. We established construct validity by discussion among a group of practitioners. The categories were:

- Use of diagrams
- Use of graphs
- Help seeking

- Using symbols and equations
- Confidence
- Commitment
- Group work
- Explaining

We chose a sample of 110 students taking chemistry at the freshmen level of a college course in a college in Taiwan. 76 students provided the whole set of data. The sampling took 6 weeks. The attrition rate was thus 31%. Students mapped their feelings at the end of each session.

In weeks two and six, students read two hypothetical case studies referring to affect. They had to assess the levels they would give to these two case studies as a method of testing for changes in self-assessment capability during the trial.

We have also used a typical class test of as an indicator of the cognitive achievement of the students.

Findings
The data demonstrate only small correlations between summative scores and group work, seeking help and the use of symbols. These are all negative, i.e. the better the student scores in the final test, the lower they are likely to score themselves in these areas. At least part of the explanation for this is the trend for lower achieving students to grade affect higher during self-assessment, as noted on the case study scatter graphs. We also note that there is a wide range of values attributed by the students to the case studies. We interpret this as suggesting that, despite the careful language used in the attribute descriptors, and despite the use of a well-established framework, it seems that these students find it very difficult to make valid and reliable self-judgments of affect related to their own learning. Two areas where there are some modest correlation with cognitive test results are in group work and in seeking help. These are areas of affect that have clear and tangible outcomes in working routine. It may be that the students find these two areas easier to self-assess.

We have attempted to create a framework of self-assessment of affective aspects of learning. Our data suggests that the students in this survey found this very difficult over a six week period, and that the variation between students making similar assessments was considerable. This throws some doubt on the present trend to make students more independent in their learning, and to give them more control over their own learning. It seems that they lack some capability in discerning their own learning. It is likely, therefore, that they will make some misjudgements in deciding where to apply their effort in learning better. We question whether students will be able to take such control over their own learning.

This implies that students will continue to rely on their teachers for guidance in continuing learning. However, we do not know whether their teachers are much better at judging learning and this should be explored.

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ADDRESSING THE ICT PROFESSIONAL NEEDS OF RURAL AND REGIONAL SECONDARY SCIENCE TEACHERS

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Abstract: Over the last decade there have been signs of a growing divide between the scientific achievement of students from rural/regional and metropolitan schools in Australia. To identify and explore the reasons for this outcome a National Survey of secondary science teachers was conducted by the SiMERR National Centre. While all rural and regional science teachers were invited to participate, a sample of metropolitan teachers was included to facilitate comparisons. Data were collected using Importance and Availability Likert scales that were combined to produce an 'unmet need' score for each item. This paper identifies and discusses the ICT resources that emerged as being a critical area of need for secondary science teachers in regional and rural Australia.

Objectives

Over the last two decades a number of important studies around rural education have been undertaken in Australia. Many of these studies were commissioned by federal, state and territory governments to identify general educational issues concerning rural communities. While these outlined many of the fundamental problems, recent data emerging in Australia has demonstrated the difficulties of attracting and retaining teachers of secondary mathematics and science teachers to non-metropolitan schools (Federation of Australian Scientific Technological Societies [FASTS], 2002; Harris et al., 2005).

To explore these discipline areas further, a National Survey was undertaken by the National Centre for Science, ICT and Mathematics Education for Rural and Regional (SiMERR) Australia (Lyons et al., 2006). This comprised five separate surveys completed by parents, primary teachers, and secondary science, mathematics and ICT teachers. While a number of factors emerged from the analyses as being critical to helping science teachers meet the needs of their students, some of the most significant issues centred around ICT. The focus of this paper is to report on these findings as they provide critical information for professional associations and employing bodies about the kinds of professional development support required by secondary science teachers in rural and regional areas.

Significance

Given the tyranny of distance in Australia, it is interesting that there is a lack of existing literature about the challenges associated with the use of ICT in teaching in rural and regional locations. To date, the majority of studies undertaken in this area have either emphasised primary education (Angus et al., 2004) or explored ICT resources and the availability of support from the perspective of the ICT secondary specialist teacher. With the emphasis in education across Australian around the incorporation of ICT into all subject areas, it would seem topical to investigate the needs of subject specialists as they attempt to address the expectations of the science curriculum in this regard. Clearly, this is the view of governments too with the Ministerial Committee on Employment, Education and Youth Affairs (MCEETYA) supporting the push to “fully capitalise upon the revolution in online learning that is taking place” (2001, p. 5).

The significance of the National Survey is that it offered a number of substantial contributions to the body of existing literature. First, it focused specifically on school science, ICT and mathematics education. Second, it compared the different circumstances and unmet needs of teachers in four geographic regions: Metropolitan Areas, Provincial Cities, Provincial Areas and Remote Areas, and quantified these differences. Third, it compared the circumstances and unmet needs of teachers in schools with different Indigenous populations. Fourth, it provided greater distinction than previous studies between the needs of schools and teachers within and across these subject areas. Fifth, the analyses of teacher unmet needs were controlled for the socio-economic background of school locations, resulting in findings more tightly associated with geographic location than with economic circumstances. Finally, many of the earlier studies on rural Australia were based upon focus interviews, public submissions or secondary analyses of available data. The National Survey, on the other hand, generated a sizable body of original quantitative and qualitative data.

Theory

International comparisons (e.g. PISA, 2000; 2003) of student achievement in science suggest that Australian students are outperforming the majority of students in OECD countries (Thomson et al., 2004). However, the same authors highlight inequities between the achievement of students from rural and regional areas in Australia when compared to their metropolitan peers. For example, the mean for Australian students collectively for PISA 2003 was 525 (OECD mean was 500) with the mean for metropolitan students being 529, provincial students (regional) 516, and remote students 489. The respective standard errors of 2.6, 4.2 and 6.8 demonstrate significant differences between students’ achievement across the three geographical areas (Thomson et al., 2004). Similar patterns were found in the PISA 2000 data (Cresswell & Underwood, 2004).

To date, the factors influencing students’ science achievement in relation to location have not been explored. However, general studies on rural education (e.g., Alloway et al., 2004; Human Rights and Equal Opportunity Commission [HREOC], 2000; Roberts, 2005; Vinson, 2002) identified issues around the attraction and retention of suitably qualified teachers, the availability of professional development, accessibility of resources, and the availability of appropriate learning opportunities for rural science students.

In terms of ICT studies, Cresswell and Underwood (2004) and Vinson (2002) reported that rural and remote schools lacked the level of resources available to city schools, particularly in the areas of ICT connectivity. However, the literature provides little detail about resourcing disparities in science.

Design and procedure

Schools in the study were categorised according to the MCEETYA Schools Geographic Location Classification (MSGLC) based on population size and accessibility to facilities and services. The MSGLC has four main categories of location: Metropolitan Areas, Provincial Cities, Provincial Areas and Remote Areas (Jones, 2004).

Science teacher surveys were distributed to 1998 secondary schools in all provincial and remote areas of Australia along with a stratified random sample of 20% (*n*=291) of metropolitan schools. Teachers were invited to complete either a hardcopy or online survey. A total of 580 secondary science teachers representing 334 secondary schools across Australia completed the survey.

The science survey consisted of four sections designed to collect demographic data on responding teachers and their schools, as well as views on a range of issues identified in the literature as possibly affecting achievement in science. The sections included a: (i) Teacher profile; (ii) School profile; (iii) Science Department/Faculty profile; and (iv) Personal reflection. The survey consisted of two Likert scales around *Importance* and *Availability* along with a series of open response items.

Data were analysed using a number of analytical tools. Categorical data were explored through frequency analyses, cross-tabulations and chi-squared significance tests with a level of significance of .001. The *Importance* and *Availability* ratings from the Likert scales were combined to produce an 'Unmet Need' score for each item, where a higher value indicated a greater unmet need for the resource or opportunity identified. These data were analysed using Principal components analysis and a Multivariate Analysis of Covariance (MANCOVA), controlling for socio-economic backgrounds and school size.

Findings

Science teachers were asked to rate the Importance and Availability of a range of material resources and support items. Ratings on these two scales were combined to produce an aggregate "unmet need" score. Table 1 shows that of the six highest rating items, five related to ICT resources or support. In contrast, conventional science resources such as laboratory facilities, consumables, textbooks and resources for specific groups attracted only moderate to low ratings. The two highest needs were for student access to computers and for help in integrating ICT into science lessons. Supporting comments from respondents indicated that the main impediment to both is limited access to school computer laboratories, for which there is great demand. Even in schools with adequate numbers of computers overall, access by science classes appears to be problematic. Respondents also reported a high need for science related software, and for support staff to maintain the ICT resources.

Table 1. Mean 'unmet need' scores, standard deviations and valid N for science respondents' ratings of the Material Resources and Support Personnel items (items listed in descending order of mean 'need' score) [Scores can range from 1 to 20]

SCIENCE RESOURCE AND SUPPORT PERSONNEL ITEMS	Mean	s.d.	Valid N
Appropriate numbers of computers for student use	**10.11**	3.83	552
Suitably skilled personnel to assist in integrating ICT in your classroom	**9.80**	4.07	549
Suitable software for teaching & learning science	**9.73**	3.77	542
Suitable learning support assistant(s)	**9.65**	3.60	538
Other computer hardware for teaching & learning science	**9.56**	3.63	542
Suitably skilled ICT support staff	**8.99**	3.76	542
Effective maintenance & repair of teaching equipment	**8.88**	3.60	544
Classroom resources suitable for teaching science to gifted & talented students	**8.85**	3.54	531
Classroom resources suitable for teaching science to special needs students	**8.85**	3.76	520
A fast, reliable internet connection	**8.81**	3.70	551
Suitable computer resources for teachers use	**8.62**	3.71	554
Suitable Indigenous Education Assistants	**8.54**	4.38	518
Access to a wide range of internet science resources	**8.42**	3.49	546
Well-equipped science laboratories	**8.24**	3.10	552
Classroom resources suitable for teaching science to Indigenous students	**8.15**	4.05	519
Classroom resources suitable for teaching science to NESB students	**7.87**	3.89	489
Suitable laboratory assistant(s)	**7.74**	3.70	545
Suitable library resources (e.g., magazines, books) for teaching & learning science	**7.73**	3.24	547
Sufficient laboratory consumables	**7.70**	2.87	548
Suitable AV equipment	**7.33**	2.91	546
Class sets of suitable texts	**6.69**	3.32	543
Worksheets for classroom teaching	**6.01**	2.90	544

Further analyses revealed significant ($p < .001$) differences in the levels of unmet need for ICT resources reported by teachers in different locations. As might be expected, respondents in metropolitan schools indicated lower levels of unmet need than their rural colleagues for most of the ICT resources. However, the highest levels of need for most ICT related items were recorded by respondents in Provincial Cities (pop. 25000-100000), rather than by those in smaller or more remote areas. These items included fast reliable Internet connections, computers for student use and assistance in integrating ICT in the science curriculum. In contrast, science teachers in remote schools indicated a lower level of need for computers than colleagues in all other locations. On the other hand, they reported higher levels of need for ICT support staff than did their colleagues elsewhere. These findings are consistent with supporting comments revealing that many remote schools are relatively well equipped with ICT hardware, but lack the support personnel to maintain this equipment and help teachers to use it effectively.

The findings indicate that ICT resources and support are a high priority among Australia's science teachers. Nevertheless, it is also clear that the levels of priority vary with the type of ICT resource and the geographical location of the school. In particular, the evidence suggests that the level of need for ICT resources is not necessarily highest among the most remote schools, but rather among those in provincial cities and provincial areas. These findings have important implications for the resourcing policies of education authorities in terms of addressing the specific needs of science teachers in different locations.

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CHARACTERISTICS OF SCIENCE DEPARTMENTS IN JUNIOR SECONDARY SCHOOLS PRODUCING HIGH VALUE-ADDING FOR LOW, MIDDLE, AND HIGH ACHIEVING STUDENTS

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Abstract: This paper identifies those junior secondary 'schooling' processes that generated outstanding educational outcomes for science in six metropolitan, rural and isolated public schools in New South Wales. The focus of the research was on Years 7-10, which is often viewed as the 'black hole' of school education in Australia. Schools selected for the study had achieved high-value added results for low, middle and high achieving students over a four-year period. Data were collected from interviews with Principals, Deputy Principals, teachers, students and parents, structured and unstructured observations, and documentary artifacts. The main findings emerging from the analysis for science departments included; teacher-student relationships; climate of the department; availability of shared resources; teaching strategies to maximise learning opportunities for students; and links established between curriculum, pedagogy and assessment.

Objectives

It is often alleged that junior secondary schooling is the 'black hole' of school education in Australia. In most State and Territory systems there have been significant developments in *post-compulsory* and *primary* schooling (particularly in numeracy and literacy) (Askew et. al., 2000). While some interesting innovation has been attempted linking the late primary/early secondary 'divide' using '*middle* schooling' initiatives: the 'black hole' between primary school and Years 11-12 has been only sporadically the subject of any close scrutiny. In New South Wales, subject departments are the organisational structures around which subject and curriculum leadership is initiated and implemented in the junior secondary school (Tomlinson, in Busher, et. al., 2000). However, minimal research has been undertaken to explore their overall impact and effect on schooling. The study discussed in this paper was designed to identify and analyse junior secondary 'schooling' processes that generated high value-adding for students in metropolitan, rural and isolated NSW public schools. Emerging from this study was evidence to substantiate the critical role played by Science, Mathematics and English subject departments in enhancing student learning. The focus of this paper is to address the research question: What are the characteristics of science departments in NSW public schools that are producing high value-added results for their low, middle and high achieving students?

Significance

Improving educational outcomes in schools is an enduring concern in most national and international education systems (Sammons et. al., 1995). Reasons for school inspection systems (e.g., as conducted by OFSTED in England), adoption of common curriculum and examination routines, and various quality assurance mechanisms all have as their basis attempts to quantify and qualify significant factors affecting schooling. Nevertheless, obtaining information that is fair, unambiguous and which can be easily understood has not always proved feasible. Measures, such as school-average performance or the use of 'league tables' that rank schools have drawn extensive criticisms from various stakeholder groups. The results are not only potentially destructive as measures of school performance; they often provide no mechanism for schools to improve their performance (Patchen, 2004).

The NSW Department of Education and Training (DET) public schooling system is the largest in Australia. It oversees the collection of quantitative data for all students attending public schools based on a series of standardised literacy and numeracy tests (in primary school) and Year 10 reference tests. This data is provided to Principals annually and used by the school staff to reflect upon their success and failure in meeting student needs. In terms of the present study, access to this longitudinal data provided an evidence-based and defensible mechanism for identifying schools achieving outstanding educational outcomes for students in junior secondary science for inclusion in the study.

The significance of the study is that it provides insights about the processes and characteristics of school departments, providing a foundation for other schools to reflect on their own practices as part of professional renewal. It also celebrates the success of public schooling in Australia by sharing examples of how groups of teachers create effective learning environments for students in junior science.

Theory

A substantial body of research literature on effective schools and effective teaching already exists (Ayres et. al., 1998). Owens (1998) and Patchen (2004) provided a useful overview of effective schools research that highlights such issues as the importance of strong leadership by the Principal (Beare et al., 1989; Hannay & Ross, 1999; Sammons et al., 1997); high expectations for student achievement from staff; an emphasis on basic skills; an orderly environment; and positive reinforcement.

While, most of this research focused on the impact of Principals or individual teachers, subject departments represented by a group of specialist teachers in the school have received minimal attention. Yet, research evidence concerned with school improvement emphasises the importance of focusing on efforts to change practices at different levels within an organisation. The largest study of differential school effectiveness in the UK highlighted the importance of variations between subject departments in explaining differences in school performance (Busher & Harris, 1999; Sammons et al., 1997). As Hannay and Ross (1999, p.346) concluded, "we need far more research on the micro-processes involved in secondary schools."

This perspective was explored in a study conducted in NSW in 1998 around the effectiveness of teachers at the HSC (Higher School Certificate – Year 12) level. A critical finding emerging from the study was that teachers considered 'effective' practice was demonstrated by “subject departments in which students had, over a period of time, demonstrated significant … success in a particular HSC course” (Ayres et. al., 1998). Accordingly, the ‘subject faculty’ or department was one of seven factors that “contributed to HSC teaching success.”

Goodson and Marsh (1996, p.54) also observed that “the subject department provides the most common organisational vehicle for school subject knowledge, certainly in secondary schools, but unlike ‘the curriculum’ it has not been widely researched or much noted in our studies of schools.” Life and learning in secondary schools in Australia are organised in terms of subject matter; the school-subject remains the preferred focus of teaching and learning and the preferred form of curriculum realisation (Siskin & Little, 1995).

Design and procedure

The research sample for the project was identified using a number of data sources to ensure the validity of their inclusion in the study. Some of these included value-added results using basic skills data (collected in Year 5 and again in Year 10), continued success with students in Years 11–12, and nomination by an independent group within the educational community (i.e., District superintendents, Teacher’s Federation). Importantly, the value-added data had to be consistent for low, middle and high achieving students over a four-year period. Once an appropriate group of schools for science were identified, Chief Education Officers (CEOs) in particular locations and administrative district superintendents were invited to provide qualitative evidence to support the inclusion of each school into the study. As a consequence, six secondary schools were identified for science representing metropolitan, regional and rural areas of NSW.

The project employed a case study approach as a means of gauging the academic, contextual, social, cultural and other sociological factors impacting student achievement in the schools. It involved intensive on-site observations and interviews with teachers, students, senior executive, and parents over the period of one week. In addition, content analysis was undertaken on a series of artifacts including policy documents, curriculum, annual reports, and school newsletters. The research team included two university academics (including one science education specialist), a CEO, and Head Teacher of science from another local school in the area. At the completion of each study, tapes were transcribed and a research report produced that summarised the major findings emerging for a particular school.

These reports were ultimately coded using NUD*IST, which enables an analysis of text-based or narrative data via a tree-node system. Ultimately, this facilitated the development of a hierarchical index of topics, themes, concepts and ideas (Richards, 2002). Grounded Theory techniques (Glaser & Strauss, 1967; Strauss & Corbin, 1998) were used to analyse and interpret the data. The process involved a series of steps including identification of discrete codes, axial coding, and finally, selective coding based around a single construct.

Findings
Analysis of the data for science departments produced four major themes including: Department climate, Department resources, Teacher-Student Relationships, and Teaching Strategies. Within each of these areas a number of factors were represented.

Department climate
This theme comprised those factors that created the 'atmosphere' of the science department so as to create the shared vision and "camaraderie" that characterised the ways in which these groups of teachers worked in the school. These factors included collegiality, support for new and inexperienced staff, enculturation, catering for individual student differences, grouping practices for students, and assessment practices.

Department resources
In schools science departments had a degree of freedom to allocate monetary funds for particular resources based upon the needs of students and teachers. However, there were many different types of resources including human and physical that contributed to the outstanding educational outcomes achieved by students in Years 7-10 in these schools. Factors included were a stable core of experienced and committed teachers, high quality leadership (not only by the Head Teacher science), teaching programs, teaching spaces, and communal teaching resources.

Teacher – Student Relationships
A critical theme emerging from these schools was the high value placed on developing positive relationships between science teachers and their students. The following quote from a Year 10 student summarises the quality of the relationships evident in these schools achieving outstanding outcomes in Science.

It probably sounds really corny but our Science class, we're like a family. I know it sounds corny but … we talk about everything, we discuss everything comfortably and it's always been like that. (LCS)

Nurturing this kind of relationship required shared expectations, mutual trust and respect, and wider community endorsement. Ultimately, these factors contributed towards student self-esteem and confidence as well as academic achievement.

Teaching Strategies
This theme identified the learning opportunities for students created by science teachers within their classrooms. In understanding the strategies observed, each department consisted of an experienced group of committed teachers who had been together for long periods of time so generally shared a similar teaching philosophy and style. Subsequently, the students received consistent, quality teaching for all of their four junior secondary years of schooling. Factors identified within this theme included engendering interest and enjoyment of science, lesson structure and organisation, variety and type of tasks, classroom management, teacher professionalism, expertise and interest in science, reflective practices and goal setting, and professional development.

These findings identify a number of major characteristics of science departments associated with outstanding academic achievement for students in science in Years 7 to 10. These relate to specific qualities of individual teachers along with an ability to work collaboratively as a team in a professional and responsible manner. While the factors are presented as independent entities, a intricate interplay between these characteristics emerged demonstrating the complexity of teaching in the secondary context.

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PROMOTING DISCUSSION IN LOWER SECONDARY SCIENCE CLASSROOMS

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Abstract: This talk will inform participants about a qualitative research study, conducted in two Year 8 science classes of two secondary schools in Brunei Darussalam, that put forward three main aims: to promote students' talk in science classrooms; to elevate interest in students towards science; and to encourage collaboration among students and teachers for effective and meaningful learning and teaching respectively. The vehicle of discussion used was consequence mapping. The overview of the study and the learning resulted will be given. Recommendations for teachers on the usage of discussion will be provided. This talk will suit middle years teachers.

Objectives

Classroom discussion is one of the teaching strategies used by teachers, but is less popular than recitation and other teaching techniques. Many teachers have difficulties in using discussion although much research including Dillon (1994) and Osborne and Wellington (2001) had shown its advantages. According to Salleh (2005), discussion provides opportunity for language use in conjunction with Science learning in classrooms; teachers should treat 'talk' in classrooms as a resource for improving communication in English as well as providing learning opportunities in Science. The main aims of this study are to address the following key areas: 1. To promote students' talk in Science classrooms. 2. To elevate interest in students towards Science. 3. To encourage collaboration among students and teachers respectively for effective and meaningful learning and teaching.

Significance

Discussion is an old teaching technique; however, discussion was not particularly taught in the local teaching institutions. Throughout the author's fourteen years of schooling, the teaching of discussion was only practised by a small number of teachers. However, neither discussion skills nor discussion rules were taught or clarified to the author at any time, either by her teachers, lecturers, or colleagues. This realisation has driven the author to promote the usage of proper discussion in Science classrooms. This paper therefore focuses on the promotion of discussion in Science classrooms and its effects on students' and teachers' personal and professional developments. The three key questions which were raised in this study were: 1. How achievable is the promotion of discussion in Science classrooms? 2. What are the advantages and disadvantages of discussion in Science classrooms? 3. Would collaborative planning be of benefit to teachers in constructing discussion in Science classrooms?

Theory
Rapid changes have been made ever since Science education in Brunei Darussalam was introduced in 1972. However, the problem of low achievement and participation of students in Science subjects still persists (Matarsat, 2003); and many students unfortunately were not attracted to the study of Science, Mathematics and technical subjects (Othman, 1999). The possible reason is that the language and culture of Science are seen as foreign and not very meaningful (Othman, 1999). According to Maimunah (1999), the achievement of Science students and their lack of interest in learning were affected by the students' poor English proficiency level. This means that more time is needed for explaining terms at the expense of understanding Science processes (Matarsat, 2003). Teachers also share part of the blame for the possible reasons of low performance in Science students. The failure of teachers to stress the relevance and importance of the subject matter to their everyday life, and to devise strategies to make the subjects interesting, may have caused the unpopularity of Science subjects (Kanagasabai 1995).

The discussion of Science is essential to improving students' learning and understanding of Science (Osborne and Wellington, 2001); however, it is not a well-established feature of Science classrooms and in fact discussion is hardly ever used in science classrooms. Discussions in science classrooms tend to be whole-class activities, based on the teacher asking questions to direct the pupils' attention, to recall previous lessons, or to test their understanding of salient concepts (Osborne and Wellington, 2001). In any learning situation, peer-group interaction is an important element (Arora, 1986). The advantages of discussion in classroom include learning the subject matter discussed, and developing discussion processes, such as how to discuss the skills and practise the dispositions and behaviours of discussion (Dillon, 1994). However, there are some disadvantages too, particularly the difficulties faced by teachers and students in conducting discussion, such as it being time-consuming and having an uncertain outcome. Despite the criticism, the major discouragement comes from the teachers' capacities, principally their indisposition to discuss, the conditions of school and social systems, and especially their antipathy towards discussion (Dillon, 1994).

Design and procedure
The study involved two separate case studies of two different science classrooms from two distant secondary schools, with elements of action research. The elements of action research in this study engaged a variety of mechanisms, to monitor constantly the step-by-step discussion process, over varying periods of time, to bring about lasting benefit to the ongoing process as agreed by Cohen and Manion (1989). The selection of two different classrooms from two widely separated areas as two different case studies shows that the studies are relatively related to one another. The methodology used in this qualitative study involved observation, document analysis, interview and questionnaire.

The observation in each classroom focused on the discussion process of one group of four students, in which an emerging common discussion pattern initiated by the students was sought. Their discussion product, the consequence map was then analysed thoroughly. Prior to the discussion tasks, two discussion pilots (initial observation) were conducted; these were to enable the students to become familiar with the discussion task, and to help both participating teachers and students to improve their skills and understanding in developing the documents. Records of observation were conducted using audio and video machines with authorized permission. Although time-consuming, the records provide easier cross-checking of data; this confirms its validity.

The observed focus groups were also interviewed separately to gather information and confirmation on the development of their discussion processes. The focus group interviews took place in a separate room in their schools for half an hour. The difficulty faced during interview was that the students sometimes cut in their friends' conversations, forgetting the rule about answering one at a time.

As for the questionnaire, two types of tools were used, that is, ordinal scale and open questionnaire. The information was intended to share the students' opinions on the promotion, advantages and disadvantages of discussion in their science classrooms. Participating teachers facilitated the students, particularly in the translation of the questionnaire into Brunei Malay dialect. The participating teachers were James, a male Science teacher from School A, and Britney, a female teacher from School B.

Findings

Participants from both schools developed a near-similar pattern of discussion developed by the observed students from Schools A and B, although they knew little the rules of discussion. The pattern was repeated in each of the discussion tasks. It started with the translation of the words into Malay in order to make sense of the questions. After developing understanding or interpreting the questions given by their teachers, students identified the types of consequences assigned, that is, whether they were asked to find positive consequences or negative consequences, so as to correctly document them later in the consequence maps after discussion. During discussion, students communicated with each other by means of brainstorming or collecting ideas; arguing and agreeing with each other's contributions, and analysing and selecting answers. These answers were written down on the consequence map.

In the classroom, the participating teacher instructed the students to write and display their selected consequences on the board after discussion. Their answers were evaluated by the others, correcting technical mistakes such as spelling errors or wrongly drawn consequence arrows or lines. Thus, opportunities arise for reevaluation by the students themselves, allowing further learning. Interestingly too, the consequence items contributed were related to various science topics taught, either from Biology, Chemistry or Physics, even though the lesson topics for both classes were supposed to be on Physics.

The development of the discussion pattern, as well as students' positive reactions to the conduct of discussion, as observed in their interactions and writings show that promotion of discussion in Secondary Science classrooms is achievable and accepted by the respondents. Discussion is successfully promoted in two Secondary Science classrooms, and the impacts shown by the students are positive. The participating students and teachers share their positive perceptions on using discussion and listed the advantages and disadvantages of using the new learning format in their Science lessons. Discussion helps both teachers and students, since it develops their personal and professional skills. Discussion conducted among teachers is no different from the discussion conducted by students; therefore, the earlier the students are exposed to the correct method of discussion, the better it is for the benefit of all, as well as increasing interest in Science.

In addition, the teachers' self-esteem was elevated by listening to a colleague's experience in conducting the same task, and through collaboration between teachers, helping them to improve more, especially for a first-time discussion facilitator. Consequently, the research aims of this study have been fulfilled, that is, promoting student talk in science classrooms; elevating interests in students towards science; and encouraging collaboration among teachers and students.

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LINKING TEACHERS' KNOWLEDGE FOR PROFESSIONAL EMPOWERMENT

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Abstract: This study investigates perceptions of professional knowledge transfer during workshops conducted by the Centre for the Public Awareness of Science for Indonesian and Sri Lankan science teachers. The teachers believed that although teaching science in a culturally meaningful manner is a challenge to implement, it could be achieved through the development of specific professional knowledge bases. This paper discusses the role of science communication when facilitating effective knowledge transfer to professionally empower two culturally dissimilar groups of science teachers.

Objectives

Scientific knowledge, although a means of interpreting universally experienced phenomena, is grounded in social context and varies significantly within dissimilar cultures, with regard to its construction and transmission (Day et al, 1985). Consequently, many science teachers feel challenged when contextualising scientific concepts to suit their classrooms. In order to overcome this challenge, such teachers need to develop specific professional knowledge bases (Barnett & Hodson, 2001).

Science teachers receive a significant proportion of professional development support in the form of in-service programs. For the past eight years, the Centre for the Public Awareness of Science at the Australian National University has been conducting professional development workshops that focus on Constructivist pedagogy and employ simple, inexpensive materials. These workshops aim at professionally empowering science teachers by enabling them to make connections between their personal experiences and science context knowledge. The following study describes the experiences of two groups of science teachers from Sri Lanka and Indonesia, and the outcomes of these two workshops.

The main aim of this study was to investigate how science teachers' professional knowledge could be developed through culturally meaningful and effective knowledge transfer. This was achieved through the following objectives: 1. To investigate how science teachers from two socially and geographically diverse backgrounds would relate to pedagogical approaches that employ commonplace concepts and simple materials to teach science; 2. To conceptualize teachers' professional knowledge and propose possible means by which their professional empowerment could be facilitated; and 3. To examine the possibility of effective science communication strategies to overcome limitations when science is communicated across cultures with different value systems; especially where English is not the primary medium of instruction.

Significance

The professional development outcomes, which the teachers from Sri Lanka and Indonesia achieved through the workshops, underpin the importance of effective and meaningful communication (especially across culturally dissimilar groups), to facilitate transfer of professional knowledge. Effective means of communication are required to develop awareness among teachers of their own knowledge bases, which need to be linked with science content knowledge to facilitate learning experiences that are contextualized within the social framework of the classroom. Literature in education research confirms that students have a better appreciation of science when it relates to familiar social constructs with which they could easily identify (Stocklmayer, 2001 and Haney et al, 2002). Communication is however, strongly dependent on the culture within which it is contextualized (Bakhtin, 1986). Communicating science (as described above), with teachers who are linguistically diverse and belong to knowledge systems that are dissimilar to Western traditions is, therefore, a challenge to facilitate. It is expected that the outcomes of this study could be further applied to other cross-cultural efforts to professionally empower science educators.

Theory

There are two aspects of knowledge that are unique to the social context of each teacher: Personal Practical Knowledge (PPK: ie. that which is the personal professional domain of each teacher; Connelly & Clandinin, 1985) and Pedagogical Content Knowledge (PCK: ie. that which links content and pedagogy in the context of the classroom; Shulman, 1986). PPK and PCK also individually contribute towards teachers' professional development. Teachers who access PPK derive personal control and confidence to teach, while PCK enables teachers to make science content knowledge more accessible to their students. The ability to make connections between these two distinct spheres of knowledge would professionally empower science teachers and thereby allow for good science teaching to be implemented (Barnett & Hodson, 2001).

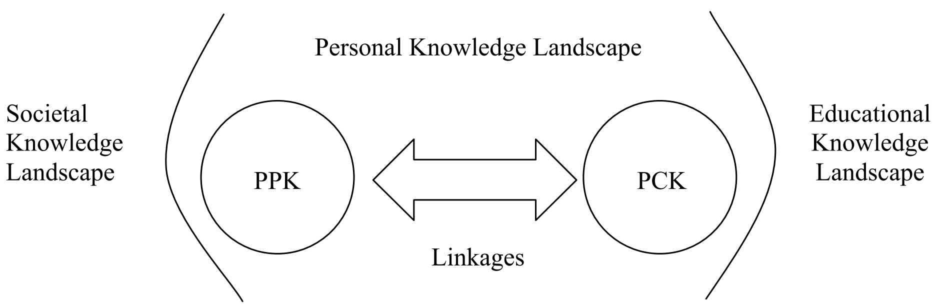

Figure1. A synthesis of teachers' professional knowledge landscape

Employing the *knowledge landscape* metaphor (Conelly & Clandinin, 1995), Figure 1 represents the interactions between the different terrains of knowledge that constitute teachers' professional knowledge landscape. Making connections between PPK and PCK requires 'linkages' to which teachers could easily relate and use to scaffold new knowledge. Since PPK and PCK are however, culturally dependent, it is more challenging to construct linkages for teachers from dissimilar cultures.

This study examines how effective science communication facilitates transfer of professional knowledge to construct linkages between teachers' professional knowledge bases. It is especially concerned with the transferability of professional knowledge by means of science communication based on Constructivist epistemology (Piaget, 1964) and the Theory of Multiple Intelligences (Gardner, 1983). Cognitive implications (Day et al, 1985) of linking PPK and PCK of socio-culturally dissimilar teacher groups are also investigated in this study.

Design and procedure

This study describes two separate professional development workshops conducted by the Centre for the Public Awareness of Science of the Australian National University, for secondary school science teachers. The first workshop was conducted in Sri Lanka (November 2005) for a group of sixty-two science teachers, while the second was a residential workshop in Australia for nine science teachers from Indonesia (August 2006).

Data for this study was gathered through participant observation records, teachers' feedback in workshop evaluations and through follow-up interviews and focus groups (Gall et al, 1996; Ball, 1997 and Keats, 1997). Interviews and focus groups were based on a series of semi-structured open-ended questions and sometimes mediated in the participants' mother-tongues.

Findings

Both groups of teachers agreed that teaching science through commonplace experiences and simple devices was more engaging and effective than the conventional methods to which they are accustomed. The teachers felt that they would be more likely to adopt this approach in their own classrooms because it is easy to relate to familiar concepts and less intimidating to use simple materials (than conventional laboratory equipment). All workshop participants acknowledged that the workshop was personally rewarding and professionally insightful. One teacher from Indonesia in particular remarked that "*There are many positive things that I can put into place at my school [about] the way science is taught…… The application of material-centred learning [ie. hands-on] in a real-life context (Translation)*".

When further inquiry was made about the transfer of professional knowledge, the participants responded that the workshops had empowered them to teach science creatively. Several of the teachers provided anecdotal evidence of utilising their personal knowledge bases (ie. PPK) to develop scientific learning experiences their students could easily relate to (ie. PCK). One such instance reported by a Sri Lankan science teacher describes how she substituted local household products to achieve similar results that were obtained from some of the workshop activities. It is evident from similar findings that the workshops didn't merely equip teachers with 'a bag of tricks' but had facilitated a significant level of professional knowledge transfer.

While investigating the communication which allowed for the transfer of professional knowledge, there was concern from the facilitators about the medium of communication. Given that the teachers primarily communicated in their own mother-tongues and that linguistic constructs are socio-culturally entrenched (Bakhtin, 1986), there was speculation whether English language as the medium of communication would have impeded any of the desired outcomes at the workshops. Both groups of teachers however, did not believe that an interpreter would have had an effect on improving the workshops' communication. Instead they alluded to effective communication strategies that were employed during the workshops, which on closer analysis revealed to be underpinned by elements of scientific communication (Stocklmayer, 2001), and to conform to Constructivist epistemology and the Theory of Multiple Intelligences.

This study provides evidence that professional knowledge transfer to empower culturally dissimilar groups of science teachers could be facilitated through science communication that is constructed effectively. In conclusion I would like to include a statement from one of the teachers: "*Some teachers continue to teach what is wrong, even though they know and believe it to be wrong, because they don't feel they have the power to correct it……We were made to feel that is alright to teach differently when we believe so ……we feel empowered.*"

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E-LEARNING IN MALAYSIA: ADULT PERCEPTIONS AS A METHOD FOR FURTHER STUDIES

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Abstract: This paper will inform participants about investigation that focused on e-learning in institution of higher learning, adults' perceptions on e-learning as a method for further studies. An online survey and printed questionnaire were conducted to find out about adults' perceptions, expectations on e-learning program. I will give an overview of the study and the survey results. Implications of the study and suggestions to institutions that engaged in e-learning for adult market will be outlined as well. This research will suit institutions and individuals involve in e-learning.

Objectives

The world economy has reached a stage where human capital is the main key to competitiveness. Human resources, intelligence and productivity are critical forces in determining economic and national development. In order to produce quality manpower, a well recognized education system is very important. The education sector was given an important role of developing a pool of knowledge workers who are productive, innovative, trainable and knowledgeable. Though there are many encouraging efforts being carried out towards this role, the percentage of young Malaysians enrolling in tertiary education was only 22% in 2001, based on the Youth Information Network (Business Network, 2002). This is a very small number compared to other countries like United States, where more than 70% of youth are enrolled in tertiary education. Considering the large pool of Malaysians not having the opportunity to receive tertiary education, there should be efforts to give them another educational opportunity. One of the ways that has been widely used in the industrialized countries is providing technology enhanced learning or electronic learning (e-learning) to the adults.

E-learning, as a method evolved from distance education, has received special attention from public universities in implementing distance learning courses. Comparing the enrolment of e-learning courses in virtual universities and traditional classroom lectures courses in conventional universities, the former is still far behind. The main purposes of the study were to understand the perceptions, acceptance and expectations of a sample of Malaysian adults on e-learning education. The research questions were: 1) How do adults perceive e-learning and how well can they accept this learning method? 2) What are the adults' expectations on e-learning programs and implementation, as compared to the traditional classroom method? Based on the findings, suggestions to higher education institutions were made.

Significance

According to the research firm Web Market Education based in Vancouver, Canada, the worldwide market for e-learning reached US$90 billion (RM342 billion) in year 2002 (Katz and Yablon, 2003). To prevent Malaysia education industry from losing out in this attractive market, this study is significant in providing an exploratory knowledge of e-learning education in Malaysia. Searching the literature will produce an overview of e-learning courses/programs offered in education institutions.

This study seeks to provide an opportunity for the adult market to voice their views about e-learning education. The target market group can give ideas on what a good and effective e-learning course should be like, and they can also share their concerns on e-learning education in the Malaysian institutions of higher learning. By conducting a survey on the prospective learners who are mature intellectually, the study aims to gain a better understanding of the adult perspective towards e-learning as an method for their lifelong learning.

For adults who are not aware of this learning method, this study can instil the awareness of e-learning and create a lifelong learning possibility for them. Their exposure to this study can trigger their thoughts and mind to further improve themselves. By becoming more aware of the e-learning method, adult learners can add values to their qualifications and skills.

Theory

According to Kenzo (2001), e-learning is an educational system concept which differs from the traditional ones in the sense of Information Communication Technology (ICT) based teaching and learning. It has four main functions: (i) delivery of ICT based contents; (ii) open access, storing, sharing, dissemination of teaching contents over Internet; (iii) virtual education at remote sites; (iv) knowledge-based processing. For Strokes (2000), e-learning uses network technologies to create, foster, deliver and facilitate learning anytime and anywhere. E-learning is characterized by speed, technological transformation and mediated human interactions. Gunaskeran, McNeil and Shaul (2002) have similar opinion that e-learning provides faster learning at reduced costs, increased access to learning and clear accountability for all participants in the learning process. It allows people and organizations to keep up with changes in the global economy that now occur on Internet time. They also concluded that e-learning can result in greater productivity, increased profitability and enhanced employee loyalty. It provides information from a greater variety of sources, increased access to knowledge for lifelong learners, improved quality of service and rapid adoption of new information and new programs.

> Adult learners represent a variety of learning styles. The interactive capabilities of some distance learning technologies, especially those available through the Internet may be more attractive to adults. As distance learning should and usually does involve multiple media to present course information, adults may like distance learning courses better than traditional classroom-based courses or in-house training sessions conducted in a laboratory (Kirkpatrick, 1994).

There have been many surveys and research studies conducted on the topic of e-learning. Lee, Ng and Ng (2001) found that perceived usefulness and ease in using computers can affect learner's attitudes. Having a positive perception can help to encourage a positive attitude towards online instruction and interactive learning. In their conclusion, past experiences and attitudes toward computers could affect learners' readiness for virtual learning. Katz and Yablon (2003) carried out a survey to assess the expectations, motivation and satisfaction of students regarding the use of Internet-based methodology as opposed to traditional lecture-based courses for the mandatory first-year 'Introduction to Statistics' course. The results showed that students who participated in Internet-based courses were able to reach achievement levels similar to those attained in traditional lecture-based courses. Prior to this, a study at California State University of Northridge had a similar result (McCollum, 1997). The study had divided a Statistics class into a traditional class and online class using World Wide Web. It is found that students who took the online course performed better than the others.

Design and procedure

This is an empirical study employing survey method, which save time and cost while being able to reach a wide variety of respondents. The questionnaire survey method allows for a wider spread of sample in short period of time. It also allows generalization to be made concerning characteristics of the entire population being studied. (Wee, 1999) Two forms of questionnaires were developed – one paper-based and one online. Both forms of questionnaires, which were identical in content, catered for general opinions, were distributed to the adults through researcher's contacts. Respondents for the paper-based questionnaire were required to return the completed questionnaires before the deadline given. By doing this, the time required to wait for completion of questionnaire was controlled with the help from researcher's contacts, and a higher response rate within limited time frame was ensured. An online survey form was designed to reach adults who have frequent access to the Internet. The cost was reduced with this paperless contact and free hosting service from the Internet. The questionnaire was posted online and the link was sent by e-mail to adults through researcher's contacts. Both printed and online surveys were done by distributing questionnaires to a snowball sample of adults in public.

Findings

The data collected revealed that e-learning has received attention and concern among Malaysia adults. A majority of the respondents who participated in this survey had heard of this learning method. The e-learning method also gives positive perception to them. Generally, adults perceived e-learning as a learning method that can give them high flexibility in time management, can suit their different learning abilities and was important to have good information technology knowledge to involve in e-learning. They also considered e-learning as a cost effective method for learning. However, they did not perceive e-learning as an interactive medium to promote group interaction and strengthen communication with peers and instructors. The lack of 'human' factor in e-learning may have caused majority of them to doubt its ability to provide quality education. From the study, it is also learned that this learning method has been widely accepted by adults. Though many of them appealed to on-the-job-training learning method, they were willing to give it a try if there was an opportunity. Nevertheless, their willingness to try will be affected by the quality issue concerning e-learning as there was a significant relationship between these two aspects.

The traditional classroom method is a widely used method in schools, colleges and institutions of higher learning. Adults have gone through this method of learning at many stages of their life. To measure their expectation on e-learning programs and implementation, a comparison was done with the traditional classroom method. A majority of adults expected e-learning to be equally as good as traditional classroom method in terms of quality. They were also quite positive that e-learning method would be replacing the traditional classroom method in future. However, the replacement may need more than five years to be realized. During this time, e-learning is expected to be continuously improving and be more widely recognized for its quality.

Results from the survey suggest that institutions should look into ways of improving quality perceptions on adult learners. Whenever offering an e-learning program, quality aspects on the program, instructor, learning materials, quizzes, examination formats and learner supports should be emphasized. The institutions can position themselves as quality driven academy by getting some worldwide recognition for their e-learning programs. Findings from the survey also showed that most of the respondents were concerned on the lack of human interactions elements in e-learning. Institutions and instructors may need to modify their delivery system by putting more human elements in it.

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MONITORING PREPAREDNESS OF FIRST-YEAR STUDENTS IN CHEMISTRY FOR PLACEMENT AND IMPROVED TEACHING

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Abstract: This study addresses the need for thorough assessment and monitoring of baseline conceptual understanding in chemistry at the secondary-tertiary interface to inform placement and teaching at the tertiary level. It reports on the development and rigorous testing of a test instrument for this purpose, its design criteria, performance and predictive power. Research was carried out at three universities that are representative of the tertiary landscape in South Africa. The results indicate that placement at some of the institutions could be revised to avoid duplication and sharpen the focus of academic offerings at these institutions.

Objectives

Curriculum and syllabus changes at secondary level introduce uncertainty amongst lecturers at tertiary level about shifts in the proficiencies and the overall level of preparedness of incoming first-year students in chemistry. The objective of this study was to draw up a Chemical Concepts Inventory for first-year students upon entry to tertiary education. A valid and reliable instrument was developed for monitoring preparedness during a period in South Africa in which syllabus changes were introduced at secondary level and government funding formulae for tertiary institutions were modified to reward increased throughput.

Significance

This study addresses the need for thorough assessment and monitoring of baseline conceptual understanding in chemistry at the secondary-tertiary interface to inform placement and teaching at the tertiary level. Research is being carried out at three universities that are representative of the tertiary landscape in South Africa, i.e. the University of Pretoria, the University of Cape Town and the University of Limpopo.

The test instrument developed in this study was rigorously evaluated according to principles from classical test theory as well as according to the Rasch model (Bond & Fox, 2001). The Rasch model elevates test design to a level of sophistication and rigour that is not possible when using raw scores only. It converts raw score test data into linear measures of person ability on the underlying construct, which is preparedness for tertiary chemistry in this case. On an ordinal measurement scale, scores are merely numerically ordered, and are often assumed to be linear. This assumption of linearity of raw score data will only hold if the difficulty gaps between each of the items are equal and if the items span the range of the trait being measured. (Boone & Rogan, 2005). Intuitively one knows that this is not the case. For example, it is much harder for a candidate to raise her performance from 95% to 100% than from 45% to 50%. Through the Rasch model, raw scores are transformed to an interval scale, where each interval has an equal distance. The difference in ability reflected by person measures of 1.50 and 2.00 is exactly the same as the difference between 0.20 and 0.70. In addition, the Rasch method generates linear item measures to reflect the relative difficulty of items. Person abilities and item difficulties can be aligned on the same linear scale using a unit called a logit. Information obtained from such an item-person map was used to evaluate the quality of this test instrument to ensure that items covered a range of difficulties appropriate to the range of abilities within the mainstream cohorts of students. The Rasch method also allows for equating of the test instrument for comparison of results collected over many years even if the instrument is modified. This makes it ideally suited for the monitoring of shifts in proficiencies of incoming students in chemistry over a period of time. Its use as a diagnostic tool and its potential to inform placement of chemistry students within different programmes in tertiary education was demonstrated.

Theory

First year syllabi in most SA tertiary institutions are fairly homogeneous and are not likely to undergo major changes in future. From the perspective of tertiary chemistry education, there is a need to establish the baseline knowledge and understanding of the discipline on which to base teaching at first year level. "The most important single factor influencing learning is what the learner already knows. Ascertain this, and teach accordingly." (Ausubel, 1968). This statement may be expanded to state explicitly the need to ascertain the level of conceptual understanding in addition to content knowledge. The nature of teaching and assessment of the physical sciences at secondary level tends to be predominantly procedural in nature, while conceptual understanding is both required and nurtured in tertiary science education.

Design and procedure

The design of the test instrument was dictated by a number of considerations. These included content validity (coverage of fundamental concepts generally accepted as prerequisites for first-year chemistry), assessment of conceptual understanding rather than recall or application of practiced procedures, assessment of representational competence (*i.e.* the ability to interpret symbolic, semantic and schematic representations) and the inclusion of test items for prediction of success at first-year level. Items assessing basic mathematical skills were included since mathematical aptitude is well documented to be one of the strongest predictors of success in first-year general chemistry, followed by a basic knowledge of chemistry concepts (Wagner, Sasser, & DiBiase, 2002; McFate & Olmsted, 1999).

The majority of test items included in this instrument were obtained from sources in the literature (Mulford & Robinson, 2002, Krishnan & Howe, 1994, Huddle, 1998, Smith & Metz, 1996, Ogude & Bradley, 1994, Wagner, Sasser & DiBiase, 2002, and McFate & Olmsted, 1999). During several rounds of refinement 65 items with excellent item characteristics (good item-total correlation, good spread across different subtopics and appropriate range in the level of difficulty) were selected. The majority of these test items are in a multiple-choice format. The rest include short answer questions and a self-constructed drawing that are assessed and coded by examiners. The test items are divided into two similar subtests (Test A and Test B) in order to restrict the time required for administration. Both subtests consist of 37 items including 9 anchor items that are common to both subtests to allow for merging of results.

The test instrument was administered at the beginning of the academic year in 2005 before instruction commenced to three groups of first-year students at the University of Pretoria, UP, (mainstream, Extended Programme and Foundation Year students), two groups at the University of Cape Town, UCT, (mainstream and Academic Development Programme students), and two groups at the University of Limpopo, UL (mainstream and Foundation Year students). The UP Extended Programme and the UCT Academic Development Programme are similar in the sense that the mainstream first-year syllabus is covered over a period of two years and is supported by extensive supervised problem solving sessions. Both UP and UL sponsor an additional Foundation Year Programme (UPFY & UNIFY) exclusively for students with good potential from previously disadvantaged communities. These programmes prepare students for tertiary education by strengthening their secondary foundation.

Findings

The internal consistency of the subtests of the instrument was determined for each sample group. The Cronbach alpha coefficients (Cronbach, 1951) computed with SPSS software® gave values between 0.80 and 0.83 for the mainstream cohorts of UP and UCT. The Rasch reliability of the whole instrument was found to be 0.81.

General trends

A thorough analysis of response frequencies highlighted a number of aspects with direct implications for teaching at first-year level. These results have been reported elsewhere (Potgieter et al., 2005), but will be summarised here. It is clear that the mole concept is still poorly understood. Students lack a sound foundation in chemical equilibrium and organic chemistry, and their preparation for electrochemistry is so weak that lecturers would have to adjust their teaching accordingly. Students struggle to carry out manipulations of algebraic expressions containing exponents. The inadequacy of mathematical skills is a factor which must be taken into account, especially when teaching topics such as stoichiometry, gas laws, acids and bases, and chemical equilibrium. Results also show serious inadequacies in the ability of students to translate between different thinking levels and modes of representation.

Comparison of cohorts

Figures 1 and 2 show the ranges of person measures for mainstream cohorts and development programmes, respectively. These person measures are a more accurate indication of ability and level of preparedness than traditional raw scores results. In terms of the Rasch model, a person with an ability measure of 0.0 logits (X-axis in Figures 1 and 2) will have a 50% probability of answering items of the matching difficulty level correctly, and a higher probability of correctly answering easier items or a lower probability of correctly answering more difficult items, respectively. The same person will have a 25% probability of correctly answering items with a difficulty of 1.00 logit and a 75% probability of correctly answering items with a difficulty of -1.00 logit. (Bond & Fox, 2001, p29).

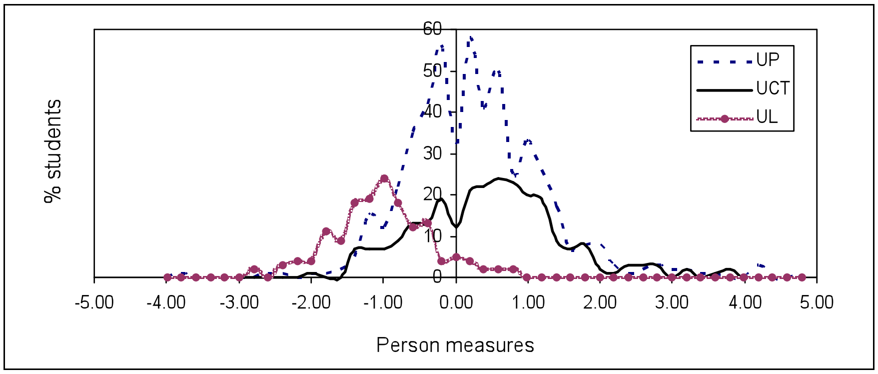

Figure 1 Person measures for the mainstream cohorts

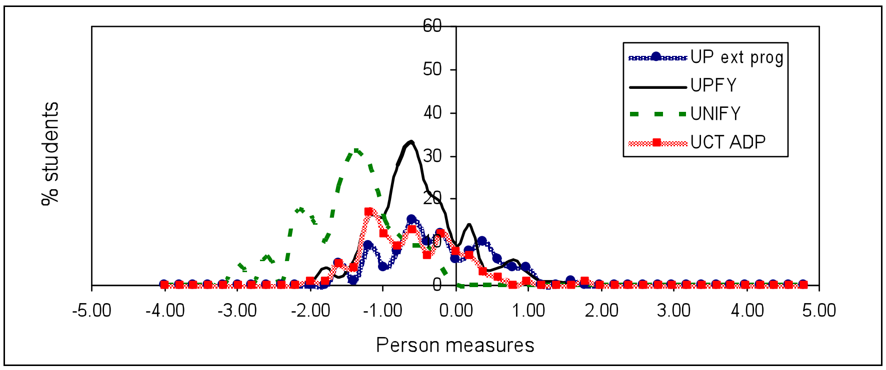

Figure 2 Person measures for the academic development cohorts

Analysis of Figures 1 and 2 reveals that the majority of mainstream students at UCT and UP have a better foundation for first year chemistry than the other cohorts. By contrast, this is true for only a small number of UL mainstream students. Most of the students in the foundation or development programmes are poorly prepared for chemistry at the tertiary level. There is no difference in the range of abilities of students in the UPFY and UP Extended Programmes. UL mainstream students are only marginally better prepared than those in the UNIFY cohort. An extensive intervention will therefore be required to prepare both groups for university chemistry.

Placement

The test instrument combined with Rasch analysis of the data shows promise as a placement tool for chemistry departments to maximize the contribution of foundation and/or extended programmes to throughput in chemistry. There seems to be duplication at the University of Pretoria in the sense that the range of student abilities within the Foundation Year Programme (UPFY) and the Extended Programme are very similar.

This situation is clearly untenable from a cost perspective. There is a moderate correlation of person measures with academic performance in mainstream first year chemistry; 0.561 at UCT and 0.563 at UP. Performance in matric mathematics is used as the strongest indicator for placement by tertiary institutions in South Africa. The correlation between performance in matric mathematics and mainstream first year chemistry in 2005 was 0.487 at UP and 0.734 at UCT. The selectivity and specificity of the instrument as a whole and the predictive power of a selection of test items are currently being assessed.

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EFFECT OF PARENTAL SOCIOECONOMIC STATUS AND STUDENTS GENDER ON SCIENCE ACHIEVEMENT

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Abstract: The substantive aim of the study was to 'examine the effect of parents' socioeconomic status, students' gender on academic achievement in science. The population of the study consisted of the students who were enrolled in science subjects at grades 11 and 12 in 366 colleges in 34 districts of the province of the Punjab, Pakistan and the sample size was 2144 students studying in grade 11 and 12. It is concluded from the study that the independent variables of parents' socioeconomic status, father's education, mother's education, father's occupation, and students' gender have significant effect on the dependent variable of science achievement in grades 11 and 12 in Pakistan.

Objectives

Science, as an important area of education, remained and served as basic requirement of every society. The study and exploration of science has and will continue to be an important component for our global future. It is universally recognized and accepted by science educators that attention must also be directed toward preparing people to use science and technology to improve their lives and to adjust changes taking place in the world around them. The American Association for the Advancement of Science (AAAS) (1990) acknowledged that "without a science literate population, the outlook for a better world is not possible". It is revealed from a number of research studies that students' academic achievement (cognitive domain) appeared to be shaped by a number of factors, which include: parental socioeconomic status, parental influence, self concepts, ability, gender, teacher, and learning environment at home and school (Singh et al., 2002; Schreiber, 2002; Okapala et al., 2001; Joyce & Farenga, 2000; Simon, 2000; Henderson et al., 2000; Elliott et al., 2000; Francis & Greer, 1999; Verna & Campbell, 1999; Gertz, 1999; Brznitz & Norman, 1998; and Caldas & Bankston III, 1997). Socioeconomic status is one of the most interesting and important issues in the natural and social sciences. This status is measured through socioeconomic indicators such as parental education, family income, and occupation, housing facility and material possession (Gray and Auld, 2000; Adler, et al. 1994; and Ornstein and Levin, 1993). Researcher has found that academic achievement correlates better with socioeconomic status than with any other separate variable (Singham, 1998). Caldas and Bankston III (1997) studied the relationship between family socioeconomic status and individual academic achievement. The researchers found that individual's family social status has an even greater positive effect on academic achievement.

Significance

Science education occupies a very eminent place in curriculum both at school, college, and university stages of education all over the world. Continuous advances in scientific and technological research have led to the growth and greater application of science in contemporary society. Accordingly science becomes a priority area in education, both at the compulsory education level as well as the level of specialization. Science education is supposed to perform a two-fold task. The prime objective, in individualistic perspective, is the cultivation of a scientific temper, which includes a spirit of enquiry, a disposition to reason logically and dispassionately, a habit of judging beliefs and opinions on available evidence, readiness to reject unfounded theories and principles, the courage to admit facts, who so ever, unsettling or disagreeable they might be, and, finally, recognizing the limits of reasoning power itself. It is also expected of science education that it would give individuals a firm grasp of the concepts and processes of science and impart to them the ability to use the scientific method of problem solving and the techniques of observation and experimentation in handling problem of comprehension or life. At the societal level, one of the major objectives of science education is to equip individuals to participate in the creation of a society which is free from poverty, hunger, disease and evils such as violence, exploitation, oppression, etc.

Pakistan entered into the twenty-first century, as an independent nuclear state. It is our national duty to create an environment through which Pakistan can gain scientific independence. We must build up our own scientific and technological potential to solve our problem and avoid dependence on foreign expertise. This purpose can be achieved only through high quality science education, which in turn will affect the career choice in science. This study by exploring the factors which influence the students' science academic achievement will help the curriculum planners, policy makers, science teachers and parents to coordinate in an effective way so that our students, after graduating from our educational institutions, have favorable science-related attitudes and better science achievement.

Theory

According to Walberg's theory on educational productivity, there are nine factors that contribute to the variance in students' cognitive and affective outcomes. The factors are students' ability, maturity, motivation, the quality of instruction, the quantity of instruction, the psychological environment at home, classroom environment, the peer group outside the classroom, and the time involved with video/television media (Walberg, 1984). The model was successfully tested as part of a national study showing that student achievement and attitudes were influenced jointly by these factors (Walberg, Fraser, & Welch, 1986).

It is revealed from a number of research studies that a significant difference exists between the achievements of students from a high and low socioeconomic environment (Okapala et al., 2001; Smith & Croom, 2000; Caldas & Bankkston III, 1999; Desimone, 1999; Gertz, 1999; Stambler, 1998; Brown & Evans, 1998; and Kruse, 1996). Out of the following three major factors: occupation, income and level of education, researchers have found that the last is the most influential in students' academic performance (Eggen & Kauchak, 1999).

Design and Procedures

The population of the study consisted of the students who were enrolled in science subjects at grades 11 and 12 in 366 colleges in 34 districts of the province of the Punjab, Pakistan. Keeping in view the parents' socioeconomic status (parental education, father's occupation, family income, parents own a house, transport and other facilities at home) 34 districts were classified into Five Groups on the basis of literacy rate, and percentage of economically active population of the district. The information about these parameters of each district was collected from Census Reports 1998. Twenty-five percent colleges from each group were randomly selected by applying cluster sampling technique. In this way, 88 (44 male and 44 female) colleges were selected (18 from group 1, 10 from group 2, 32 from group 3, 12 from group, and 16 from group5). A total of 2400 set of research instruments were sent to the students studying at grade 11 and 12 in these 88 selected colleges and 2144 set of research instruments were received back.

The demographic information was collected through Demographic Variable Information Proforma (DVIP) developed by the researcher. The information about science achievement scores of students at intermediate level (grade 11 and 12) were collected from the Result Gazette for the Intermediate Annual Examinations of all the eight Boards of Intermediate and Secondary Education in Punjab. Data were analyzed by applying Analysis of variance and t-Test.

Findings

Verna and Campbell (1999) concluded that parents' socioeconomic status was found to influence achievement. Breznitz and Gabriella (1998) concluded that students from low socioeconomic background performed more poorly than students from high socioeconomic background. Caldas and Bankston III (1997) found that individual's family social status had greater positive effect on academic achievement. Velez et al. (1993) discussed that socioeconomic status, measured by parents' education or occupational status was positively associated with achievement. The present study also found that students from high socioeconomic status obtained higher means (648.87) on science achievement in the Intermediate Examination than the students from average (528.13) and low socioeconomic status (488.33).

Greenfield (1996) discussed that statistically significant differences in achievement were found among students on the basis of their gender. Subotnik and Strauss (1994) examined gender differences in classroom participation and achievement and concluded that gender affect the performance of students in class. Mirza and Malik (2000) concluded that overall performance of girls was better than that of boys at all levels of education starting from primary to college level in Pakistan. The present study concurs with Mirza and Malik (2000) and Greenfield's (1996) findings that science achievement of female students (Mean=583.62) in the Intermediate Examination was better than the science achievement of male students (Mean=505.62).

It is concluded from the study that the independent variables of parents' socioeconomic status, father's education, mother's education, father's occupation, and students' gender have significant effect on the dependent variable of science achievement in grades 11 and 12 in Pakistan.

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SCIENCE ON THE FRONT PAGE: VALUES AND SCIENCE IN EVERYDAY NEWS

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Abstract: Out-of-school opportunities for science learning are contextualized socially, culturally, and politically, and thus convey value-laden representations of science. What does this mean for students who engage with science in out-of-school settings? How might it affect people's perceptions, ideas and understandings about science in their everyday lives? This paper uses an interactive contextual model to depict the processes and factors influencing people's response to a science learning opportunity. The model is described and its use illustrated in the context of learning about science from front page newspaper stories. The paper is suitable for all levels of science learning.

Objectives

This paper is about the value-laden representations of science in everyday newspaper stories and what they might mean for the people who engage with them. What kinds of values are portrayed? Where do they come from? How might they affect people's perceptions, ideas and understandings about science in their everyday life? These questions are explored using an interactive contextual model to depict the processes and factors influencing people's response to an opportunity to learn about science. The purpose of this paper is to describe the model and to illustrate its use in the context of learning about science from everyday news stories, where the "newsworthiness" of the science is subordinate to the entertainment potential of the news event.

Significance

Learning in and about science occurs through all kinds of human experiences, both in school and out. Out-of-school engagement with science includes interaction with one's family, peers and acquaintances; the media – written texts, broadcast media and the Internet; public institutions, such as science museums and interpretative centres, whose mission activities frequently incorporate education relating to science; and government and community organizations that provide science-based information. To a greater or lesser extent, these out-of-school opportunities for science learning are contextualized by socially, culturally, and politically determined factors, and in this way they convey value-laden representations of science. The considerable research base on learning science outside of school contains little explicit reference to values. Yet, for school children, and especially for those people whose formal schooling is past, out-of-school experiences are influential determinants of how they think about science and make science-related decisions about issues in their everyday lives.

The ability to read, understand and evaluate newspaper articles relating to science is considered to be fundamental to scientific literacy (Millar & Osborne, 1998; Shamos, 1995). The findings of considerable research based on high school or university students' ability to read critically newspaper reports in science were summarized by Bisanz and

Bisanz (2004) to reveal generally poor skills in following scientific argument and evaluating credibility. Values have not been dealt with explicitly in this body of research, neither has there been a research focus on "everyday" news stories that are topical yet have a significant science aspect. When the intention is not to communicate science, but to engage readers, the inflection of social values may be considerable. This is particularly so when the stories are front-page news. Chubin (1993) argued "that people learn and form opinions about science from the front page of the daily newspaper" (p. 334) so it is of interest to examine what might be learned about science from stories considered by editors to be of sufficient interest to appear on the front page.

This paper's significance lies in the interactive contextual model proposed to describe how science information is recontextualized into a science story with which people may interact, and the factors affecting that interaction. The model has broader application in the communication of science, it is demonstrated in this paper in only one context: the implicit communication of science in newspaper stories that appear on the front page. Specific focus is placed on the interaction between values relating to the nature of science, and values relating to social, civic and environmental responsibilities.

Theory

The nature and outcomes of engagement with science in out-of-school contexts is a multi-factored process and the outcomes depend on both the way science is presented and the characteristics of the person who engages. Figure 1 provides a simple diagram of the key elements in this process. At the top of Figure 1 is depicted the Science (shown with a capital S) that is familiar to scientists; the product (and process) of scientific research. To enable a lay person or a school student to access that science, there needs to be some interpretation of it, an encoding perhaps, into a form more readily understood. Such interpretation might result in a media report, an information brochure, an easy-to-read internet site, or a school text book. The process of interpretation deconstructs and then reconstructs the Science information into a science-related story. (I use the term "story" as does Milne, 1998, in that once ideas are presented selectively we are not telling the facts, we are telling a story.) The choices made in this restructuring process depend on its purpose and imbue the story with the values of the interpreter(s). When a person engages with this science-related story, what is understood and learned may be unique to the individual, because the nature of the person-story interaction depends on the personal context of the individual, including his or her background experiences, interests, and motivation for engaging with the story. In order to make use of any information gained, people deconstruct and reconstruct the story into a form that is useful to their personal needs and circumstances. Their subsequent understanding of the story and any decisions they might make on the basis of it are bound up with their own value system.

The model in Figure 1 depicts an interactive, contextual process in which values play a major role. It has constructivist and socio-cultural underpinnings and is informed by an extensive body of literature about the communication of science and why and how people learn science from a range of out-of-school sources, in particular how they rework and recontextualize science information into a form that makes sense to them (see, for example, Falk & Dierking, 2000; Goldman & Bisanz, 2002; Layton, Jenkins, Macgill, & Davey, 1993; Silverstone, 1991; Wellington, 1993; Wynne, 1991)

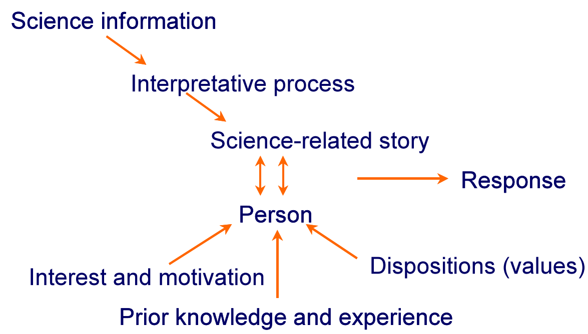

Figure 1 Responding to a science story is an interactive contextual process

The interpretation of Science information into a science-related story in a newspaper combines journalistic and editorial processes that are well-described by science journalists and analysts (e. g., Nelkin, 1987; Spinks, 2001). Nelkin (1987) identified three critical kinds of decision-making in the journalistic process – selecting what is news, what aspects of it should be reported, and how it will be written about. The values of the journalist will be called upon in making these kinds of decisions. Once written, the science story passes through the editorial and sub-editorial value filters, and the Science information may become subordinate to the entertainment potential for readers. The decision to publish at all may depend on whether or not it is a “slow news day”.

Clearly, this interpretative process of moving from Science information to science-related story involves myriad decisions, most of them based on values other than the epistemic values related to the nature of science and scientific knowledge. The result is a value-laden science-related story that an individual may choose (or not) to read. Willingness to read the story, ability to understand it, and the reader's response to it, are influenced by the personal circumstances/context of the reader. An individual seeing the story may read it in order to become informed, or because they are interested or curious, or because it contains information particularly relevant to them. A story about a new biological control for aphids on roses may interest a gardener, for example, who chooses to reduce the use of insecticides in favour of the biological control. Such examples demonstrate how the cognitive, affective and volitional dimensions of values come into play. Other times, the potential reader may be indifferent to, or even avoid engagement with, the science-related story. In all of these possible responses, the individual's choice to read or not, the ability to understand or not, and the disposition to respond or not, depend upon the individual’s personal context and, especially, personal values. This freedom to choose is a characteristic of learning out of school.

Design and Procedures

The interactive, contextual model presented above is tested using data from written text in newspapers, which, despite the pervasiveness of television, remain a major source of information for the public.

Two front-page science-related stories were chosen. The news events occurred on consecutive days in June, 2005. The first concerned about 100 false killer whales that beached themselves. Efforts by over 1000 volunteers managed to herd all but one of the whales back out to sea by the end of the day. The whale rescue was the single story on the front page of the local paper and further articles continued the story as the only news topic on pages 4 and 5. The front page photograph of volunteers attending to whales had the superimposed headline: "Saved from a slow death". The second story concerned two cane toads (a toxic, introduced species) found at a produce market. One was dead and the other was soon killed by a quarantine officer. The front page story superimposed the headline "Cane toad invaders found" over a photograph of the two dead toads.

Both stories promoted values relating to preserving biodiversity and conservation of native species, and of social and environmental responsibility, but in contrasting contexts. There was also significant science information conveyed in the coverage of both stories, providing science learning opportunities for the reader. In the paper, the values portrayed about the nature of science, and about social and environmental responsibilities are analyzed in the context of the model.

Findings

We know very little about ordinary people's responses to everyday newspaper stories. It is a difficult area to research without changing the “everyday” context, and hence threatening the research validity. Nevertheless, it is important that people who read newspaper reports have the skills to read them critically and to learn from them. Ways to promote discussion about values (Allchin, 1999), or for teaching about controversial issues *(*Oulton, Dillon, & Grace, 2004) have been suggested for classrooms, but the question of who skills the general public, and how this might be done, remains unanswered. Perhaps the model described here will assist to guide relevant research.

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SCIENCE EDUCATORS AS CHANGE AGENTS FOR SCIENCE INDUSTRY SUSTAINABILITY: THE SCIENCE CAREER INVENTORY (SCI) & CULTIVATING MORE SCIENTISTS.

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Abstract: This paper is aimed at teachers, academics and resources industry professionals. Australia is confronted with an unsustainable shortfall of scientists and researchers. The downturn in secondary school level students enrolling in science, technology, engineering and mathematics has contributed to this. A new Science Career Inventory (SCI), has been designed to ask current industry professionals, researchers & students about career aspirations in the hope that educators can better attract new students into scientific disciplines. The SCI will showcase an industry that cares a lot about the future of science education.

Objectives

Sustainability in the mineral resource sector is dependent upon skilled people solving problems and adding value to Australia's common wealth. The downturn in schools students enrolling in STEM (science, technology, engineering and mathematics) courses has caused a shortage of students choosing research careers in the minerals and energy sector and thus confront Australia (and arguably other developed countries) with an unsustainable shortfall of scientists and researchers (Bartier, Tuckwell, & Way, 2003). It is hoped that the development of this new tool will offer greater insight to solving the impending skills shortage.

Significance

At the same time that more than a third of Australia's export income is earned by the country's mineral resource and energy* industry, the supply of young science graduates gaining the academic credentials and experiences in technical areas needed to maintain a high level of scientific research and development continues to dwindle. The problem is well-documented, but no easy solution has become apparent (Chemical & Engineering News, 2003, Churach, 2004).

Does one work to live or live to work? No doubt this may seem to be a silly question, but it is one more and more people ask in the 21st century. In Western societies unhappy career choices often lead to unsustainable life situations. No doubt this quandary presents itself quite early in life. Even a child of 4 or 5 years of age will answer the age-old question of 'What do you want to be when you grow up?' The question of why an individual chooses one occupation over another has interested researchers throughout the past century and forms the basis for this study.

Theory

Pioneering work in the area of career choice was done by Parsons (1909) when he classified people as either career-decided (i.e., certain) and career-undecided (i.e., uncertain). Williamson's (1937) followed on several decades later with work offering evidence that contradicted the then prevailing belief that one's career choice predicted academic achievement. His research went beyond Parsons' work by categorizing peoples' vocational choices as very certain, certain, or uncertain. Still, this rather simplistic, either-or dichotomous model of career choice fitting all respondents into decided and undecided categories produced mixed and inconsistent results (Slaney, 1988). The human decision making mechanism seemed to be much more intricate and involved than that described by merely either-or forced choices.

The idea that career choices constituted a more dynamic process was introduced in the 1950s (Ginzberg, Ginsburg, Axelrad and Herma, 1951). They interviewed a wide array of people from varying backgrounds and concluded that most do not make a once-only decision concerning career choices. They argue that people generally tend to experience a developmental process that over a period of time progresses through six stages beginning with fantasy (as pre-adolescence) through interest, capacity, values, tentative choices and finally to a final, realistic stage (crystallization).

Super (1953) presented a five-stage developmental theory including: growth (childhood), exploration (adolescence), establishment (early adulthood), maintenance (middle adulthood) and decline (later adulthood). Additionally he put forward the view that "career" encompasses the sum total of all the roles one plays during a lifetime and presented the concept as the Life Career Rainbow. He emphasized the idea that one's self-concept has a great deal of impact on career choices and that this self concept constantly is shaped by and in turn shapes the individual's life experiences. Ginzberg, et al., and Super have been challenged, modified, refined and adopted by dozens of researchers, but the main contribution they all made was to put forth the idea that careers involved a great deal more than just what occupation one chose in order to earn a living. More, they all supported the notion that career selection was an ongoing process that was continually affected by the dynamics of one's life experience and constantly changing as one progressed through life.

The past few decades of research into career choice have focused on designing tools to better assess the direction in which the individual's vocational preference develops. In light of this, Hartung (1995) suggests that there have been two great movements in this area of measurement and refers to them as first-generation and second-generation measures. He describes the first-generation measures of career choice status as those that produce total indecision scores. By design, these instruments are not multi-dimensional and for that reason have engendered a great deal of controversy. A second-generation of measures characterizes vocational indecision as multidimensional constructs that take into account greater complexities in career decisions. These include more complex dimensions such as individual comfort and rationale for making career decisions are taken into account.

The authors of this paper hypothesize that a retrospective study of why (the reasons) people have already chosen an occupation path (e.g., a career as a researcher in the energy and mineral resources industry) could offer a valuable insight into the problem of declining academic enrolments leading to careers in these areas. The problem is not trivial in that as the current generation of researchers retire, there is an inadequate supply of qualified people to offer a chance at a succession plan for the industry that provides nearly half of Australia's net wealth (Nicol & Woffenden, 2002). This paper reports on the progress of a study employing a career choice inventory, the Science Career Inventory (SCI). It is hoped that one result of this pioneering work exploring the motivational factors leading to these career choices will be a wealth of data useful to educators, industrialists and the community at large.

Design and Procedures

The development of a tool aimed at assessing the motivational factors affecting career choices that lead an individual to become a scientific researcher in general and into the energy and mineral resources industry in particular required a great deal of input from those currently working within the industry. The authors of this paper conducted numerous interviews and had many conversations with professionals who have already made the career choice in question, namely a science-based career in energy production, geological exploration, mining and/or extractive metallurgy. This resulted in identification of six general areas that could possibly offer strong motivation to someone making a career choice within the energy and mineral resources industry. These six areas are: Financial, Academic, Relationship, Lifestyle, Altruistic and Personal Esteem.

The process of designing a questionnaire to assess the importance of each of these concept areas sought to develop clusters of summated questions ─ a series of questions aimed to tap a particular motivational concept. Each item is designed as a statement which the respondent is asked to answer on a 5-point Likert Scale ("strongly disagree" to strongly agree"). Summated questions allowed for a numerical score to be computed for each participant by totaling all the responses within a given cluster (scale). The primary questionnaire consists of 36 questions with each of the six motivational areas comprising six different items. An additional 14 Likert Scale questions were included along with three open-ended questions in an attempt to learn more about specific issues relating to career selection. Background and demographic data was collected at the beginning of the instrument.

When considering the sample for this study, it was noted that there are differences in the motivations for people to enter the career of their choice and that these may be different at various stages of their life. Based on earlier work by Churach & Rickards (2006) three different versions of the SCI were developed: a Professional SCI form, an Undergraduate Student SCI form and a Post-Graduate Student SCI form. The Professional form of the SCI was administered to a geographically diverse sample of professionals in Australia, North America, Europe and Africa. The Postgraduate and Undergraduate forms of the SCI were completed by students in Australia and are compared and contrasted to the Professional results. Quantitative data were collected using the SCI and qualitative data were gathered using a combination of the SCI form and through semi-structured interviews.

Findings
This paper reports on the findings of a sample of several hundred respondents, all of whom were either professional staff within the energy and mineral resource sector or students studying disciplines that would most likely lead to that career choice. Of those completing the Professional form of the SCI, nearly all had completed an undergraduate degree and more than half had earned postgraduate qualifications.

Qualitative data suggests that teachers had the greatest influence on the career choices of those included in this sample population. Of these teachers, the overwhelming majority were high school science teachers, though quite a few mathematics people were mentioned. The value of informing secondary school science teachers about the energy and mineral resources sector is heightened by their direct contact with students who may want to consider these areas as a career choice. School teacher professional development programs and experiential workshops are a positive way to enhance teacher comfort with the knowledge required to understand these careers better so that they are able to confidently inform students. There were also many university-level lecturers and professors mentioned as sources of inspiration. Interestingly enough, only one participant made a mention of a high school career counselor as having any impact on career decisions.

Certainly human interaction can be seen to have the greatest effect on career choice decisions and much work has been done in science education and teacher-student relationships. It is apparent that the "Relationship" scale is seen to be the biggest driving force in career selection in this study, but differences are noted between people currently working within the sector and students looking at a future career within the industry. It is also clear that nearly all participants had a strong interest in the general area of sciences and mathematics at least as early as high school. Additionally, it can be concluded that this sample population generally has a strong aptitude in these disciplines for the simple reason that nearly all have or are working towards degrees related to the profession.

Putting these findings together indicates that, at least in this sample population, career choice was greatly affected by the inter-workings of three key components. Firstly, people choosing professional careers in the energy and mineral resources sector had a strong enough aptitude to gain entrance to and complete a technical degree in a tertiary institution. Secondly, people choosing professional careers in the energy and mineral resources sector had an initial interest in the academic areas of science and mathematics. Finally, people choosing professional careers in the energy and mineral resources sector report a strong influence by relationship factors within their professional lives and that being involved with a team working towards a common goal and having personal friendships within the industry are important components of career satisfaction.

Contribution
So how does this research impact on environmental science education? Simply put, the world is at an ecological crossroads in terms of the societal demand for a high standard of living on one hand and the unsustainable nature of our industry on the other. Answers can only be found by bright, capable young people choosing science and research careers

aimed at solving these problems. The authors hope some of the findings from their work with the SCI can have an impact on developing created interest in science and research careers.

Considering the interaction of forces highlighted in the three career choice components listed above, is there any way one could have a positive impact on trying to influence more careers within the science and mathematics area in general and the energy and mineral resources sector specifically? Of the three components sited, certainly little can be done to affect the innate scientific and mathematical aptitude possessed by the target population. However, the authors hypothesize that the participants in this study were open to inputs concerning a general interest for and liking of technical areas during formative, adolescent years and continue to be influenced by these interpersonal relationships throughout their careers. In context of the findings concerning the large impact that school teachers (particularly school science and mathematics teachers) have had on the career choices of those involved in this study, it seems likely that any initiative aimed at influencing these teachers in particular would likely have a positive impact on the career aspirations of their students. In short, science teachers are heroes and may offer the most likely key to a sustainable resource pool of young scientists and researchers.

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ENRICHING GRADE ONE STUDENTS' EPISTEMOLOGICAL UNDERSTANDING OF SCIENCE USING STORIES ABOUT SCIENTISTS

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Abstract: This presentation will report on a qualitative study conducted with 11 grade one students in an urban city in Canada. The purpose of the research presented in this paper was to examine how stories about scientists influence grade one students' images of the nature and purpose of scientific work (i.e., what scientists do, where they work and the social nature of their work). The stories and activities (e.g., journal writing, discussions, drama) were presented over thirteen 40-50 minute lessons. The implications of the results for research and classroom practice will be discussed. This presentation will suit primary teachers and academics.

Objectives

Broadly speaking, the objective of the research presented in this paper was to examine how stories featuring the work of scientists influence grade one students' epistemological understanding of science. The following research question guided the study: How do stories featuring the work of scientists influence grade one students ideas about: a) the nature of scientific work (what scientists do; where they work)? and b) the purpose of scientific work?

Significance

Students' "images of science" (Driver, Leach, Millar & Scott, 1996) including their images of the nature of scientific work are widely accepted as important aspects of their scientific literacy (National Research Council, 1996) and have important implications for how they learn and engage with science in a classroom context (Hofer, 2001). For several decades, science education researchers have documented junior, intermediate and senior students' understanding of the nature of science - including students' perceptions of the purposes of scientific work, the nature and status of scientific knowledge (e.g., the relationship between explanation and evidence) Driver et al., 1996) – yet, there has been limited research on the nature of students' perception of scientific work in the early years (K-2). Research conducted with students in the early years has mostly focused on documenting their images of scientists (e.g., gender, ethnicity and stereotypic characteristics). While these studies have provided clues about students' views of what scientists do, the findings from these studies have mostly been in the form of general descriptions which focus on the discipline of the scientist depicted by students (e.g., chemistry, biology work). Moreover, this research has involved mainly large scale quantitative studies which have almost exclusively relied on the DAST (Draw-a-scientist-test) (Chambers, 1983). Despite the reliability and frequent use of the DAST, however, several researchers have expressed concern that students' drawings of scientists likely reflect their knowledge of the public stereotypes of scientists and their work rather than their personal knowledge and beliefs (Solomon, 1993).

Furthermore, the majority of studies that have examined students' views about the purpose of science have been with intermediate and senior students. The few studies that have been conducted with *upper* elementary students have shown that the majority of students do not hold a "sophisticated" view or understanding of the purposes of science – one which recognizes that science seeks to create explanations about the world (Carey, Evans, Honda, Jay & Unger, 1989; Elder, 2002). Students' views were characterized as "poor" (i.e., students were either unable to convey a purpose of science or their views were vague) or "fair" (i.e., students emphasized the activities of science without relating them to the purpose behind the activities) (Elder, 2002). However, we have little insight into the ideas students in the early years hold about the purpose of science. Hence, this small-scale qualitative study is significant in that it draws on multiple data sources (e.g., semi-structured interviews, student work, classroom observation) – not only the DAST – and sheds light on students' ideas about the purpose of science. On a practical level, this research has important implications for teachers and parents interested in instructional strategies effective in enriching young childrens' epistemological understanding of science.

Theory

According to the social constructivist learning theory advanced by Vygotsky (1978), language plays a key role in thinking and learning. Thus, the social context is considered central to the development of students' ideas and understanding as it provides students with the opportunity to articulate their views, hear the views of others and, in short, co-construct and negotiate meaning (Hodson & Hodson, 1998). Cochran-Smith's (1986) view of story readings as "joint ventures" is consistent with a Vygotskian perspective which recognizes the important role of scaffolds in enabling students to 'bridge' the gap (i.e. their "zone of proximal development") between their "potential" level of development (what a student can do with the help of a more competent person) and their "actual" development level (what students can do independently) (Hodson & Hodson, 1998). She emphasizes the role played by the story reader as "mediator" between the text and students. As a mediator, the story reader can employ a variety of strategies to scaffold students' meaning-making process or interpretation of the text.

Pedagogical approaches used to broaden or modify students' images of scientists and views of the nature of science can be characterized, generally speaking, as either implicit or explicit approaches. More recently, a reflective dimension has been added to the explicit approach to emphasize the role of analyzing learning activities and creating generalizations about the epistemology of science (Khishfe & Abd-El-Khalick, 2002). An explicit and reflective approach is consistent with a Vygotskian social constructivist orientation and Cochran-Smith's (1986) notion of the story reader as "mediator".

Bruner (1986) distinguishes between two modes of thought: the paradigmatic and narrative mode. While the paradigmatic mode of thinking involves the use of logic and analysis, the narrative mode is concerned with meaning making and the production of stories. Narratives are constructed out of concern for the human condition (Bruner, 1986) and are therefore well suited for the portrayal of the work and lives of scientists. Moreover, Bruner (1986:14) notes that stories construct two "landscapes" simultaneously: the "landscape" of action involving an agent, their intention(s) and the situation, and the landscape of consciousness which includes "what those involved in the action know, think or feel". This landscape of consciousness embedded in narratives provides readers and listeners with the opportunity to empathize with the thoughts, actions and emotions of scientists featured in stories (Solomon, 2002). As noted by Solomon (2002) science stories can present the work and life of scientists in a rich socio-cultural and historical context.

Design and Procedure

This study primarily relied on the assumptions and methods of the qualitative research paradigm: it was naturalistic, interpretive and particularistic (Strauss & Corbin, 1990). It did not aim to make generalized claims or attempt to establish cause and effect relationships between the stories presented and the results. This study includes 11 grade one students (6 to 7 years old) and their teacher in a low socio-economic, multiethnic k-6 school located in an urban city in Canada. All students represented visible minorities and were from diverse backgrounds: Sri Lankan, Chinese, Filipino and East Indian. The intervention lessons (story readings and follow-up activities) were presented over thirteen 40-50 minute lessons using an explicit and reflective approach. Data collected at the beginning of the study informed the design of the lessons. One of the aims of these lessons was to help broaden students' understanding of the nature and purpose of scientific work. The nature of the stories and activities will the described in more detail in the final paper alongside the criteria used in choosing the scientists featured in the stories.

This study utilized three research techniques: classroom observation, semi-structured interviews and document analysis. Students were observed during the storytelling and follow up activities. Classroom observation focused on student talk related to their views of scientists as well as students' engagement/interest in the story activities. Semi-structured interviews of students and their classroom teacher were conducted at the beginning and end of the study. Students were asked open-ended questions to elicit their impressions on scientists (What do scientists do? Why do they do this?). The classroom teacher was interviewed to obtain her observations and perspectives on students' images of scientists and any changes in their views throughout the study. The following documents were collected: story discussions (audio-taped and transcribed), students' follow-up activities related to the stories about scientists, pictures of scientists (including draw-a-scientist-tests) and students' science journal entries.

Student interviews, stories about scientists and draw-a-scientist-tests were analyzed using a coding process which began with the identification of important categories highlighted by the research on students' images of science (Driver et al, 1996; Elder, 2002; Solomon et al., 1994). The affective dimension of scientific work was not a category highlighted at the beginning of the study but was identified using an inductive coding technique which involves allowing research findings to emerge and is based on the grounded theory approach by Strauss and Corbin (1998).

Findings

Students expressed multiple views of the nature of scientific work both before and at the end of the study. At the beginning of the study, the most prevalent perception of scientific work and the purpose of science was to produce "stuff" – potions, buildings and technical devices. Ten out of 11 students considered "making or building" things as one of their images of scientific work -perhaps their central image (i.e., the first image they describe and the one they provide the most examples for). Even when students talked about scientists conducting experiments, further probing yielded the notion of making either potions, a technical device (e.g., robot) or an alien. By the end of the study, all students' views of the nature of scientific work were broadened to include cognitive processes such as thinking, guessing, wondering, asking questions, observing, etc. although this view did not replace some of students' other views. Students continued to include making and building structures and potions as an image of scientific work. At the end of the study, all eleven students described the purpose of scientific work as including "figuring things out" or studying or learning about either nature in general or specified aspects of nature.

At the beginning of the study only 4 students expressed the view that scientists can work "outside" compared to 10 students at the end of the study. Moreover, by the end of the study, students acquired additional images of the nature of indoor and outdoor locations where scientists can do some of their work (e.g., observatory, library, office, gardens, forests).

In contrast to the beginning of the study where no student described scientific work as involving an "affective dimension", at the end of the study 5 out of 11 students described scientific work as involving an "*affective* dimension". Two dimensions of the affective nature of scientific work were noted: 1) appreciation for nature or the objects of scientific inquiry; and 2) affective responses related to conducting scientific inquiry.

The findings suggest that stories featuring the work of scientists presented using an explicit and reflective approach can contribute to enriching children's understanding of the nature and purpose of scientific work.

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EXPLORING THE ATTRIBUTES THAT ENABLE AND INHIBIT THE IMPLEMENTATION OF AN INTEGRATED CURRICULUM IN A MIDDLE SCHOOL SCIENCE CLASSROOM

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Abstract: The objective of this research was to explore the attributes that enable and inhibit the implementation of an integrated curriculum in a middle school science classroom with particular emphasis on the balance of the tensions created around each attribute. We examine how these tensions impact on the implementation and outcomes of the integrated project and seek to identify how the balance is maintained in a science classroom. Our research determined that although this project had many of the attributes previously considered as necessary for successful integrated projects the project was not considered by the teachers and researchers as overly successful. At all levels (administrative, integration team and classroom) unresolved tensions resulted in a tipping of the balance, with attributes became more inhibiting than enabling. We feel teachers walk a tightrope to balance the tensions necessary to create successful outcomes.

Introduction

One of the cornerstones of middle school philosophy is the implementation of a relevant curriculum focussed on the needs of adolescent students (Beane, 1995, 1997; Hurd, 2002). A natural consequence of such a curriculum is that it does not fall neatly within the boundaries created by the learning areas, or subjects, such as science, described in the Western Australian Curriculum Framework (Curriculum Council, 1998) and in other curriculum documents throughout the world (AAAS, 1993; National Research Council, 1996). This inconsistency creates tension for middle school teachers of science who strive to enact an integrated curriculum of relevance to their students while at the same time complying with subject-based requirements such as subject specific conceptual outcomes and assessment and reporting structures. This tension, which originates in opposing philosophical approaches to curriculum (Gardner, 2004; Leonardo, 2004; Schoenfeld, 2004), becomes evident in the real world of middle school classrooms as factors that enable and factors that inhibit the implementation of an integrated curriculum (Venville, Wallace, Rennie, & Malone, 1999). The challenge for innovative middle schools is to find ways of holding the enabling and inhibiting conditions in a kind of productive tension (Wallace, Sheffield, Venville & Rennie, in press) that will make possible the success of an integrated program over an extended period of time.

In a recent analysis of integrated science curricula in middle schools that spanned a decade, we identified a few key attributes likely to impact on the success or otherwise of an integrated program (Wallace et al., in press). The list of attributes included small and stable learning environments, leadership, team activities linked to the classroom, in-school planning time, flexible timetable and community links. These findings resonated with research conducted in other states of Australia (Pendergast et al., 2005), in the USA

(Flowers, Mertens & Mulhall, 2003), and Canada (Hargreaves, Earl, Moore & Manning, 2001). While recognising the importance of isolating key attributes, we also cautioned against the tendency to see the manifestation of these individual attributes in a school as a recipe for successful integrated programs (Wallace et al., in press). Rather we noted that the list of attributes may not be exhaustive, that the combination and interaction of attributes is as important as the individual attributes, that schools exhibit the attributes in different ways, and that all the attributes were not present in all of the successful programs that we observed.

Objective

In our continuing quest to understand the process of curriculum integration, we recently conducted a case study in a Western Australian middle school that challenged our understanding of the attributes that enable and inhibit the implementation of an integrated curriculum. That case study is the focus of this paper. The objective of the research was to further explore the attributes that enable and inhibit the implementation of an integrated curriculum in a middle school science classroom with particular emphasis on the tension that surrounds each of the attributes (Wallace et al., in press).

Significance

A major goal for science education espoused in curriculum documents is that students develop an understanding of how science and society are mutually dependent (AAAS, 1993; Curriculum Council, 1998; National Research Council, 1996). These documents convey the message that, in order to become effective future citizens, students should understand how the use of scientific products and techniques impact on society. There is growing evidence that an integrated school curriculum can have a useful role in preparing young people for future engagement with the social consequences of scientific developments (Ratcliffe, Harris, & McWhirter, 2004). At the same time, research has identified that long term, sustained integration is extremely difficult to maintain and often ebbs away with time (Wallace et al., in press). The significance of this research is that it delves into the complexities of implementing a curriculum that integrates science with social science and other learning areas. This research goes beyond identifying the attributes that enable and inhibit curriculum integration and explores the tension surrounding these attributes and the subsequent consequences in a real world middle school classroom context. The findings have direct consequences for classroom practice because they show how the delicate tension surrounding these attributes can be tipped to enable the success or otherwise of integrated projects.

Theory

Findings from Wallace et al. (in press) were used to construct an analytical framework for this current study that included the six attributes likely to impact on the success of an integrated program. A broad outline of each of the six attributes is included in the following paragraphs.

The first and most striking attribute of the successful integrated programs studied by Wallace et al. was small and stable learning communities that typically involved an interdisciplinary team of teachers (4 or less) with shared responsibility for a small (less than 90) group of students. The programs, staff and relationships within these teams were reliable and not subject to change. Leadership, the second attribute, was often cited as important in the sustainability of integrated programs observed by Wallace et al. Leadership came in many forms ranging from hands-on transformative leadership of the principal to enabling support in the form of resources provision and encouragement. The most pervasive form of leadership in the successful programs was the kind distributed across teaching teams, commonly referred to as teacher commitment or enthusiasm, shared responsibility and joint contributions.

The third attribute of the successful programs was that team activities were closely connected to the classroom and included such things as shared curriculum materials, team teaching, collaborative development of themes and coordination of assessments. Quality planning time, the fourth attribute, was closely related to team activities and also was a common refrain in all studies conducted and analysed by Wallace et al. In-school planning time served to provide teachers with time to collaborate and innovate, and indicated that such work was important and central. The fifth common attribute was the enabling role of a flexible timetable. Typically, the central timetable established only the broad structure while pedagogical decisions about student grouping, teaching time and space allocation were devolved to the teaching team. Flexible timetables had a common goal of lengthening blocks of learning time and reducing the number of transitions students needed to make between experiences. The sixth and final characteristic of the integrated programs described by Wallace et al. (in press) was community links. This attribute highlighted the importance of bringing understanding of policy and practice regarding an integrated curriculum to the community, that the projects were relevant to the local community and involved collaboration with community members.

Design and Procedure

The design of the research was a detailed case study of one teacher and her two Year 8 classes (12- and 13-year-olds) participating in a 10-week integrated project about community access for people with disabilities. The purpose of the project was to bridge the divide between science, social science and other learning areas by enabling students to understand how the application of scientific knowledge (such as simple machines, levers, ramps, friction, etc.) impact on the lives of disabled people living in their immediate community.

The school, Gosport Community School (all names are pseudonyms), is located in suburban Perth, Western Australia. The teacher, Clare, was responsible for teaching science to two Year 8 classes and four Year 9 classes in one middle school team. Data were collected from multiple sources through various data collection techniques including classroom observation, student surveys, formal interviews with the participating students and teachers at the commencement and conclusion of the project, informal discussions with teachers before and after lessons, attendance at staff meetings, and collection of curriculum documents and student work samples.

The various forms of data were coded for identification and scrutinised for attributes that enabled and inhibited the curriculum integration process in the context of the case study.

Once an initial list of attributes had been identified, these were compared with the attributes in the analytical framework previously described. Similarities and differences between the attributes found in the case study data and the analytical framework were noted and a second round of data scrutinisation was implemented to isolate data that demonstrated the tension around these attributes. The results of the analysis showed that many of the categories identified by Wallace et al. (in press) also impacted on the implementation and success of this project. One further attribute, teacher pedagogical content knowledge, also was identified.

Findings

The findings are structured around the six attributes from the analytical framework as well as the extra attribute of teacher pedagogical content knowledge. A discussion of the tension created by each attribute in this case study is presented.

Small and stable learning environments: The middle school learning team that was the focus of this study at Gosport Community School was designed to be a small learning community within a much larger structure. While the entire school had a population of about 1600 students, the middle school was composed of a number of learning teams, each comprising six specialist teachers and 120 students. The teachers in the learning team shared an office and, as a result, were isolated from teachers who were responsible for teaching similar subjects in other learning teams. The results demonstrated tension between Clare's role in the learning team and her role as the designated science teacher.

Leadership: Leadership from the team leader was very supportive of the project and Clare referred to the team leader as her "mentor." However, a great deal of tension emanated from the aspect of leadership that Wallace et al. (in press) referred to as distributed leadership. While all teachers in the team initially agreed to a joint plan for the project, several of them fell back to default discipline-focussed teaching plans and did not contribute to, or share responsibility for, the integrated project in any meaningful way.

Team activities linked to the classroom: Team activities between Clare and the team leader were supportive of the integrated project and included activities such as shared curriculum materials and team teaching. Due to their lack of interest in the project, however, the linking of team activities to the classroom was not evident among the remainder of the learning team. The lack of team teaching was exacerbated by Clare's science class being taught in a small laboratory, separate from the regular open-plan team classroom. The advantage of being in a specialist science laboratory with access to appropriate equipment was at odds with the enabling attribute of linking team activities to the classroom.

In-school planning time: The middle school team had one hour of planning time each week structured into the timetable. The majority of the meetings throughout the term, however, focussed on the upcoming Year 9 camp and behaviour management issues. The discussions in meetings were not about the teaching and learning within the project and tension was created because discussion focused on concerns about the students' behaviour.

Flexible timetable: The timetable established the broad structure as described by Wallace et al. (in press), however, the flexibility was used on only a limited number of occasions to enable guest speakers to come into the school and for excursions. The flexibility in the timetable was not taken to the full potential.

Community links: The project was instigated by an outside person who reached out on behalf of the local disabled community in a bid to inform and engage students. It was a real and authentic project that had strong visual and practical links with the local community. While this was seen by Wallace et al (in press) as an enabling attribute for integrated projects, the students in this case study remained unenthused and disengaged from the science that was presented as part of the project. Tension was created because of the difference in expectations of what should engage adolescent students.

Teacher pedagogical content knowledge: An attribute identified as impacting on the success or otherwise of the integrated project that was not previously identified by Wallace et al (in press) was the pedagogical content knowledge (PCK) of the teacher. Clare's inexperience and lack of well-developed PCK impacted on her classroom practice such that the management of the students' behaviour and the need to keep them on-task dictated most of the activities implemented in the classroom. She reported feeling hampered by the students' poor behaviour and recognised that her lack of teaching experience created tension and impacted on her skills in the classroom.

Conclusion: The existence of several attributes considered to support curriculum integration in a school may not guarantee the successful implementation of an integrated project. The findings of this research show that each attribute is in delicate tension between inhibiting and enabling curriculum integration. Schools and teachers must not simply assume the success of a project if these attributes are in place, but they must work to favour the enabling side of the tension so that integrated projects result in positive teaching and learning outcomes.

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PRE SERVICE TEACHERS' CONCERNS AND UNDERSTANDING AS RELATED TO THEIR ABILITY TO PERFORM RICH TASKS

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Abstract: In the new B.Ed. (Early Childhood) course, it is planned to have a unit in the third year of the course that will build on student teachers' previous studies of Mathematics, Science and Technology and Enterprise. This project, completed during the current unit of the course, attempted to explore pre-service teachers' rich task mini-teaching experiences to evaluate their perceptions and understandings of an integrating learning model. The pre-service-teachers thoughts and experiences were captured using a survey and supplemented by analysing a series of 'conversations' between two of the student-teachers at the beginning and conclusion of the course. Using Hall and Hord (1987) Concerns-based Model and the hierarchy of understanding by Dlamini, Rollnick & Bradley (2001) the pre-service-teachers' concerns and understanding of rich-tasks in the classroom were mapped and examined. Results indicated that students had begun the process that would enable them to make changes to their understanding to incorporate 'rich tasks' into their classroom practice. The concerns these students still possessed and how their understanding was developing has enabled researchers to reshape their practice in the new integrated unit of maths, science, technology and enterprise.

Objectives.
This study seeks to explore student-teachers learning experiences in a 'rich task' mini-teaching environment, and evaluate student-teachers' perceptions and understandings of integrating learning. The study surveyed the experiences and perception of the pre-service teacher cohort towards the rich task mini-teaching they had completed. It also examined the concerns and feelings of two students during conversations over the course of the program, mapping their concerns using Hall and Hord (1987) Concerns-based Model and Dlamini, Rollnick & Bradley (2001) understanding of the teaching of rich-tasks in the classroom.

Specifically addressing the following questions
1. What were student-teachers thoughts and experiences about their ability to perform rich tasks and consequently implement them into their classroom
2. Using Hall and Hord (1987) Concerns-based Model and the hierarchy of understanding by Dlamini, Rollnick & Bradley (2001) what were the student-teachers' concerns and understanding of the teaching of rich-tasks in the classroom

Significance.
When teaching in tertiary learning environments it is valuable to consider students perspectives including their concerns and understanding of tasks, when planning and implementing of programs (Hall & Hord, 1987; Hayes, 2002). In this course pre-service

teachers focused on a 'rich task'which requires the participants to consider several learning areas and a different approach to teaching and learning. Pre-service teachers need skills and knowledge to be able to design, implement and evaluate 'rich task'. The cohort of pre-service teachers' were asked to examine their experiences and consider how successfully they implemented the 'rich task'into the mini teaching session. In addition to the survey, conversations between two pre service teachers were captured and interpreted using two models; Hall and Hord's (1987) stages of concern to map pre-service teachers' concerns at the beginning and end of the course; and Dlamini et al. (2001) five stage hierarchy of understanding was used to examine the ability of the two pre-service teachers' to understand how rich-tasks would work in the classroom. Using the survey data from the entire Early Childhood pre-service teacher cohort and examining in detail a few pre service teachers concerns and understanding we will be better able to scaffold further learning experiences to improve their understanding where necessary and address any persistent concerns (Hall & Hord, 1987; Hayes, 2002).

Theory

In the curriculum there is a focus on integrating learning which highlight that effective education enables students to make connections between ideas, people and things, and encourages students to see various forms of knowledge as related and forming part of a larger whole (Council, 1989). This focus, along with the debate in educational community about change and integration across the curriculum, highlights the benefits of an integrated curriculum for both teachers and learners (Beane, 1995; J. Beane, 1997). Murdoch (1998) argues that skills, values and understandings are best taught and assessed within meaningful 'connected' contexts. The research gathered focuses on the connectedness of maths and science and when including aspects from other areas included technology to develop the notion of rich tasks (Marsh, 1993). Rich Tasks, as authentic assessment tasks, associated with Queensland New Basics Curriculum, are explicitly integrated and required students to produce work that does not belong to any one subject. The New Basics Project (2001) identifies the characteristics of a 'rich task' to have; real-world value, draw on a repertoire of practices, range across operational fields and are challenging. Rich task provide students with the opportunity to choose from and use a larger range of learning area skills, and to use them in an integrated, creative and purposeful fashion. Although 'rich task' vary in the complexity of what is expected of students, all of them incorporate multiple learning areas and enterprise characteristics, reflect the overarching outcomes and teaching and learning principles of the curriculum framework, involve the use of a rubric scoring system, and encourage creativity and higher order thinking skills, plus a range of learning experiences and classroom practice. Flewelling and Higginson (2003) state that the richer a task, the greater the opportunity for the student to learn and demonstrate learning. It should be measured in terms of what it tells the student, what it brings about, what it elicits or draws from the student, what feeling, desires, or activity it stirs or arouses in the student, and what it allows or encourages the student to do, achieve and learn.

Design

Context in the classroom. After completing previous units in the three learning areas, it was considered appropriate that pre-service teachers are encouraged to perceive links across the three learning areas, and through rich learning experiences, be able to plan, implement and evaluate the children's understandings, skills and attitudes accordingly. This unit was carried out during the compacted semester due to the students doing a four week block practice at the end of the unit. This unit is a partnership of maths and science as the technology and enterprise learning area was treated separately. Each learning area discussed planning individually in the two disciplines with some approaches to teaching the disciplines discussed. Pre-service teachers were required to prepare and implement a rich experience for the mini-teaching as a one-off experience where the concept of the rich tasks in the Queensland New Basics program was to be completed in a 45 minute lesson with a small unfamiliar group of primary students. Following the mini-teaching experience, the pre-service teachers were asked to reflect on the experience with regard to the integration and richness of the experience to develop the children's understanding of mathematics, science, technology and enterprise concepts, skills and attitudes. The project was examined using the pre-service teacher survey that asked the cohort about their experiences during their rich task mini teaching project. Using Hall and Hord (1987) Concerns-based Model and the hierarchy of understanding by Dlamini, Rollnick & Bradley (2001) the pre-service teachers conversations were examined and their concerns and understanding of rich-tasks in the classroom were identified and mapped.

Procedure

This project, completed during the current unit of the course, attempted to explore pre-service teachers integrated rich learning experiences in a mini-teaching environment, and evaluate their perceptions and understandings of integrating learning. Pre-service teachers thoughts and experiences were examined using a survey during the unit, and this was supplemented by analysing a series of two 'conversations' between two of the pre-service teachers at the beginning and conclusion of the course.

Survey. A survey was conducted at the beginning and completion of the course to examine pre-service teachers experiences and ideas relating to rich-tasks, of the ten questions, five were answered using a 5 point Likert scale, from strongly disagree to strongly agree an example of which is The mini teaching experience was an effective experience for you. The other six questions required open ended responses and included; 1) In what way has the unit assisted you with your understanding of integration, 2) What have you learnt as a result of this unit in relation to designing and implementing a rich task learning experience for science and mathematics. The questions were subsequently coded, identifying and analysing the major themes from the open ended questions.

Conversations. The project also followed conversations of four volunteer pre service teachers as they developed their ideas about rich tasks and their use in the classroom. These conversations provided rich discussion and dialogue guided by a few key questions and they were captured on tape at both the beginning and at the end of the Mathematics Science unit. Questions included: What do you understand by the terms "rich task/experience" and "integration?" Outline what your needs may be for being able to provide rich learning experiences in Mathematics, Science and Technology and Enterprise in the classroom. These conversations enabled the researchers to build-up a picture of the pre-service teachers' concerns about the rich tasks and integration models that were modelled during the semester, and consequently the pre-service teachers' understanding of the strategies.

Findings

Responses from the pre service teachers completing the survey highlight that pre-service teachers still have concerns that relate to aspects the 'rich tasks'. Although 45% report having a better understanding of aspects of the tasks and 65% agreed or strongly agreed that the unit had demonstrated how maths and science could be integrated, some written responses indicate that students are still wrestling with the implementation of 'rich tasks' and required further explanations. From the conversations the two pre-service teachers reported in this study, (given pseudonyms Graeme and Ruth) made changes to their thinking and understanding over the course of the unit. Initially Graeme and Ruth were focused on their definitions for the terms 'integration' and 'rich task' and trying to determine how these two concepts were different. During the first conversation they were able to define an integrated task but struggled to perceive what constituted a 'rich task' and were seeking out information from each other to build up their own developing understanding. According to Hall and Hord (1987) and Dlamini et al., (2001) the student teachers were seeking out information about 'rich tasks' and were at an 'informational' level of concern, and as such they were at the 'unawareness' level of understanding. Ruth also showed she had personal concerns about how aspects of the project would impact on her abilities as a teacher and consequently was seen to be expressing 'personal' concerns (Hall & Hord, 1987). During the conversation at the conclusion of the unit both Graeme and Ruth had shifted their level of concerns. They were discussing how the 'rich task' could be managed and implemented in the classroom, how to be reported to parent and demonstrating 'management' concerns. They were even considering how the task was impacting on the students learning, demonstrating some aspects of 'consequence' concerns.

The adoption of 'rich tasks' when planning for mathematics, science and technology and enterprise requires time and appropriate intervention strategies to be successful. One means of achieving this is through modelling and mentoring integration within the teacher preparation program. However, the process through which the pre-service teachers were moved can make their identity unsettled, uncertain and uncomfortable, especially if the approach is something unfamiliar to them (Hayes, 2002). They cannot, therefore, focus on the specific approach that can be implemented but are more concerned with their understanding of their role as a teacher. They also don't have the experience in the classroom to use as support. This can also be true of practising teachers or lecturers who struggle with teacher centred versus the student centred approach to teaching and learning. As Hayes (2002) states, there are three categories associated with the change in thinking of an approach or problem: a) letting go, b)going with students' interests, and c) asking the right questions.

Only speculative conclusions can be made from this project that relate to the movement of the participants through the stages of concerns and levels of understanding. It is anticipated that the students will move up and down the stages and levels until further mentoring and application takes place. The components of the concerns-based approach

(CBAM) were shown to be effective, in the upward movement of the stages of concerns and increased level of understanding, for the focus volunteer pre-service teachers when evaluating their progress in their understanding of 'integration' and 'rich tasks'. Concerns data, along with continued mentoring of pre-service educators, can provide a foundation for a ground-up approach to effect systemic change of thinking about approaches to teaching and learning mathematics, science and technology and enterprise.

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ANIMATION DISPLAY SPEED AND THE LEARNING OF COMPLEX SCIENTIFIC CONTENT

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Abstract: Learners viewed animations of kangaroo locomotion at half or double normal speed. Before viewing, participants arranged a model kangaroo to represent the disposition of its body parts for five main hopping cycle phases. They repeated this task after having viewed the animation. Photographs of the pre and post-test arrangements of the model were compared by measuring changes in the angles of the respective body parts. Improvements in aspects concerning macro information occurred in both speed conditions but improvements for micro information occurred only in the slow condition. This presentation is relevant to science teachers from primary school to university level.

Objectives

This presentation addresses the broad issue of how the design characteristics of explanatory animations may influence their effectiveness as resources for science learning. The burgeoning use of animations in technology-based science learning materials has been driven largely by advances in computer hardware and software that have greatly facilitated the authoring, presentation and distribution of these materials (Plötzner & Lowe, 2004). Technical feasibility aside, the enthusiastic adoption of animations by those who produce resources for science education is undoubtedly due in part to their supposed affective impact on learners. However, this adoption also appears to reflect a conviction that dynamic graphics have particular information processing advantages over the static graphics traditionally used to depict temporal change in science textbooks. These advantages can be attributed to the capacity of animations to present dynamic information to learners directly and explicitly (Lowe & Schnotz, in press). In contrast, the depiction of dynamic phenomena by way of static graphics is indirect and implicit so that interpretation by learners can involve considerable uncertainty. Despite the promise of animated graphics with respect to science learning, recent research indicates that the very characteristics which appear to give animations advantages over static graphics may also disadvantage the learner by introducing additional information processing challenges. Problems can occur when there are mismatches between the way in which the animation presents key task-relevant information and the capacity of the learner to process that information effectively. The investigation reported here deals with one of the fundamental design parameters for educational animation that has the potential to produce such mismatches - the speed at which temporal changes are presented.

Significance

Although animations are now much easier to produce than in the past, they nevertheless remain more expensive to produce than static graphics. Research findings on the comparative effectiveness of static and animated graphics have thus far been equivocal (Tversky, Morrison & Bétrancourt, 2002) with the expected clear superiority for animation not materialising. In the absence of demonstrable advantages for animations, the question arises as to whether the additional expense involved in their production is justified. There is also a growing realisation that attempts to characterize one or other of these types of graphics as educationally superior overall are probably misguided (Schnotz & Lowe, in press). Rather, it may be that the characteristics of specific graphics need to be examined more closely. One class of explanations for the lack of superiority of animated over static graphics concerns the particularities of an animation's design (in essence, how the dynamic information they contain is presented to learners). It has become increasingly apparent that merely *exposing* learners to this information in a direct and explicit way does not necessarily result in them extracting those aspects that are relevant to a given learning task. Failure to extract task-relevant information seems particularly likely when the learners lack background knowledge about the domain depicted in an animation (e.g. Lowe 2003, 2004). Such learners tend to extract aspects from the display that are conspicuous rather than thematically relevant. This suggests that bottom-up processing of the displayed information predominates, with the perceptual salience of graphic elements relative to their immediate visual context being a major influence on whether they are attended to or neglected. The specific visuospatial and temporal properties of individual graphic elements both contribute to their conspicuity. Thus, a large entity that moves relatively rapidly across the viewer's visual field is particularly likely to be noticed. Its *dynamic contrast* (Lowe, 2005) with the rest of the display can be especially compelling. This tendency for our attention to be attracted to behaviourally distinctive features of our visual environment appears to be a deep-seated perceptual predisposition (and one with obvious fundamental survival value). Unfortunately, the perceptual salience of graphic elements in animations is not necessarily aligned with their thematic relevance. As a result, learners who are novices in an animation's depicted domain may extract high salience low relevance information while overlooking less conspicuous aspects that are far more crucial to the learning task (Boucheix, Lowe, Soirat, 2006). Under these circumstances, learners need to be given animations that more closely align the perceptual salience of information (and therefore likelihood of its extraction) with task relevance.

Theory

Complex animations contain multiple graphic elements that vary in both their visuospatial and temporal characteristics. Collectively, these varied components form a hierarchical dynamic structure with successive embedding of micro within macro level information (Fischer, Lowe, & Schwan, 2006). With static graphics, the *visuospatial* manipulation of a close-up view makes small component elements (that would otherwise be visually insignificant relative to their context) become more readily perceptible. For animation, the analogous *temporal* manipulation to this reduced scope of depiction would be a reduced presentation speed (Schnotz & Lowe, in press). However, implementation of such an approach would run counter to the apparent prevailing orthodoxy amongst producers of learning materials that animated material should mimic the actual behaviour of the referent content as closely as possible. Nevertheless, it does appear to offer a way of increasing the likelihood that high relevance aspects of an animation that are normally low in perceptual salience will be noticed by domain novices. Slower-than-normal presentation speed should alter the perceptual salience profile of graphic elements constituting the animation such that micro level information is privileged. Conversely, a higher-than-normal presentation speed should privilege macro level information.

Design and Procedure

The materials used in this study were half-speed and double-speed versions of the same looped animation of kangaroo locomotion (side view). Teacher Education students at Curtin University (N=50) with no special knowledge of how a kangaroo hops were randomly allocated to view either version. They participated individually in the study during which their task was to learn how a kangaroo's various body parts change during the hopping cycle. These groups were split so that half in each watched for equal times and half for an equal number of cycles. Before viewing the animation, participants undertook a pre-test in which they arranged a jointed two-dimensional model kangaroo to show the general disposition of its body parts during the five main phases of the hopping cycle. These arrangements were photographed for later analysis with respect to how closely the angles of a representative selection of macro and micro body parts corresponded to the angles depicted in the animation. Next, participants watched either the slow or the fast animation with exposure set according to either time or cycles. Following the animation, they were again asked to arrange the kangaroo model to show its disposition for the five hopping cycle phases and their arrangements photographed. Pre-test to post-test changes in the angles of the selected micro and macro body parts were calculated to obtain scores indicating the relative effectiveness of the different conditions in supporting participants' extraction of micro and macro information from the animated depiction of kangaroo locomotion.

Findings

The results for macro information showed that the animation was generally effective in helping participants to learn about the larger-scale aspects of kangaroo locomotion. The overall mean pre- to post-test improvement per body part across all conditions was 24.4^{o} ($SD = 21.7^{o}$). ANOVA revealed no significant main effect of presentation speed for macro information. In contrast, a significant main effect of speed was found for micro information; $F(3,47) = 6.48$, $p<0.05$, with a tendency for gains in scores amongst those in the slow group and losses for those in the fast group ($M_S = 20.2^{o}$, $SD = 28.2^{o}$; $M_F = -15.0^{o}$, $SD = 63.6^{o}$). No main effect was found for exposure and there were no significant interactions.

In this study, extraction of information from the animation appeared to be affected by its playing speed but not the type of exposure. However, the effect of playing speed was particular to the extraction of micro level information with benefits arising from viewing of the slow version of the animation. Contrary to expectations, the results indicate that extraction of macro information was relatively robust across both speed conditions. This finding indicates that the greater accessibility of micro information in the slow condition is not achieved at the expense of macro information. In the fast condition, the perceptibility of micro information (e.g. concerning the kangaroo's foot) was relatively low given its context of the far more conspicuous macro information (e.g. concerning the kangaroo's leg). In terms of competition for the viewer's limited attentional resources, the body parts with smaller size and movement constituting the micro information were neglected in favour of the more visually compelling larger body parts whose movement cut across a considerable portion of the display area. It is assumed that the slow presentation speed made the changes in micro aspects of the kangaroo's locomotion more readily perceptible because they were no longer being strongly masked by the macro aspects. This meant that the viewer's attentional resources were less likely to be largely captured by the macro aspects and processing capacity was available to be directed to the more visually subtle micro level changes embedded within the macro context. In essence, the slow speed animation allowed the micro level changes to be noticed and extracted. The question arises as to why the macro aspects do not prejudice extraction of the micro information in the slow condition. One possible explanation is that with the half speed animation, the cyclic nature of the macro changes is less likely to be temporally chunked by the viewer. Under normal circumstances, we can process animal locomotion more efficiently by chunking movements into broad scale cyclic patterns rather than dealing with the embedded fine details. However, an animation that uses an unrealistically slow playing speed produces dynamic changes that are inconsistent with our everyday knowledge of how animals move under the influence of the earth's gravity and atmosphere. This makes it less likely that the kangaroo's locomotion will be perceived largely in terms of its macro aspects with the result that the micro aspects are more likely to be accessed by the viewer. Contrary to the current preference for *behavioral realism* in the design of educational animations (Schnotz & Lowe, in press), the use of speed manipulation to selectively influence the extraction of different levels of information has potential to improve animation's effectiveness as a tool for learning complex subject matter. In scientific and technological systems, there are many instances where key aspects of system behaviour are visually subtle and yet of crucial importance to comprehension. In this study, the extraction of micro information was fostered by using a slower-than-normal speed. However, there are also circumstances in which key macro level information (such as slow movements or long period cycles) is not readily accessible at normal playing speed but becomes apparent if played more quickly (Fischer, Lowe, & Schwan, 2006). Playing an animation at different speeds holds the promise of facilitating extraction of multiple levels of information and thereby supporting deeper comprehension of complex subject matter with a hierarchical dynamic structure.

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RE-FRAMING PRIORITIES IN AUSTRALIAN SCIENCE EDUCATION FOR A NEW CENTURY

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Abstract: This session will present a fresh view of a problem in science education that confronts every educational jurisdiction in democratically governed societies: that of positioning a future scientist relative to the future citizen. The transformation of a Science for All/STS syllabus into the outcomes based form of scientific literacy of the Victorian Curriculum and Standards Framework will be used to exemplify a change in thinking about Science curriculum over the past decades. This change has been supported by a wider societal trend to discuss education in terms borrowed from the market. An alternative perspective will be presented.

Objectives

Science education, both in an Australian and international context has, since the late 1960s, been broadly driven by the rhetoric of one of three significant movements: Science-Technology-Society (STS), Science for All and scientific literacy. (In listing the movements in this way I treat the Science for the Citizen movement as a branch of STS). However, all of these movements have been transformed by the educational contexts of the late 1990s, which saw, in my home state of Victoria, the rise to pre-eminence of a particular style of scientific literacy, an outcomes-based form exemplified by the Curriculum and Standards Framework (Board of Studies, 1995).

The shift to this style of scientific literacy was supported by a wider societal trend to discuss education in terms borrowed from the market. The late 1990s were a time when ideas such as competition, profit and "user pays" gained strong currency in education, as did a particular rhetoric of accountability. The objective of this study was to identify the difficulties and dilemmas faced by the emblematic movements in Science Education, listed above, in the context of the shift to market-liberalism in education, and to describe the shifts in style and emphasis that have occurred from their inception until today. One aspect of this study was to consider the impact that today's style of scientific literacy has had on the initial vision of Science for All (Fensham, 1985).

Significance

The findings that will be reported here form part of a larger study. That larger study is one of very few of its sort. It examines the impact of post-patrimonial market liberal thinking on the social contract between a scientist and his or her community, and then examines the emblematic movements of Science education from the perspective of a proposed form of that social contract. In this paper I argue that our current priorities in scientific literacy act against the inclusive and emancipatory intent that underpinned Science for All from its inception. I suggest that the significant global issues, such as sustainability, facing our communities in the 21st Century need a renewed understanding of what Science for All might mean today, and a rethinking of how we convey to Science teachers our vision for the scientifically literate citizen and the citizen scientist.

Theory

The analysis is underpinned by the following social analysis. Education in Australia has, until recently, been framed according to a classical liberal ideal. From the perspective of this ideal, it is a task of family and community to support the achievement of independence by those entitled to it. This independence has traditionally been reserved for a few privileged individuals: initially, those who would become male heads of households. These individuals become free to make *contracts* with other individuals, and move away from the position of dependence, which they have *status* only to the extent that they are awarded the protection of a *contractual individual*. The agency that comes from achieving contractual individuality has gradually been extended to other groups: women, for example, or the colonised, but it has always been accompanied by a recognition that independent autonomous freedom would never be awarded to members of certain groups, such as the disabled. However, classical liberalism had this in common with the welfare state: they both insisted that those who could achieve independence owed a burden of obligation to those who could not. This was patrimonial governance.

We live at present in a time of post-patrimonial governance. In this framework each person is seen as capable of being an autonomous, contractual individual. The predominant form of post-patrimonial governance is that of the market. In this form, it is assumed that individuals have the resources to operate as free agents in the market place. All individuals are presumed to possess the same agency, and there is relative blindness as to the *ab initio* inequalities that exist.

Yeatman (1995; 1997; 1998a; 1998b; 2000a; 2000b; 2003; 2004) points out that status and contract have never been mutually exclusive; contract does not replace status, but rather it extends and builds upon it. Market liberal contractualism, or *neo-patrimonial contractualism* denies this underpinning, but Yeatman proposes an alternative world view which she names the new contractualism. The new contractualism insists that individuals be treated as individuals, but it recognises that contractual individuals can only come to be, and continue to be in the context of a community. In this way, the new contractualism cuts across the model of an individual as a "single ambulatory center of selfishness" (Saul, 1997, p.2).

There are two conditions required to support individual contractual standing. The first is that we do not accept the market liberal assumption that people are already individuals, capable of free choice both in terms of being able to make that choice and then to act upon the decision. Instead we must recognize the work done by the community initially to bring about a capacity for choice, and the continuing work that is done to support agency both in cognitive and physical terms. The second condition deals with the way we view the ongoing contractual relationship. Under the classical liberal and market liberal contractual models, contract governs entry to and exit from relationships, but in the new contractualism we see conduct within a relationship in a new way and are concerned that the contractual equality of persons must be respected and supported throughout the term of the relationship. Becoming a contractual individual cannot exempt one from the claims of community; further, those who may be tempted to deny these claims, for example, those with expertise in an area, must adopt a new relationship with their “clients” – not a paternalistic “speaking for” the client, but rather an approach that respects and supports the other’s “voice” and choice.

In theorising this study, I view the expert-client relationship in science from the perspective of the new contractualism, and consider the implications of this perspective for secondary school science curriculum. I consider, in particular, the manner in which two curriculum documents position Science and the student with respect to their communities.

Design and procedure

This study involved an analysis of curriculum documents and the writings of key individuals involved with the emblematic movements listed above. The analysis was informed by the social analysis provided by Anna Yeatman (op. cit.). This paper will illustrate the transformation of Science for all into an outcomes based form of scientific literacy using The Science Framework (Malcolm, Cole, Hogendoorn, O'Keeffe, & Reid, 1987) and The Curriculum and Standards Framework (Board of Studies, 1995),

Findings

Curriculum change in school science is a conservative process. Studying science in the senior years of high school is still seen as preparation for the further study of science at the tertiary level. This, in turn, has an impact on the extent and the nature of the change that is possible in the middle school. There are many possible reasons for this emphasis, but in my view the most powerful influence is that of academic scientists in University faculties of science and engineering.

Our vision for the scientifically literate citizen has become restricted to that of a participant in a scientifically literate workforce, and our vision for that workforce is largely framed by the needs of academic scientists. The iconic movements of Science education: STS, Science for All and scientific literacy all have generally exempted the best science students from ‘General Science’ by seeing the “Science for All/STS courses as being for non-specialists only. In doing this, they have largely transferred the responsibility for science in society from the expert scientist to each individual citizen.

Although the intended audience of Science for All was the citizen, intending scientists were largely seen as a separate group. Thus, they were effectively exempted from the sort of science education deemed necessary for the future citizen. However, the interests of inclusivity and access meant that every child had to be allowed the chance to proceed to future studies in science. So, because Science for All was not seen as preparation for future scientists, any child who might want to continue with science took the courses intended for future scientists. In addition, because these courses could be seen solely as a preparation for further study in science, they tended to teach a traditional and a-contextual version of science.

It is not our vision for the educated citizen that must change, but our vision for what it means to be an expert. The expert, as an individual, is positioned in many communities, but the two that are of significance here are the community of science, and the wider community that this expert will come to serve. In this service role, the expert will have to deal with the range of individuals who need advice, individuals seen as individuals and also as members of the community. The expert must herself acquire the requisite depth of vision, to see the individual positioned in community and to balance competing interests. This facility will be at least as important as any specialised science knowledge she will have gained.

We must dramatically revision the education of experts. What becomes important about scientific knowledge is the expert's capacity to see it in a variety of contexts, to choose what is important and to reframe and explain it in ways that make it accessible. In a sense this perspective demands that we take seriously the idea that knowledge is socially constructed but see that scientific knowledge cannot be solely the possession of scientists. It also demands that as secondary school science teachers we take absolutely seriously our claim to be educating the future citizens of a democracy.

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REAL WORLD SCIENCE: AN INDUSTRY / SCHOOL PARTNERSHIP DESIGNED TO INCREASE STUDENT INTEREST IN SCIENCE AND AWARENESS OF CAREERS IN SCIENCE AND ENGINEERING

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Abstract: Real World Science involves a number of Senior High Schools, Local industry and tertiary institutions. In its initial phase several initiatives were identified as potential strategies to address the shortage of science and engineering graduates from the local area. The difficulty was how to best to implement these initiatives to achieve the desired outcome. Baseline data contributed to identifying an interphase model between partners which aims to facilitate dialogue and understanding for the development of teaching resources, professional learning opportunities and student programs aimed at engaging student interest in science. This presentation is relevant to teachers, academics and generally those in building similar partnerships.

Objectives

The Kwinana Industries Education Partnership (KIEP) is a partnership between industries in the Rockingham / Kwinana area of Western Australia, The Kwinana Industries Council, 10 local high schools, 2 Education Support Units, TAFE and Murdoch University. KIEP is a Local Community Partnership which has (generally) been involved in providing vocational education opportunities for students within the local community over the last 11 years. In 2005, the KIEP initiated a number of strategies, collectively known as the Real World Science Project (RWS) as strategies to address the decline in the number of science and engineering graduates (McManus 2004). Even though the KIEP recognised the importance of increasing student interest in science and science based careers, the question is how best to structure this project to meet to achieve the desired outcomes?

Significance

The Relevance of Science Education (ROSE) report (Jenkins, E.W. and Pell, P.G. 2006) identified even though students generally have positive attitudes towards science and technology, this is not reflected in their attitudes towards school science. Neither does school science facilitate student awareness of science based careers Further school science fails to contextualise science for students and many initiatives aimed at increasing student awareness of science based careers focus on the science and not the 'reality of the profession' (OECD 2006) Though teachers and industry identify the Real World Science project as a means by which to address these issues in the local area, there is no established model which facilitates partner dialogue and understanding for the development of resources, teacher professional learning opportunities and student programs to achieve the desired outcomes.

A model is currently being trialled and modified which enables partners to collaboratively contribute to a number of initiatives depending on their area of expertise, being either content specific (industry member) or pedagogy (teacher / professional development). Each phase of this model consists of a key discussion or focus points to contextualise student programs and raise awareness of and interest in science as a possible career. The discussion points were derived from the five non content based outcomes of the West Australian curriculum. Thereby attempting to provide an interphase between partners directly targeting the project outcomes and supporting teachers with their teaching programs rather than offering a purely an add on service.

Theory

The non content outcomes used to develop RWS initiatives collectively represent scientific literacy defined by Rennie, Goodrum and Hackling (2001) as "the capacity for persons to be interested in and understand the world around them, to engage in the discourse of and about science, to be skeptical and questioning of claims made by others about scientific matters, to be able to identify questions, investigate and draw evidence based conclusions, and to make informed decisions about the environment and their own health and well-being." Their 2001 report identified the importance for science education to develop some level of scientific literacy for all citizens as well as providing a "suitable background for those (perhaps 20%) who wish to become scientists or pursue other science based careers".

Teachers in the KIEP identified the non content outcomes (scientific literacy) as reasons for teaching science and accessing the RWS project as well as the need for up to date relevant resources. On a national scale the absence of suitable teaching resources has been identified as a reason contributing to the gap between the intended and implemented curriculum consequently "the science they (students) are taught lacks relevance to their needs and interests and fails to develop key aspects of scientific literacy" (Rennie, Goodrum and Hackling 2001). Therefore an essential component of the RWS project is to provide professional learning opportunities to assist in the development of relevant contextualised teaching resources.

Real World Science is providing a component of professional learning (for all partners) in order to effectively implement RWS initiatives. Funding for teacher relief, and established teacher / industry networks are facilitating interactions between stakeholders in the development of resources, exchange of information and supporting best pedagogical practices to achieve the desired outcomes and to ensure sustainability

Developing scientific literacy and professional learning strategies are two theoretical components being implemented to contextualise school science and stimulate student interest in and awareness of science based careers. Student career choice though primarily based on interest (OECD 2006) is complex and consists of many components including, variety of choices (OECD 2006), efficacy (Pajares 1996 and Lee 2002 and Mau 2003), Gender (Lee 2002) and stereotypes (OEDC 2006) to list but four. It is not feasible within the resources of this project to address all of these issues separately however questions relating to efficacy, gender and interest in science should be included in tools which measure the outcomes of specific programs within the project.

Design and Procedure

As highlighted earlier, one of the key outcomes of the RWS project is to address the decline of enrolments in science and engineering. However, students who are interested in science may have no or little perception of science and engineering as a career prospects (OECD 2006). This significant factor was highlighted to the KIEP recently by a survey collected from yr 11 physics and chemistry students attending a national chemistry conference (INTERACT 2006). Some of these students, though having selected post compulsory science subjects indicated they had been unaware of the spectrum of careers available in chemistry or the fact "that (the) scientists enjoyed what they did". Therefore, in addition to targeting student interest in science, the RWS project needs to adopt strategies aimed at raising student awareness of science and engineering careers throughout secondary education as a strategy to achieve the project outcomes.

Individual or specific initiatives such as lectures and industry tours are currently being refined within the context of the non content (scientific literacy) outcomes. Primarily, industry tours will target year 12 students and teacher professional development while lectures and mentor programs will be provided across the board depending on need. Even though these may be individual or isolated events, pre and post surveys relating to student interest, career awareness, efficacy and gender will be collected to contribute to evaluating the overall effectiveness of the project.

Four 'teacher in industry placements' are due to take place during 2007 with the aim of developing local resources which can be accessed by science teachers within the KIEP. Due to a number of considerations, these placements will focus on the development of a single activity or resource. The two placements currently being negotiated ('Custom Composts' and 'Verve energy') will be supported with professional development materials focusing on pedagogical practices which develop scientific literacy. The Assessment of Scientific Literacy in the OECD/PISA project has provided initial guidance as to the structure of the materials provided. Haney and Lumpe (as cited in Beck et al 2000) identified a professional development framework which includes a critical mass of 80-90% of teachers in each school to form a peer structure providing support for educational reform. Though only one teacher will be primarily involved in each placement, other teachers from either the same school or within the KIEP network will be included in the process to provide the necessary peer structure which will contribute to the overall sustainability of the initiative. In measuring the effectiveness of this initiative, data will be collected in relation to teacher change and student interest in science and awareness of science careers.

Findings

Statistics have been collected on the number of students from partner schools selecting post compulsory science subjects and science and engineering based tertiary degrees with the intention this will be tracked over the course of the project. Though important and initially considered by the KIEP partners as an indicator of the success of the project "extrapolating student interest in specific disciplines from numbers of students in science and technology studies must be done with caution, as the relationship among numbers, choices and the degree of interest are complex and indirect" (OECD 2006).

Consequently, additional tools evaluating student interest in school science and awareness of science based careers will be implemented to complement this data.

Responses collected from a lecture attended by high school students (n=140) at Murdoch University support the need for measurement tools in addition to quantitative data on student subject selection. In developing this specific lecture some basic principles of scientific literacy were applied to contextualise energy use and sustainability and concluded by introducing engineering a potential career. The analysis indicated students generally perceived the content as relevant to their future and the real world and though not explicitly included in the survey, two students identified the role of engineers in the development of a sustainable future. Nine others were interested in knowing why the lecturer became an engineer, what he liked about his job and the qualifications he needed. Although needing refinement, the evaluation tool and general process provided valuable input into the development and implementation of RWS initiatives.

During 2006, data was collected from approximately 90% (65 of 72) of science teachers within the partnership to determine how to target RWS initiatives to best meet their professional needs in relation to the project outcomes. In general, teachers in the KIEP identified strongly the principles of scientific literacy as reasons for teaching science more so than specific scientific knowledge. Teachers also identified RWS as a source of teaching resources, professional development, excursions and means by which to access local industry. Though this project is still developing and trialling a number of strategies it has been identified that Scientific Literacy principles are the common link between teacher professional development, school science and student learning experiences contributing to student interest in science and awareness of science based careers.

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ANIMAL ETHICS IN ACTION – EDUCATION AND CHANGE

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Abstrac: This paper details what is possibly a world first where students as young as 10 years of age are applying for regulated ethical approval for investigations involving the use of live animals and where teachers are approved to provide rich, relevant experiential learning experiences for students from early childhood centres, primary schools and secondary schools in New Zealand.

In 1999 the law governing the welfare of live animals in New Zealand changed with the passing of a new Animal Welfare Act. Part 6 of the new Act brought significant changes to the legal obligations of schools and tertiary education in the areas of research, testing and teaching. This paper will situate the use of animals in schools in the New Zealand legislative and regulatory environments of education and animal welfare. It will trace the development of a Code of Ethics for use by schools and individual students, the establishment of an appropriate Ethics Approval Committee, and the experiences of the approval process in its first year of operation.

Animals are involved in teaching and learning in New Zealand Early Childhood Education (ECE) centres and schools for a number of reasons. These may include;

- for observation as a loved pet,
- as a centre or classroom pet,
- for pet days where students and teachers share their feelings for their pets and appropriate care is observed and rewarded,
- for science, biology, equine, animal care, aquaculture and agriculture teaching, or
- for individual investigations such as for Science Fairs, CREST Awards and other similar activities and events.

For many students these activities may provide for them the opportunity to

- have a shared pet,
- respect animals as living organisms,
- learn about the welfare issues of animals and how these needs must be met at all times,
- observe the complete life history of an animal,
- identify and investigate the range of environmental, physiological and behavioural factors influencing living animals, and
- understand the complexity of environmental interactions involving animals.

In New Zealand, the use of animals in research and teaching has been governed by legislation since1960. This legislation was designed with a focus on the welfare of animals in agricultural purposes, or their use in medical research (human and animal), pharmaceutical and regulatory testing environments. The use of animals in schools was included and some schools or students applied for approval via approved Animal Ethics Committees for use of animals in research and teaching at this level, but the requirement was more often ignored, either consciously or through ignorance. In 1999 the law in New Zealand changed with the passing of a new Animal Welfare Act. In this change, the animals included in the legislation were extended to include all vertebrates, crabs, squid, lobster and crayfish. Humans are not included; in New Zealand there is legislation and regulation specifically separate relating to the use of humans in research and teaching. This new Animal Welfare Act brought significant changes to the legal obligations of schools and tertiary education in the areas of research, testing and teaching, and also introduced penalties for non-compliance with the provision for heavy fines on individual and institution as well as imprisonment.

At this stage, the NZ Ministry of Education decided not to renew its existing Code of Ethics for the use of animals in schools, largely because of the very low number of applications for approval from schools. It should be noted it never had an approved Animal Ethics Committee to operate under its Code.

The NZ Association of Science Educators (NZASE) and the Royal Society of New Zealand (RSNZ) knew that animals were being used in research and teaching in schools to a far greater extent than the history of approval for applications indicated. Such use was primarily in class work in senior biology classes and by individual students in their investigations for Science and Technology Fairs. With the non-renewal of the Ministry of Education Code of Ethics, some schools established their own approval committees, others attempted to use tertiary institution codes and approval committees, and others continued ignorant of the requirements. The disadvantages of using existing tertiary committees were that they were becoming reluctant to handle school applications because of work load and associated costs and also because they were technically not able to accept such applications unless the school was specifically included in their own Codes coverage. They also often took some time to consider the application, by which time student interest was often lost, or attempted to impose tertiary perspectives on school activity. For these reasons, more and more schools and students became reluctant to apply for approval. This led to two situations: the most common was that schools no longer used animals in their teaching programmes, or that they did so in contravention on the legislative regulations.

Concerned that many students were now being deprived of learning experiences with living animals and that many schools and individual students were now breaking the law and in doing so were also making themselves liable to heavy legal penalties, NZASE and RSNZ sought evidence of the use of animals in research and teaching in schools and so the need for a Code of Ethics specifically for the use of schools and school students.

What animals are included in the Animal Welfare Act (1999)?

The definition of an animal in the Act includes:

- all vertebrates including amphibians, birds and fish;
- octopus, squid, crab, lobster, crayfish;

- mammalian fetuses, avian or reptilian pre-hatched young in the last half of gestation or development and marsupial pouch young.

What activities fall within the Act?

"Manipulation" is a legal term defined as: "... interfering with (meaning altering) the normal physiological, behavioural, or anatomical integrity of the animal by deliberately - Subjecting it to a procedure which is unusual or abnormal when compared with that to which animals of that type would be subjected under normal management or practice and which involves -

- Exposing the animal to any parasite, micro-organism, drug, chemical, biological product, radiation, electrical stimulation, or environmental condition; or
- Enforced activity, restraint, nutrition, or surgical intervention; or
- Depriving the animal of usual care; ..."

Ethical approval is legally required only if live animals are to be used. Approval is not required if invertebrates are used in teaching or for investigations unless they are octopus, squid, crab, lobster, crayfish. It would be expected that all invertebrates are given the Five Freedoms i.e. the highest level of animal care and welfare and that the principle of the 3R's (Russell and Burch) will also apply – that as small a number as possible are used.

What is research, testing, and teaching?

When an animal is manipulated its integrity is interfered with in some way. "Research, testing, and teaching" is defined as:

(a) Any work (being investigative work or experimental work or diagnostic work or toxicity testing work or potency testing work) that involves the manipulation of any animal; or

(b) Any work that is carried out for the purpose of producing antisera or other biological products; and involves the manipulation of any animal; or

(c) Any teaching that involves the manipulation of any animal.

This section of the Act contains two exemptions from the definition. Veterinary practice where the veterinarian has accepted responsibility from the owner or person in charge of the animal for the health and welfare of the animal, and is providing the animal with direct and continuing care; routine manipulations that are undertaken by management agencies fulfilling responsibilities or functions under legislation administered by DOC and under the Fisheries Act 1996 are exempt from the Act.

The use of animals in schools for teaching purposes

Most classroom animal use in New Zealand involves family pets brought to school for simple observation and behaviour studies and for learning the responsibilities of humane care. Such use does not constitute a manipulation and thus does not require AEC approval.

Thus

- Observation of behaviour in normal or unaltered environments;
- Observation of body structure and function;

- Measurement of growth e.g. regular weighing to chart a growth curve; and
- Breeding to teach reproduction and development through activities such as
- observing the goldfish swimming in the tank in the lab
- identifying by observation the birds which visit your garden
- examining and identifying the gut contents of fish caught by local fisherpersons in six different local lakes
- recording weight of calves reared on a farm would not require ethical approval.

Studies which would require ethical approval include;

- catching and measuring eels in the local streams to determine the age profile of the population
- colouring the seed to determine if hens have a preference for a particular colour of seed
- drenching lambs with a 'natural' drench made from a local crop instead of following the normal practice of using a commercially available and approved drench
- placing a cow on its own in a paddock for two days, then inroducing other cows into the paddock at the rate of a new one every two days

While observation only does not require approval, observations which interfere with hierarchy such as "pecking order" in fowls or groupings in dairy herds do require approval prior to the work being carried out.   The degree of stress which an animal is placed under is a crucial defining point in the application of the Act.

Sufficient evidence was found of activities requiring approval, and NZASE/RSNZ proposed that the Ministry of Education support the development of a Code of Ethical Conduct and approval committee specifically for use by schools and individual students. The Ministry agreed and a Code of Ethical Conduct for the use of Animals (CEC) in research and teaching in schools and early childhood centres was approved by the National Animal Ethics Advisory Committee in 2004.

The NZASE Animal Ethics Committee was established early in 2005 and began meeting in mid - 2005. Composition of the committee is defined by Section 101 of the Animal Welfare Act 1999 and must be composed of:

- One experienced member of the biological science secondary teaching profession nominated by the New Zealand Association of Science Educators,
- One member engaged in biological scientific research,
- One veterinary surgeon appointed by the Code Holder on the nomination of the New Zealand Veterinary Association,
- One member appointed by the code holder on the nomination of the territorial authority or regional council, and
- One member appointed by the code holder on the nomination of the approved organisation concerned with the welfare of animals.

The committee meets physically four times a year, and holds monthly teleconferences in the intervening period. To date in 2006 the committee has considered 65 applications; 3

for use of animals (mud crabs) in class based investigations in senior biology teaching programmes, and the others for use of a range of animals in student initiated investigations, generally for Science and Technology Fairs or CREST Awards. The animals involved in student investigations range from household pets such as cats and dogs to feral animals such as opossums and birds to captive animals such as mice. In general, investigations have focussed on:

- developing devices to improve the welfare of pets
- investigating feed preferences
- investigating efficacy of commercially available animal products or home-developed substitutes
- behavioural changes in animals

Students and teachers who have applied for ethical approvals have found the process informative and supportive as they receive comment on the detail of their planned investigations and in becoming more aware of the potential risks to the welfare of the animals they are working with or the stress which such animals may be placed under.

Schools can be granted approvals for a maximum of 3 years; however students can only be granted one year approvals. Presently, there is no charge to the school or the student for the approval to be considered by the committee or for it to be approved, such costs are funded by the Ministry of Education Annually a number of approved investigations or activities will be monitored by a representative of the committee who will report back to the NZASE Animal Ethics Committee on how the investigation is being carried out. All teachers and students granted approval must submit a detailed return to the NZASE AEC by December 1st annually for inclusion in their annual report to the National Animal Ethics Advisory Committee.

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THE QUALITY OF STUDENT-DESIGNED SCIENCE EXPERIMENTS

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Abstract: This study is about how school students design science experiments from given experimental task statements. Students were tasked to design experiments either as apparatus/material set-ups or as experimental procedures to be carried out. Three specially selected task statements were presented to 300 secondary three students. Their designs were evaluated against a set of criteria with advice from a panel of science educators and teachers. Students' works were found to range from standard textbook experiments to experiments with creative designs. These findings should provide useful suggestions to secondary school teachers on how experimental science may be taught in class or laboratory.

Objectives

This study has two objectives: to explore the range of qualities of student-designed experiments and to identify students' thinking and learning habits that may help them to effectively design an experiment from a given experimental task statement. The study was inspired by the current development in the Singapore's science curriculum in which the present summative assessment of laboratory practical skills is gradually being switched to a formative assessment mode in secondary schools and colleges. The summative mode is a one-off sitting of the Science Practical Examination at the end of a two or three year secondary school or college course while the formative mode, also known as School-based Science Practical Assessment (or SPA), assesses students during laboratory sessions throughout the school year. Both summative and formative modes are assessed at the Ordinary Level and Advanced Level Examinations administered by the Singapore-Cambridge Local Examination Syndicate, under the Singapore's Ministry of Education. The transition took effect since 2004 following a need to develop creativity and inquiry-mindedness in each student going through the school system (Ministry of Education, 2006). One of the skills assessed in SPA, both at the Ordinary Level and the Advanced Level examinations, is the ability of students to plan investigations and design experimental set ups. In the summative mode, students are prepared for practical examinations through drill-and-practice on standard experimental procedures. In the formative mode, students are expected to formulate their own procedures. This spells a totally new challenge to their teachers because there are no familiar experiments to refer to and no model answers from past examination questions to compare with. The routine drill-and-practice sessions in the laboratory would not help prepare students for SPA since a wider range of experiments is now being used to assess students. On the skill of planning investigations and designing experiments, teachers will need to know the technicalities involved in the experiment as well as how their students think and learn. This study hopes to provide science teachers with some insights into the technicalities of the science experiment and the knowledge about how students learn and think when they are confronted with a science experimental design task.

Significance

The transition from summative mode to formative mode of assessment is not just a shift in the administrative paradigm within the examination system. It is also a watershed in terms of the focus on the learning experience of the student as well as the pedagogical strategies adopted by the teachers. This study involved detailed considerations on the technical aspects of each experimental task, including the scientific explanation behind the design and the experimental results obtained. It also involved looking into students' thought processes as they attempt to choose appropriate laboratory hardware and materials, to assemble a set up and to formulate a set of procedures to address the experimental aim of the design task. Understanding students' preferred learning and thinking habits may help teachers choose or re-align their pedagogical strategies so as to help develop flexibility and creativity in the students' approaches to the tasks.

In considering the technical aspects of school science experiments, much effort and funds have to be put into preparing the assessment materials (Collins and Bell, 2004). From several in-service workshops involving 100 trained science teachers, a list of experimental design tasks were crafted. These tasks involved simple experiments taken from school textbooks or examination papers, as well as experimental ideas inspired from common everyday objects and processes. This list includes the three simple experimental design tasks identified for the current study on the qualities of student-designed experiments. The teachers worked on some of these tasks and found that for each experimental task there could be more than one way to design the experimental set ups and several approaches can be taken to formulate the experimental procedures (Tan, 2005, 2006). Teachers may then be informed by this study on the need to generate the different ways to design an experiment and hence allow them to gauge the range of qualities of the students' experimental designs.

Traditional school laboratory lessons often provide procedures on how to perform the experiments, collect data and analyze findings. Backus (2005) argued that such lessons are hindrances to higher levels of thinking. Instead of providing laboratory worksheets with standard procedures, Backus suggested an engagement of students in drawing up their own experimental procedures. By removing the procedures, there will be more opportunities for student inquiry. While this is applaudable, simply removing procedures may create a vacuum in the students' learning experience. Open-ended approaches are effective in acquainting students with scientific research. This generally requires independent work and is thus suitable for the more academically capable students who have also mastered "the necessary content knowledge and possess(ed) the adequate practical and thinking skills to carry out the experiments" (Arce and Betancourt, 1997, pp.114).

Theory

Yager (1994) attributed the success in teaching anything about Science/Technology/Society to the sort of practical work done in school. The practical work has to be carried out from the student's own learning experience, and not those of the teachers or curriculum developers. "If such work is to be useful and meaningful, the student must identify and experience the idea, the activity, and the laboratory as needed"

(Yager, 1994, pp. 29). In Yager's statement of opinion, two essential theories of learning may be identified. The theory related to experiential and reflective learning (Dewey, 1933; Kolb, 1984) and the macro level of learning in school science as explained by Johnstone (2000).

John Dewey (1933) advocated reflective thinking as a way which enables us to have a more wholesome understanding of life experiences and David Kolb (1984), who introduced the Experiential Learning Cycle, further supported reflection as an experiential learning process in almost any learning situation. Science and Technology are subjects which are best learned through experiential learning. A reflective learning environment in the classroom or laboratory can provide the opportunities for both teachers and students to learn science more meaningfully and impactfully. Reflective learning is a habit of mind that will result in meaningful learning (Moon, 2005). Such learning opportunities allow students to reflect, discover and hopefully also understand and apply their new found knowledge and skill in other learning situations. Since habits can be "caught" through exposure or practice, perhaps even with a motivation to acquire it (Covey, 1989), it will not be unreasonable to assume that making students habitual reflective learners in school is a feasible strategy to develop the student as the inquirer and empower the teacher as the leader of inquiry in the classroom or laboratory.

Johnstone (2000) proposed three levels of learning chemistry: symbolic, micro and macro level. In experimental science, there is indeed an involvement of all three levels. However, in the laboratory, conducting the experiment requires basically a hands-on approach. Students may have learnt about the science behind the experiment. However, any teacher in school would have noticed the delightful exclamations from students when they witness first hand some "magical" episodes of chemical reactions or discrepant events beyond their own expectations. These episodes may therefore support Yager's comment about "useful and meaningful" practical work. Students' encounters with experimental work at the macro level will provide them the relevant learning experiences to reflect upon. They can then better relate Science and Technology to the real world (or Society) they live in.

Design and procedure

This study made use of three specially selected experimental design task statements (compiled into a task list known the *Experimental Design Task List*, or *EDT List*). The tasks were selected to meet the curricular requirements in the GCE Ordinary Level Chemistry Syllabus 5068 (Ministry of Education, 2006). The students were given the EDT List at the end of their Secondary Three year of study. This is to ensure that they had a year of learning chemistry at the upper secondary school level. The first task required students to design an experiment to estimate the amount of dissolved solids (in mass units) in a sample of muddy water. The second task required them to compare the amount of energy that may be obtained from two different fuels (alcohol and kerosene were given as examples). The last task engaged students in a selection of appropriate laboratory apparatus to prepare iron (III) chloride in two different states, namely the solid and aqueous states. The first task involved formulating a procedure to find the amount of dissolved solids and the corresponding apparatus/material set up for the procedure. The students were required to illustrate the procedure with drawings of the experimental set up. In the second task, students were only required to write out the procedure and in the last task, students were asked only to draw the apparatus/materials set-ups.

A list of common laboratory apparatus and materials are provided. The students were given between 30 to 60 minutes to complete the design tasks on paper with the researcher and assistant providing only administrative help. As the instructions in the EDT List were brief and clear, only a few students sought clarifications. These students were identified but not excluded from the study. Their experimental designs were then collected, collated and sorted out based on a set of criteria formulated with advice from a panel of science educators and senior school science teachers.

Findings

Results from the analyses of the three tasks yielded interesting designs from the students. Results from the first task had been evaluated in details while the other two tasks are still being evaluated. The 300 students were selected as convenient samples from eight different secondary schools with varying academic performances. Only the result from the analysis of the first task is reported in this paper.

Some examples of “unconventional” methods include finding the difference in weight between equal volumes of two samples: filtrate and distilled water. The difference is the estimated amount of dissolved solute. The traditional method refers to the “textbook” method of filtration – filtering off the undissolved solids, evaporating the filtrate to dryness (or crystallization) and finding the weight of the remaining solids. There are at least two other alternative methods.

35% of the students’ experimental designs was classified under the “textbook” method, including 16% being fully correct on procedure (as prescribed in the mark scheme). While recognizing the importance of accuracy in experimental data collection by the students (for example, “spitting” of solids during heating or loss of material during filtration), performance is based on decisions made about the choice of procedure, that is, the logical sequencing of procedures.

12% of the students’ experimental designs were apparently the result of a misunderstanding or a misreading of the task statement in which the residue in the filtration procedure (undissolved solids) is targeted instead of the filtrate (this excludes students who mistaken the word “residue” for filtrate; evidences may be found in cases where diagrams drawn indicated they really meant evaporating the filtrate but labeled the filtrate as “residue”).

A worrying 53% (or slightly more than half the sample) did not have the correct chemistry knowledge or application skills to deal with the design task. This is despite the task being relatively simple and is a typical assessment question. Some students suggested chromatography while others thought distillation or fractional distillation could be used to determine the amount of dissolved solids. It may be argued that such procedures, like distillation, can still allow the students to obtain the undissolved solids in the distillation flask, but such methods are inappropriate. In some cases, students suggested evaporating the whole mixture (which would have, theoretically, allowed them to obtain the combined weight of both dissolved and undissolved solids in the sample of muddy water).

Results from the first task in this study indicated that the experiment could be designed in more than one way. Hence, the first objective of the study is supported by this fact – as shown by the students' variety of designs. Detailed analysis of the students' designs further showed that there is a trend towards using a "safe and tried-out" design – that is, the text book method. Yet, there are others who displayed some creative ideas in trying to conduct the experiment. This may indicate that students' thinking and learning habits may have an influence towards their approach in designing the experiments. A related study in profiling students' learning and thinking preferences provide some evidences on prominent learning-thinking profiles supporting students' abilities to design appropriate experiments. If teachers are able to identify these habits or profiles, then aligning their pedagogy to bring out these habits of learning or thinking in most of their students may provide them with better chances of designing appropriate experiments.

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PRE-SERVICE TEACHERS' CURRICULUM CONTENT KNOWLEDGE OF QUALITATIVE ANALYSIS IN CHEMISTRY

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Abstract: This study sought to determine pre-service chemistry teachers' understanding of the reactions and procedures in qualitative analysis (QA) by administering a diagnostic test to 270 pre-service teachers. The results showed the pre-service teachers had similar difficulty in explaining the reactions and procedures as 915 Grade 10 students who sat for the same diagnostic test in a previous study. This study also indicated the feasibility of using diagnostic tests to audit the curriculum content knowledge of pre-service teachers and to introduce the curriculum content to them. This paper session will suit teacher educators and middle school chemistry teachers.

Objectives

Qualitative analysis (QA) practical work requires students to carry out a series of procedures using reagents, apparatus and appropriate techniques to identify anions, cations and gases, and/or to deduce properties of unknown substances. Tan et al. (2002) administered a two-tier multiple choice diagnostic instrument, the Qualitative Analysis Diagnostic Instrument (QADI) to Grade 10 students found that they had difficulty understanding the reactions and procedures involved in the identification of cations and anions, for example, the ion-exchange reactions resulting in the formation of precipitates, and the formation and reaction of complex salts. This study sought to determine the extent of graduate pre-service teachers' understanding of the same reactions and procedures in QA by administering the QADI to them. It also explores the feasibility of using diagnostic tests to audit the curriculum content knowledge of pre-service teachers and to introduce the curriculum content to them.

Significance

Lenton and Turner (1999) found that science graduates did not necessarily understand and have sound knowledge of all parts of their own specialised subject, and that teaching or training in the subject area during a teacher-preparation course did not necessarily improve subject matter knowledge. "Teachers' knowledge about the subject matter and their conceptions about the phenomena they teach can enhance or limit students' learning" (Valanides, 2000, p. 250), so Lenton and Turner (1999) were concerned that the pre-service teachers might be "perpetuating the teaching of basic misconceptions in science" (p. 71). Indeed, studies have shown that pre-service teachers have alternative conceptions similar to that of students, for example, in the areas of chemical equilibrium (Quilez-Pardo & Solaz-Portoles, 1995) and redox reactions (De Jong, Acampo, & Verdonk, 1995). Teachers may unwittingly transmit their alternative conceptions to their students, and when they have the same alternative conceptions as their students, they think that there is nothing wrong with their students' conceptions (Wandersee, Mintzes, & Novak, 1994).

Thus, in addition to studying students' understanding of difficult science concepts, it is also important to determine teachers' understanding of the concepts. This is to enable teachers to be aware of their own difficulties and alternative conceptions, and how these problems may affect their teaching and their students' learning of the concepts. Lenton and Turner (1999) suggests that some form subject knowledge audit is necessary to gain an understanding of the alternative conceptions held by pre-service teachers so that guidance can be offered at an early stage of their programme. They also propose that teacher preparation programmes teach subject matter to the pre-service teachers, or have structured independent study if there is little time for face-to-face teaching.

Theory

Concepts are acquired early in life, that is, children spontaneously develop theories and explanations for things and phenomena that they encounter in their everyday life (Driver et al., 1994). Some of these conceptions differ from the experts' views due to "children's self-centred and human-centred points of view, their limited experiences and everyday use of language and their interests in mini-theories to explain specific events" (Osborne & Wittrock, 1985, p. 69). Students may undergo instruction in a particular science topic, do reasonably well in a test on the topic, and yet, do not change their original ideas pertaining to the topic even if these ideas are in conflict with the scientific concepts they were taught. Duit and Treagust (1995) attribute this to students being satisfied with their own conceptions and therefore seeing little value in the new concepts. Another reason they proposed was that students look at the new learning material "through the lenses of their preinstructional conceptions" (p.47) and may find it incomprehensible. When the students' existing knowledge prevails, the science concepts are rejected or there may be misinterpretation of the science concepts to fit or even support their existing knowledge. If the science concepts are accepted, it may be that they are accepted as special cases, exceptions to the rule (Hashweh, 1986), or in isolation from the students' existing knowledge, only to be used in the science classroom (de Posada, 1997; Osborne & Wittrock, 1985) and regurgitated during examinations. Additional years of study can result in students acquiring more technical language but still leave the alternative conceptions unchanged (de Posada, 1997).

Design and procedures

The QADI was administered to 270 graduate pre-service teachers who enrolled in a chemistry pedagogy course from 1999 to 2003 in a teacher education institution in Singapore. One hundred and seventy-one of these graduate pre-service teachers were assigned chemistry as their first (major) teaching subject (C1) and 99 were assigned chemistry as their second (minor) teaching subject (C2). The graduate pre-service teachers are required to have two teaching subjects in their Postgraduate Diploma in Education course. The majority of the pre-service teachers taking chemistry as their first teaching subject had science degrees and majored in chemistry. The rest had material science, material engineering or chemical engineering degrees. Those who were assigned chemistry as a second teaching subject had at least Grade 12 chemistry if not a minor in chemistry at tertiary level. This group of teachers comprises mainly science graduates who majored in mathematics or biology. The content of the chemistry pedagogy course and the way the course was conducted were similar for both groups of pre-service teachers.

The participants were told to read up on Grade 10 QA a few days prior to the test. During the test, they were instructed to answer the items in the QADI without any discussion. There was no time restriction for the test, and on the average, the pre-service teachers took between 45 to 60 minutes to complete the QADI. If any pre-service teacher believed that the correct answer could not be found in the options provided, he/she could write it down at the back of the answer sheet – only 14 did so, each for one or two items. The participants' answer sheets were marked using an optical mark reader, and their results were analysed using SPSS version 11 (SPSS, 2002). Each item was considered to be correctly answered if a participant correctly responded to both parts of the item (Peterson, Treagust, & Garnett, 1989).

Findings

Alternative conceptions were considered significant if they existed in at least 10% of the student sample as a higher minimum value, say 25%, would possibly eliminate some valid alternative conceptions from the results (Tan et al., 2002). In general, the percentages of pre-service teachers in the two groups having the various alternative conceptions are similar but lower than that of the Grade 10 students. Many alternative conceptions still existed despite increased exposure of the pre-service teachers to chemical education.

The testing of anions and cations usually involves ion-exchange reactions resulting in the formation of precipitates (if any) – the colour of the precipitate and whether the precipitate reacts with excess reagent give clues to the identity of the unknown ion present. Butts and Smith (1987) found that students could not relate the formation of a precipitate in an ion-exchange reaction to the low solubility of the salt. This study was no different – many of the pre-service teachers and Grade 10 students believed that displacement reactions took place in which more reactive ions displaced less reactive ones. For example, when aqueous sodium hydroxide was added to aqueous zinc chloride, 11% of the C1 group, 20% of the C2 group and 25% of the Grade 10 students believed that the 'more reactive' sodium ion displaces the 'less reactive' zinc ions in the reaction.

A further step in the test for cations is to add excess alkali to any precipitate formed to determine if the precipitate reacts with the excess alkali to form a complex salt. For example, zinc hydroxide is amphoteric, and will react with excess aqueous sodium hydroxide to form a soluble zincate, while copper(II) hydroxide will react with excess aqueous ammonia to form a soluble ammine. However, pre-service teachers (C1, 14%; C2, 15%), and to a greater extent, Grade 10 students (29%), believed that the precipitate merely dissolved in the excess alkali because there was more space/volume for it to dissolve in. Tan et al. (2002) argued that many students seemed to rely on perceptually-dominated thinking (Ebenezer & Erickson, 1996) – if a solid disappeared in a liquid, then it dissolved in the liquid or if no new substance was formed then no reaction had taken place. The pre-service teachers studied more advanced inorganic chemistry, and so did not have as much difficulty as the Grade 10 students with complex salt formation.

However, in another item where aqueous ammonia is added to silver chloride precipitate to form a soluble silver ammine, many pre-service teachers (C1, 37%; C2, 46%) and Grade 10 students (41%) thought that ammonium chloride was formed in the reaction because it was a soluble salt. Secondary chemistry students have to memorise a list of common soluble and insoluble salts, and in that list, it is stated that all ammonium salts are soluble. Thus, the pre-service teachers' knowledge of complex salt formation could have been pushed into the background by their stronger memories of soluble salts and their perception that the precipitate 'dissolved'.

The pre-service teachers had difficulty explaining the tests for anions. For example, pre-service teachers and Grade 10 students thought that dilute nitric(V) acid had to be added so that the unknown substances could react 'properly' with silver nitrate(V) (C1, 12%; C2, 20%; Grade 10, 22%) and lead(II) nitrate(V) (C1, 22%; C2, 37%; Grade 10, 35%), respectively. Acidifying a mixture is a common procedure in QA practical work, but the reason why remains a mystery for many participants. They did not realize that the function of the acid was to react with sulfate(IV) or carbonate ions, if present, producing sulphur dioxide and carbon dioxide which could be identified by the appropriate tests.

Two two-tier multiple choice diagnostic tests, the QADI and one on chemical bonding (Tan & Treagust, 1999), were administered, since 2001, to every intake of pre-service chemistry teachers in the author's institution. After the tests, the pre-service teachers were assigned a number of questions to discuss in small groups and to present their answers to the rest of the class. The feedback received was that these sessions were valuable to the pre-service teachers as they clarified many things that the pre-service teachers took for granted, or were not aware of, in chemical bonding and QA. This highlighted the need to include sessions of chemistry content knowledge, for example, discussion of concepts which secondary students have difficulty understanding (Garnett, Garnett, & Hackling, 1995; Nakhleh, 1992) in the preparation of chemistry teachers in Singapore. However, the pre-service teachers first have to be motivated to examine their understanding of basic chemistry concepts – many pre-service teachers were 'shaken' after the tests, and this made them very receptive to such examination during their methods as well as assessment modules. The use of diagnostic instruments and the discussion of items that follows can be a way of auditing pre-service teachers' chemistry content knowledge and incorporating curriculum content knowledge in a teacher preparation program, as suggested by Lenton and Turner (1999).

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USING 3D VAST-MODELS™, VIDEO ANIMATIONS, AND A WEB-BASED VIDEO ANALYSIS TOOL FOR INVESTIGATING STUDENT LEARNING OF ATOMIC STRUCTURE AND THE PERIODIC TABLE

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Abstract: Hands-on 3D VAST-Models™, narrative video animations, and a Video Analysis Tool were used to investigate secondary students' learning of atomic structure and the periodic table. A three-week curriculum was implemented reflecting chemistry's historical development. Data was, in part, collected as video and analyzed using an Evidence Based Decision Support theoretical framework and Video Analysis Tool. Students preferred tactile macroscopic 3D models to text and figures because of difficulties in interpretation and constructing abstract mental models. Animations assisted in understanding historical experiments. Representations, models and animations promote active inquiry, exchange of ideas, and allow comparative argument for model use in chemistry.

Objectives

In this paper, we address our research question: What do secondary school students learn and understand about (a) atomic structure and (b) the periodic table using VAST-Models and animation videos through lessons that are presented in a historical context?

Significance

One on-going research dimension to learning and understanding in high school chemistry is the use of multiple representations to facilitate instruction, both for teachers and students. In our research, we have tried to assist an identified problem concerning learning foundational concepts in atomic structure and the periodic table. We developed a series of hands-on models and selected video clip animations to integrate into a thematic curriculum reflecting the historical and experimental conceptual development of chemistry. Our study results reveal that students prefer using hands-on 3D VAST-Models and video animations for learning atomic structure and the periodic table. Preference is given to hands-on models because they promote active inquiry, exchange of ideas, and comparative critiques for the use of multiple models in representing atomic structure. Animations demonstrated the historical development of experimental evidence and arguments used in constructing atomic theory. We contend that understanding atomic structure is a necessary prerequisite for developing meaningful understanding of the periodic table and a history of chemistry.

Theory

Multiple representations are essential components for learning and understanding in chemistry (Treagust, 2006) and are considered especially important for developing knowledge in chemistry including atomic structure and the periodic table, the foundations of introductory chemistry. Representations can be categorized by scale, the macroscopic, microscopic, and symbolic levels (Gilbert, 2005). Gilbert (2005) posits for visual representations, at least five modes are common to chemistry including a (i) concrete/material mode, such as the "ball and stick" for chemical bonding; (ii) verbal or descriptive mode including spoken and written explanations for phenomena; (iii) symbolic mode referring to the chemical symbols, formulae, and equations used; (iv) visual that includes graphs, diagrams, and animations such as the 2D and pseudo-3D dimensional representations for chemical structure; and (v) gestural that use body movements such as students moving around in circles in a room to represent atomic orbitals. Visual representations and models have become established and useful frameworks for inquiry in science education research (Coll & Taylor, 2005; Mathewson, 2005) to investigate students' knowledge construction and understanding in various science domains (see Gilbert, 2005). However, it seems that especially in chemistry with its accompanying values in the use of models and modeling, from both historical and philosophical perspectives (Justi & Gilbert, 2000) that multiple representations are particularly important and useful.

Various science education researchers have documented that teachers and students share difficulties in constructing a meaningful dialogue for linking macroscopic entities into theoretical and symbolic scientific explanations. We share their concerns, and our studies are focused on learning with visuals, that include animations and the development of 3D hands-on VAST-Models (*Visualizing **A**tomic **S**tructure **T**hrough-**Models***) as tools for macroscopic representations linked to symbolic entities for atomic structure. In addition, we have created a curriculum that uses a historical approach of inquiry-based instruction. Through our research, we hope to contribute new methods and insight for students doing (Taber, 2003), learning (Harrison & Treagust, 2000; Taber, 2004; Wu & Shah, 2004), and understanding atomic structure using historical (Arabatzis, 2006; Weinberg, 2005) exemplars through classroom discourse. Our framework for investigating the role and use of models by students is concordant with a view that "concepts, hypotheses, principles, theories and 'laws' in science are 'model-based' and models "… serve as conjectures, explanations, didactic devices and communication vehicles" (Mathewson, 2005, p. 533). In addition to exploring students learning of atomic structure, we are also investigating the use Evidence Based Decision Support and a Video Analysis Tool (Hill, Hannifin, & Recesso, in press) for our data analyses.

Design and procedure

In response to surveys of chemistry teachers and students, we developed hands-on 3D VAST-Models™ and identified video animations that could be used to enhance secondary school classroom inquiries into the use of models and representations for learning atomic structure using a historical approach. VAST-Models™ were developed along with the historical context of knowledge development of the atom including the Greeks in which Empedocles 4 elements are compared and contrasted with the single entity of Democritus, followed by Dalton, Thomson, Rutherford, Bohr, and Schrödinger's models. In addition, we decided to explore the feasibility of using narrative video animations designed for university instruction that explain several classic chemistry experiments and models typically found as single figures in secondary level textbooks.

Sixteen QuickTime digital video clips (13 and 3 respectively for content in atomic structure and the periodic table) were selected and used (Whitten, Davis, Peck, and Stanley, 2005).

Our study included 40 Grade 11 students (two classes: Class A = 22 students, 9 females, 13 males; Class B = 18 students, 10 females, 8 males) enrolled in an elective introductory College Prepatory (CP) chemistry high school course in the southeastern United States. Both classes were composed of mixed-ability, non-tracked students and all students had received a basic introduction to chemistry in Grades 6 and 9 in required physical science courses. The classes were on a Block schedule meeting 75 min/day/lesson for one semester (90 instructional days). The teacher had been teaching chemistry for over 15 years.

Throughout the instructional unit, assessments routinely used by the teacher for evaluation of student learning in the course, were administered to the students and used for data. In addition, two formal research instruments were used for the specific evaluation of the models and videos used in the study: (1) a questionnaire was given to all students and, (2) a semi-structured interview was given to five randomly selected students from each class. The purpose of the questionnaire was to gain general information about the students' opinions concerning the instructional units, whereas the interviews were used to investigate students' understanding of atomic structure and the periodic table.

The interview protocol consisted of 3 parts, questions focused on understanding (1) the VAST-Models, (2) selected video clips of classical experiments, and (3) a teach-back in which the student was asked to teach the interviewers atomic structure based on an element chosen by the student. Interview data was collected as digital video and was analyzed and categorized using the Video Analysis Tool (VAT) based on a framework of Evidence Based Decision Support (EBDS) that utilizes a "lens" system (Recesso, in press). In our research, we developed and used a lens system based on three levels of representation science education researchers have used in chemistry: macroscopic, sub-microscopic, and symbolic (Gilbert, 2005). The questionnaires were analyzed using Likert scale items and open-ended questions were categorized.

Findings

In the questionnaire, 40% of the students stated that hands-on models are very helpful. 36% stated helpful, 8% not useful, and 8% of students mentioned VAST-Models confused them. Some of the benefits for using tactile visual hands-on models noted by the students through the questionnaire and interviews are that: (a) comparing and contrasting models help students to develop a meaningful appreciation for the historical development of models and the benefits and limitations models offer in understanding chemistry, (b) models are able to demonstrate scientific processes used in chemistry that can not be done through wet laboratory activities, but may also be used to enhance understanding such as the flame test used to identify particular elements. (c) models can be used to simplify complicated ideas and concepts for structures for unobservable entities common in the language of chemistry. (d) hands-on models have offered students an opportunity to socially construct and enjoy chemistry inquiry. In the teacher administered summative examinations on atomic structure and the periodic table, students performed significantly better in comparison with previous semesters. Our in-depth student interviews and "teach-back" affirmed their ability to describe and construct representations for atomic structure and the periodic table.

Although consistently about 75% of the students found the video animations useful, we have determined that special attention must be given to videos clips if they are to be used to enhance chemistry instruction. Narrative video clips do not stand on their own even with carefully constructed explanations. Rather, students need specially designed questions that require the students to carefully view a video clip to identify the purpose, processes, and results that can be claimed as they are represented. In addition, videos should be shown more than once at the students' discretions and discussed. We have found that our 3D VAST-Models for atomic structure can be used to enhance secondary chemistry instruction for both teachers and students.

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ENGAGING RURAL STUDENTS IN AUTHENTIC SCIENCE THROUGH SCHOOL – COMMUNITY LINKS

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Abstract: There is wide acceptance that many secondary school students find their school science experience uninteresting and lacking relevance. There is also evidence that traditional school science fails to adequately represent contemporary science practice. One well regarded way of addressing this issue is through community linked science activities. This paper will describe such activities, and present a series of case studies of community linked school science programs aimed at engaging students in authentic science. It will discuss the nature of learning outcomes associated with such activities, issues of innovation and sustainability, and the factors that lead to successful experiences for students.

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Introduction

There is abundant evidence that many students in Australia and other developed countries are becoming increasingly disengaged with school science, finding it to a large extent irrelevant to their interests and concerns, the pedagogies authoritarian, and the content unrelated to contexts they would recognise as significant (Lyons 2005, 2006; Lindahl, 2004). There is also evidence that traditional science teaching does not capture the nature of contemporary science practice, being overly focused on the development of canonical abstract ideas and not paying sufficient attention to the multi disciplinary nature of contemporary science, the ethical and social and personal settings of science, or the human aspects of scientists' work and passions (Tytler & Symington 2006).

Objectives

This issue, of students engaging with science in meaningful contemporary contexts, has been linked to an increasing incidence of school science activities that link outside the classroom with local or global communities. There are many organizations such as environmental groups like the Gould League, government departments such as primary industries, non-government organizations such as CSIRO, or industries that run programs for schools and have strong links into schools on an informal basis. The Australian School Innovation in Science Technology and Mathematics (ASISTM) project is framed around notions of linking students with a variety of support persons outside the classroom. This paper, which is supported by SiMERR (the national project Science, ICT and mathematics education in rural and regional Australia), will explore this phenomenon in terms of the experiences it provides for students, the learning outcomes, and factors affecting the success of the project. The research questions driving this study are:

- What is the Australian experience of research into school-industry science links?
- What are the different types of ways in which schools link with community in the teaching and learning of science?
- How are communities thought of, in projects of this type?
- What do these school and community linked projects in science offer to students in terms of learning and engagement?
- What are the conditions that frame the nature of the experience, and affect the success of the project?
- What problems do these projects purport to solve, and what structures and processes are put in place to ensure positive outcomes for students?
- How should we think of sustainability in relation to these projects, and what are the conditions under which such projects are sustained?

Significance

There is an increasing incidence of community projects in Australia, based on a concern to make schooling more relevant to students. One can argue that meaningful learning entails situating the learning in contexts that are relevant to the learner. Dewey argues that the real issue for meaningful student learning is the need to link classroom learning to students' lived experience.

The Victorian School Innovation in Science (SIS) project developed a set of components of effective teaching and learning, based on interviews with effective teachers of science. Many of these teachers emphasised community links in their teaching of science, and the SIS Framework included a community linked component:

> *The classroom is linked with the broader community* -A variety of links are made between the classroom program and the local and broader community. These links emphasise the broad relevance and social and cultural implications of science, and frame the learning of science within a wider setting. (Deakin University, 2003, p. 9, 40)

Examples of community linked practice included a secondary science coordinator in a coastal area school, who ran units on dune ecology, waves and the physics related to surfing, drawing on local resources. The SIS project spawned a range of school and community linked projects, encouraged by its pedagogical focus, and the creation of coordinators within schools with a brief to encourage and support change and innovation (Tytler & Nakos, 2003). It is quite striking, in SIS, how most of these community linked projects occurred in rural schools and clusters. It is possible the linking of school and community is easier to achieve in rural towns where teachers have more embedded relations with community members and the school is a more overtly acknowledged community resource.

At a recent conference organised by the Australian Council for Educational Research, on "Boosting student learning in science", two speakers focused on community links Rennie (2006) reported on a number of community linked projects, including a bird watching census in the Perth area in which student observations formed part of a scientific data set to trace changes in bird population, a Year 9 air quality project that investigated the major

cause of air pollution in a mill town, and a "Living with tiger snakes" project run by the manager of a wildlife centre. These projects were very successful in engaging student and community interest, and arguably offered a more authentic experience of a contemporary science issue, than is possible with classroom based use of pre-packaged case studies. However, they occur outside the normal curriculum (although she makes the point they are integrated into the science at the school). Research is needed into models of school and community links that are both embedded and sustaining.
Davies (2006) described a curriculum at the Australian Science and Mathematics School (ASMS) that is contemporary in its engagement with current issues and developments in science, and in its use of scientists and other community members to provide connectedness with issues and ideas beyond the classroom setting:

Other types of community linked projects include visiting scientist schemes, family science nights, excursions to science centres with associated project work, and science and technology competitions such as the Science Talent Search in Victoria, or the solar car challenge, or the Energy Derby. There are many links also between schools and organizations that offer programs for school students, such as Water watch and Salt watch. In Australia, the recent Australian School Innovation in Science, Technology and Mathematics (ASISTM) project has sparked a lot of activity in schools, linking with universities and outside agencies to bring expertise into schools. The program seems to have spawned a considerable variety of activities in schools, involving schools liaising with university students, practising scientists, and industries to develop programs.

Design and procedure

The study being reported has two parts. The first is the development of a typology of school-community projects. In the authors' experience, while many teachers and systems people can supply anecdotes of school science connecting to community, each person's knowledge is very partial, and the projects they describe are widely different in character. This first part of the study represents an attempt to bring some order into the way we think about community linked science activity. An internet search was carried out to identify a range of projects, including searches of government and NGO and industry sites, and school sites. A number of government and NGO personnel were consulted to tap into their knowledge of such projects. A framework is being developed, describing the type of community involved in the link, how the project sits in relation to the science curriculum, the nature of integration across subjects, and type of content being focussed on (eg technology and science, or environment).

The second part of the study involved the construction of case studies of seven community linked science projects. These involved a project combining science and woodwork, and a community science resource, a project in which mathematics and science are being used to enhance community participation, two projects involving competitive design and racing of vehicles, a mathematics and community project, a winemaking and agricultural production project, and a collaboration with the Australian Defense Organisation. The projects were identified by recommendation by key systems personnel, and the final set was chosen to represent a variety of cases. A phone interview with the project coordinators took place to ascertain the nature of the project and its progress. This was followed by a visit in which the coordinator was formally interviewed, and multiple perspectives were gained by interviewing community representatives, other teachers, students, and community based initiators. From this data detailed case studies were constructed of four of the clusters, and used to interrogate the issues surrounding successful implementation.

Findings

Part 1 of the study explored the main variants in school community projects. Projects varied from informal monitoring projects (eg. Weather monitoring or streamwatch) that took place outside of the normal school timetable, to large scale problem based projects that occupied considerable curriculum space, such as the design and racing of a solar energy vehicle. The type of community organization ranged from local councils to large scale industries, and government departments. The agency accorded to students in designing their own procedures varied considerably. The full paper will present a typology of projects, with examples, to clarify the breadth of possibilities for bringing contemporary community science into the classroom.

Part 2 of the study yielded four rich and detailed case studies and three portraits of projects. These will be presented in the final paper. The analysis will focus on the following points.

- *Actor networks:* The success could be seen to rely on the coming together of a number of strategic factors, including the need to enlist the support of significant players in the community and school, and to have some control over the significant infrastructure items that determine school practice such as timetabling.
- *Student outcomes:* A variety of outcomes were discerned, embedded in the nature of project activities, or explicitly expressed by students. These included attitudinal effects and understandings of the way science works within community settings. In some cases significant conceptual learning and enthusiasm was apparent.
- *Drivers:* In each case the project had been conceived of by an enthusiastic teacher who had the energy and vision to sustain momentum for the project. In each case one could conceive of the innovation as solving a particular problem.
- *Teacher qualities:* In the cases presented, the driving teachers had experience outside of the classroom, and in some ways each project represented an out of school passion of the coordinator's. In a number of cases teachers had come to teaching late, after a history of working in a science-based area. Implications will be drawn from this.
- *Innovation:* A number of these projects are funded under the ASISTM program, which places a high premium on innovation. In the project we have been working with a definition of innovation as involving a process of assembling and maintaining a novel alignment of ideas, practices and actors, to overcome a site-specific issue (Smith, 2006, forthcoming). These alignments were achieved to address problems that enlisted the support (sometimes passive) of principals and other key players.
- *Experiencing innovation:* Often, projects were complex in the way different players experienced them. It was important to gain the perspective of a number of players.
- *Funding:* Funding, where it was provided, was used to support ideas that were already in train, in response to perceived problems. Funding supported the major innovation, rather than prescribing it.

- *Community:* In these projects, community is envisaged in very different ways. The paper will discuss productive ways in which we might think about community, for schools in future wishing to make links.
- *Rurality:* In each case the successful implementation of the project required the coordination of a number of features, and an understanding on both sides of the school science – community divide what the needs of the other was. It is argued this favours rural schools in conceiving of and sustaining such projects.
- *Sustainability:* In looking carefully at the project processes and achievement it is clear that many more outcomes occurred than conceptual learning, and what is referred to as being sustained or not is problematic. The paper discusses sustainability in depth.

In summary, the typology of projects, and the case studies, show the richness of ways of linking school science with community, and the range of outcomes – for staff as well as students – that can be achieved. The study has resulted in a number of lessons regarding the sustainability of innovation, which could form the basis of a set of advice for schools, community, and policy makers in supporting school initiatives involving school and community.

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TEACHING SCIENCE THROUGH MODELS USING A COMPUTER MODELING TOOL

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Abstract: The purpose of this study was to examine the extent to which preservice elementary teachers were able to construct viable scientific models with a computer-modeling tool, namely Model-It, and teach a sixth-grade science lesson through computer models. The results of the study showed that (a) Model-It, through its scaffolds (i.e., Plan, Build, and Test modes), enabled the majority of preservice teachers to build models that were structurally correct, (b) participants' models were structurally correct but simplistic, and (c) 65% of the participants preferred to teach science using the explorative modeling method, 27% the expressive method, and only 8% both the explorative and the expressive methods. In essence, Model-It effectively scaffolded preservice teachers' first modeling experiences and enabled them to quickly build and test their models. It is however recognized that systematic efforts need to be undertaken in teacher education departments to adequately prepare prospective teachers to teach science through computer models.

THE USE OF WRITING TASK IN TEACHING TO ENHANCE STUDENTS' UNDERSTANDING AND ATTITUDES TOWARD CHEMISTRY

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Abstract: This paper reports on the use of writing as alternative teaching strategy in Chemistry classrooms. The teacher employed a mixed teaching method, namely direct teaching and free format writing assignment, in two Year 11 chemistry classrooms in the Indonesian secondary school context. Along with the normal teaching approach, the teacher asked students based on their preferences to a write story about the topic being learnt, namely the functional group of organic compounds. This study describes and analysis the students' writing and the students attitude towards activities. The students writing varied from a fictional story, posters and poems. This study found that writing activities enabled students to express and elaborate on their understanding of the concept being learnt using their own language that cannot be facilitated through traditional teaching and learning approach. The students also expressed their preferences toward writing activities despite the anxiety that they experienced during the process of writing.

Objectives

The quality of science education in Indonesia, particularly at secondary school level, as reflected in the students' outcomes in national science examinations, is very disappointing. During the last eight years, the average score of students' achievement on the national science examination was less than 4.90 of the 10.00 scale. In addition, Indonesian students' performance in international assessments supports this finding. Based on the results of assessment organized by the International Educational Achievement (IEA) as reported in the Third International Mathematics and Science Study (TIMSS), Indonesian students ranked at 34th and 32nd out of 38 countries which participated in the assessment for mathematics and science achievement, respectively (Martin, Mullis, Gonzalez & Chrostowski, 2004). Similar results from the Programme for International Students Assessment (PISA) study were reported that among 41 countries, Indonesian students were ranked at 39th and 38th for mathematics and science achievement, respectively (OECD/UNESCO-UIS, 2003). Among other things that may have caused this low achievement is the teaching approach used in the classrooms adopted by most science teachers. Teaching and instruction in Indonesian school science have long taken the didactic approach due to the heavy burden that teachers hold in the course of carrying out their responsibilities (Thair & Treagust, 1999; Wahyudi & Treagust, 2001). This claim is corroborated by the current research findings that identify the factors which encouraging science teacher to use didactic approach. The teachers' lack of confidence in doing experiments and demonstration and lack of skills in carrying out instructional design has lead the teachers to only emphasize on teaching concept and formula during their teaching activities. Therefore, it is not surprising if the teachers felt comfortable and tended to employ didactic teaching approach which is merely characterized by chalk and talk (FMIPA UNY, 2002). Teachers need to think and use alternative teaching approaches to facilitate students' learning. For that reason this study that investigated the use of writing task as alternative teaching approach in chemistry was conducted. The aim of this study was to investigate the use of writing task as teaching strategy in chemistry classroom. Two research questions were formulated to guide this study: (1) To what extent writing task in chemistry help students to understand the concept being learnt? (2) What are student's perceptions toward writing task activity?

Significance

The advantages of using narratives in particular and writing to learn in general are clear. Howvere, very few of such research have been conducted in Indonesia (Wahyudi & Treagust, 2001). In order to bridge this gap, this study reports the result of using writing task as alternative teaching approach in learning concepts of functional groups of organic compounds. The significance of this study is grounded on some assumptions. First, the study may provide an alternative teaching strategy for Indonesian science teachers and their students. Second, this study may help teachers to fulfill one of the goals of science education in Indonesia that stated that students should be able to communicate scientific understanding to different audiences for a range of purposes (MOEC, 1993). Student's ability in communicating their science knowledge can be exercised, enhanced, and practiced via the use of writing task in teaching and learning process.

Theory

A number of studies on writing have revealed that writing activity has great influence in learning and suggests that student writing might be used as a tool for enhancing science concept development (e.g., Abell, 1992; Butler, 1991; Sturtevant, 1994). Kober (1993) asserted that when students are asked to write about their reasoning processes or attitudes, they are forced to structure their arguments in a more coherent way. During the writing processes students clarify their own understanding and thus hone their communication skills. In addition, Moore (1994) claimed that writing function as one of the most powerful tools for discovering, organizing, and communicating knowledge. Rivard (1994) believed that the importance of the writing process is that it is not only for learning about something or acquiring such knowledge, but also for producing a personal response to something, clarifying ideas, and for constructing knowledge. Furthermore, Resnick as cited in Rivard (1994) suggested that writing has a potential role as a cultivator and an enabler of higher order thinking. Writing can serve as a powerful heuristic for learning new information when it is done for communicative purpose and when the writer [learner] attempts to integrate new information with previous knowledge. Writing by its nature may enhance the thinking process. When a student engaged in the writing process, he or she tries to organise his or her ideas, refines them, and present them to the reader in order to get the ideas across. As well, Glynn and Muth (1994) claim that reading and writing activities in the science classroom play important roles in the learning process; while reading, students not only gain confidence and satisfaction in the concept they have learned but also they may overcome misconceptions they held before. It was highlighted that through writing activities students can express their knowledge in their own words and writing can connect them to daily occurrences. The writing process allows students to explore concepts or themes so that they will eventually achieve higher level of understanding of the concepts.

Finke (1978) claimed that a narrative in teaching science enables student to store and recall information or concepts being learnt easily. A Narrative makes the information or concepts more memorable since the attention paid to it as story element rather than isolated facts or discrete concept. Moreover, narrative makes the concept more meaningful by generating the relevance in non scientific context. Steiner (1982) found that students' ability to write in science classrooms correlated with their test scores. Writing improved students' understanding; writing showed attestation what students did or did not understand, and hence can be used to improve lectures. Goodman and Bean (1983) confirmed that the writing task in an undergraduate organic chemistry course was very effective in teaching students both the rhetorical strategies appropriate to writing reports and in improving their scientific thinking.

Research focused on the effect of writing activity upon students achievement revealed promising results. Hand, Prain, and Wallace (2002) used a quasi-experimental control group design to investigate how writing influenced performance on science test items in ninth and tenth grade classes. They found that students who wrote about a topic performed better on a higher-order question about that topic that was part of their unit exam.

The impact of writing activities in science classroom on student's attitude toward the subject was reported by Woolnough (1999) who claimed that year nine students involved in active modes of writing, such as writing in their own words and summarizing their thinking, were more enjoyable and better for their learning. Moreover, Hanrahan (1999) also concluded that in a journal writing study, students generally liked the approach, although some criticized it because they had hard time thinking about what to write. Most students found this type of writing preferable to what they normally did in class.

Design and procedure

This study involved Years 11 students of SMA Negeri 1 Banjarmasin, Indonesia. A total of 57 students of two classes participated in this study. The samples were drawn based on the willingness of the students to take part in the writing assignment. The study was qualitative in nature. Along with the traditional teaching approach, the students were asked to create writing about the concept being learned, namely, the functional group of organic compounds, in their own language. Students can use any form of writing such as short story, poem, fictional story, or posters. They are given three weeks to complete the task. At the end, they are given opportunity to express their opinions regarding the writing activities.

Data coding helps researcher to define categories and organise them into some form of order and structure (Cohen, Manion, & Morrison, 2000). Accordingly, qualitative data obtained from the students' writing and their reflection were coded and classified to help the researchers in interpreting the phenomena. Following the data coding processes is the identification of pattern or theme. This identification allows the researchers to create a coherent explanation or description of aspects that contribute to the usefulness of writing in chemistry teaching (Merriam, 1998). In this study students' writings were categorized into poem, poster or story and followed by analyzing toward the concepts being used or explained in the writings, on the correctness of concepts usage. Students' opinions toward writing activities as expressed in their reflection toward writing activities were also reported.

A simple format of data coding with combination of numbers and characters, for example SW.S1, was used to cross reference data to the transcripts. The first two letters indicate that the data were drawn from the student's writing, the second and third characters name the student who wrote the writing. Similarly, a student's writing reflection was coded as SR.S2 read as student 2's reflection on writing activity.

Findings

Students' writing varies from simple poems to a well-structured short story. In general, of a total 57 writing submitted to the teachers, consist of 28 (49%) simple poems, 15 (26%) relatively comprehensive poems and 14 (25%) essays in a short story form. Where the simple poem merely describes the properties of the organic compounds; a more comprehensive poem describe the properties of compounds and the chemical reactions among them, and the use of the compounds in daily life. The essays in a form of short story also varied from simple descriptive to a more comprehensive explanation of the properties of such functional group of organic compound. This study identified that writing activity enable students to demonstrate their understanding of the concepts being learnt into such a context that more meaningful for them.

Analysing students' reflections on writing activities revealed several interesting comments that show their various attitudes toward writing as a way of learning chemistry. Most of them gave positive comments and only few who expressed relatively negative commentary such as the writing activity had packed the schedule and got him extremely busy. Students' commentary were classified and presented in several assertions as follows: (1) The activity is unique, surprising and enjoyable (SR.S1; SR.S2; SR.S5; SR.S7); (2) The activity is useful for student to understand the concept (SR.S1; SR.S5; SR.S9; SR.S10; SR.S12); (3) The activity enhance students' attitude toward chemistry (SR.S10; SR.S11). Overall the results suggest that the use of writing in teaching chemistry enable students to achieve a better understanding of the concepts being learnt and improve student's interest to learn chemistry.

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PERCEPTIONS OF BEGINNER AND EXPERIENCED TEACHER EDUCATORS TOWARDS THE USE OF ICT TOOLS FOR LEARNING SCIENCE

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Abstract: This study explores how two groups of teacher educators who were new to the use of ICT for teaching and learning perceived the efficacy of ICT tools for conducting practical work. Forty teachers from two countries involved in this study. Data were collected using the Constructivist Learning Environment Survey (CLES); Survey of Faculty Attitude toward Information Technology (FAIT) and Efficacy of ICT as Tool for Learning Science. This study found respondents who hold positive perceptions toward constructivist learning environment and positive attitude toward IT tend to have better perception toward the use of ICT tools for learning science.

SCIENCE DEPARTMENT WORK ENVIRONMENTS OF EARLY CAREER SCIENCE TEACHERS IN NEW ZEALAND SCHOOLS

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Abstract: Teacher vacancies in Science in New Zealand secondary schools continue to rise. Additionally, it has been reported that early career teachers are leaving teaching. Consequently, the retention of high quality early career secondary school science teachers is imperative. Nine early career secondary school science teachers were interviewed, using a semi-structured format, regarding their perceptions of their science department. Features that the early career teachers found helpful and problematic to their professional lives were identified and examined against Moos (1974) three dimensions of work environments. Aspects that could be considered in the support and retention of early career teachers are discussed.

Objectives

There is a current crisis in New Zealand regarding the recruitment and retention of secondary school teachers. *The Monitoring Teacher Supply Report 2006* (Ministry of Education, 2006) predicted, that the growth in secondary school rolls would continue until at least 2007. Furthermore, from 2003 to 2006 the science subject area has been one of the most difficult to fill.

The majority of secondary schools are structured into subject departments. It is with in these departments that teachers define their professional identities, that there is a source of collegiality, routines and responsibilities (McLaughlin & Talbert, 2001). Consequently, given that the retention rate of New Zealand science teachers is lower than expected, the secondary school science department is worthy of study.

Not only is the recruitment of science teachers an issue in New Zealand, but also the retention of teachers at the beginning their careers is problematic. Early career science teachers' (teachers in their third, fourth or fifth year of teaching) everyday work resides in science departments. Given that the statistics indicate that it is teachers in the early stages of their career that are leaving the profession, the authors suggest that the perceptions of this group of teachers regarding their department work environments should be examined. The issues of teacher retention and the literature about work environments led to the following research questions: 1. What are early career science teachers perceptions of their subject department environment? 2. Do early career science teachers regard their subject department as a positive or negative work environment? 3. What work environment is most supportive of teacher growth and retention?

Significance

The difficulty of recruitment could be tempered if science teachers remained in teaching. Secondary school students deserve high quality teachers and a learning environment in which stability is a feature rather than the continuous disruption from the changing employment of staff within a secondary school. Consequently, the retention of high quality secondary science teachers is imperative.

Whilst some overseas research has been conducted in secondary schools on work environments (Dorman & Fraser, 1996; Fisher & Fraser, 1990; McLaughlin & Talbert, 2001; Yee, 1990) the work tends to focus on either classroom-level environments or school-level environments and does not consider subject departmental-level work environments. Research that does focus on the subject department (Siskin, 1994) does not focus specifically on science departments. In addition, most of the research conducted in the secondary sector considers a range of teacher experiences. Consequently, the early career teachers' voice is lost amongst the myriad of teachers' voices.

Since little research has been conducted about early career teachers or about secondary school subject departments it is fitting to carry out research in early career teachers' perceptions of their subject department environments in their secondary school to gain a better understanding of the social world in which early career teachers work. This in turn, could give us some insight into how they would prefer their work environment in order for them to remain in teaching.

Theory

Human environments can be described by examining the psychosocial and social dimensions of the environment as perceived by either insiders or outsiders, in a framework of person-milieu interaction (Moos, 1974). Moos stated that to adequately describe social environments three dimensions needed to be considered. These dimensions were the personal development dimension, as indicated by the individual's involvement and collaboration; the relationship dimension, as indicated by the way people relate to each other and the system maintenance and system change dimension, as indicated by how structured the system is and the degree of clarity of expectation. This paper is framed by these constructs.

The literature identifies a number of factors regarding work environments that lead to satisfaction in the job and retention of teachers. If early career science teachers perceive they are working in a positive work environment then the authors suggest that they are more likely to feel satisfied about their job and remain in teaching. The intrinsic rewards of professional challenge and autonomy have been indicated to positively affect job satisfaction (Kim & Loadman, 1994). Positive professional relationships with students and colleagues are also significant (Kim & Loadman, 1994). Students are the critical context for teachers work. Teachers often describe their work and the rewards they receive in terms of student-teacher relationships (Lortie, 1975; McLaughlin & Talbert, 2001; Yee, 1990). Relationships with colleagues and professional socialisation have also been identified as influences on teacher quality and retention (Yee, 1990). Whilst this factor has been cited as significant the reality is that a culture of individualism often exists within secondary schools (Fullan & Hargreaves, 1996). The authors suggest that the department work environment will have a role to play in either encouraging isolation and reinforcing norms of individualism or welcoming strong collaboration (Fullan, 2001).

A lack of administrative support and leadership is also important in determining whether teachers remain in the profession (Billingsley, 1993; Ingersoll, 2001).

Design and procedure

Qualitative data were gathered by interviewing nine early career science teachers who work in secondary schools of a large New Zealand city. The participating early career teachers came from different decile schools and schools of different roll size. There were also biographical differences in terms of years of teaching, gender and ethnic group. The participants were interviewed in a one-to-one situation using a semi-structured interview format. Interviewing in this manner enabled the researcher to "understand and interpret social reality through the meanings that the informant attaches to their life experiences" (Minichiello, Aroni, Timewell & Alexander, 1990, p. 101). Consequently, an in depth understanding of the early career teachers and a richer, full, description of the social reality could be achieved.

The teachers were interviewed about their perceptions of their work environments. In addition, questions were asked to find out their career aspirations. The interview involved probing to discover whether they would continue to stay in teaching and what features of their work environment were helpful or unhelpful. Data were analysed for emergent themes within an interpretivist paradigm (Robottom & Hart, 1993). Data were 'de-contextualised' by segmenting and coding data and then 're-contextualising' data. Themes were identified (Tesch, 1990) and conclusions drawn and verified (Miles & Huberman, 1994).

Findings

Some teachers perceived their environments positively and others perceived their departments negatively. The major theme that arose in determining whether their work environment was positive or not was the perceived supportiveness of the department. The support could be relational or could occur through systems of discipline or systems of organisation and resourcing.

Professional Development and Relationship Dimension

A key feature that teachers reported was important in the science department work environment was collegiality. For those teachers who reported a collegial atmosphere in the department they talked about a sense of belonging. The culture within the department was one in which ideas and resources could be shared and not create a competitive and hierarchical department. There was a sense that the teachers were not isolated, individualised and sharing ideas or concerns about students was expected and welcomed.

In non-collegial departments, the perception was that the environment was competitive. This led one teacher to feel 'mocked' by her colleagues rather than supported. For others, they were frustrated about people ignoring their teaching suggestions and they felt there was little interest in them professionally. This resulted in them feeling undervalued, disrespected, less inclined to take risks and less inclined to be creative.

Another feature that was important was the professional interest of others. Feedback from colleagues was one way this could occur. Some teachers reported they had no feedback and in other cases the feedback was not constructive. Both the absence of feedback or limited feedback was not seen as helpful and created an environment of isolation. For those teachers who received feedback they found it useful to their development as a teacher. They felt valued because someone was taking a professional interest in their work. The feedback occurred formally, through an appraisal system or informally, through discussions with individuals or groups of colleagues within the department.

As well as support from colleagues the relationship with the students was perceived as a key aspect for the teacher's satisfaction in the classroom. Students were both a source of satisfaction and stress for some teachers. The disruptive behaviour of the students caused the teacher to lose confidence and reduce their self worth and this impacted on the satisfaction they had for teaching. However, if the subject department had an air of collegiality and support this would often override the issues with the students.

Systems Dimension

One of the features that continued to arise for the early career teachers was the importance of organised systems. In particular, the systems connected to resourcing and the systems connected to discipline were significant. These systems needed to be structured and well managed. The major concern was regarding equipment or textbooks that were too old or unavailable. The teachers found this frustrating as it interfered with the ways in which they wanted to teach and the classroom climate they wanted to create. On the other hand, those teachers who were in departments who had indicated their department involved sharing resources reported resources were plentiful and well organised.

Out of the nine teachers three teachers intended to leave their school at the end of the year. Two of the teachers to travel overseas and one was busy applying for promotional positions in another school. Only one of these teachers was overwhelmingly positive about her department work environment and was considering asking her school for leave and had every intention of returning. Whilst not suggesting causality, it is interesting to note that the two teachers who were least complimentary about their work environment intended to leave their school at the end of the year. The authors suggest that if the environment does not support a culture of collaboration and collegiality the early career teacher will decide to leave permanently or move schools. Whilst moving schools may help to retain teachers in the short term, it is unlikely to resolve the underlying issues of retention in the long term.

Of the teachers who wanted to remain in teaching very few wanted to become head of a science department. If they did want promotional positions through a hierarchical career path, they wanted this because of the opportunities to be able to make change. For those who aspired to positions of responsibility the power that they perceived the position brought was significant in their career decisions and the ability to make changes within a department.

The early career teachers had similar perceptions regarding what features created a work environment that impacted positively or negatively on their professional lives. If we are to retain early career teachers in secondary schools the authors suggest policy makers, teacher educators and the teachers in the subject departments need to become engaged in a debate about how to support teachers in their everyday role and make the features indicated by the early career teachers a reality. This may prove extremely challenging but is worth examining if we are to retain quality teachers in secondary schools. A move that will ultimately benefit the students they teach.

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RESEARCH-ENHANCED TEACHING AT MURDOCH UNIVERISTY VIA THE RISE WIND ENERGY PROJECTS

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Abstract: This paper examines the impact on students of involvement in projects related to wind energy carried out at the Research Institute for Sustainable Energy (RISE) at Murdoch University. These projects have given the students a hands-on approach to learning the science and technology of wind energy and in each case have involved an industry partner. The findings discuss the relevance of the RISE 'wind projects' to renewable energy education, research-enhanced teaching and constructive learning as well as the concept of scholarship of engagement between industry and academia. This paper would be of interest to tertiary teachers and academics in education research.

Objectives

Research-enhanced teaching can lead to a more integrated form of student engagement with research and involves the students with academics in inclusive communities of scholarship (Brew, 2006). At Murdoch University in Perth, Western Australia, research-enhanced teaching of students in the discipline of Energy Studies has occurred through involvement of students with research projects associated with The Research Institute of Sustainable Energy (RISE). RISE is based on the campus of Murdoch University and its primary role is in assisting the development of the Australian sustainable energy industry. The on-campus presence of RISE and the involvement of University academic staff in RISE affairs means there are close links between the activities of the Institute and the teaching activities at Murdoch. Wind energy is one of Murdoch's key areas of research strength and students have either been involved with research work connected with the RISE Small Wind Program at the RISE Outdoor Test Area (Whale & Pryor, 2005) or with the RISE Wind Monitoring Program. In the former case, students have been involved in wind turbine testing at one of the wind test stations at the RISE Outdoor Test Area whereas the latter case involved wind resource assessments of sites in Western Australia. In all cases the projects involved industry partners.

The aim of this study was to assess the impact on the students of involvement in the RISE 'wind projects'. The specific research objectives were:

1. To examine the impact of the wind projects on constructive learning by studying the effect that working with wind turbine technology and/or wind data had on the students understanding of wind energy concepts taught in their courses,
2. To examine the impact of the wind projects on student employability by studying the effect that the exposure to contacts and procedures from industry had on employability skill sets and career choices, and
3. To examine the relationships between academic and industry partners in the wind projects in the context of scholarships of engagement.

Significance
Renewable energy education has emerged as a new discipline in its own right with its own interdisciplinary curriculum that satisfies the criteria for sustainable development (Jennings, Lund & O'Mara 2000). Murdoch University offers a number of degrees and courses related to Energy Studies including undergraduate degrees in Sustainable Energy Management and postgraduate courses in Energy Studies including Masters degrees in Renewable Energy and Environmental Architecture. The courses aim to produce graduates with a broad-based knowledge of renewable energy systems, who are aware of the environmental, economic and social implications of installing energy systems as well as the technical aspects of the energy technology itself. This broad knowledge content means that the degrees and courses attract students from varied academic backgrounds.

As one of the fastest growing and most cost-competitive renewable energy technologies (Ackermann & Söder, 2002), wind energy is a core subject area in the curriculum. The discipline of wind energy requires knowledge of many branches of science and engineering: meteorology, aerodynamics, mechanical engineering, electrical engineering etc. as well as knowledge of policy issues and economics. During their studies, however, it is very likely that the student will have to explore far from their existing knowledge base in order to cover the required fields of knowledge in wind energy. Use of the RISE wind facilities offers the chance for the student to enhance their reading with experiential learning gained by participation in the wind projects. The significance of this work will give insight into the constructive learning that is occurring through the use of the RISE wind facilities in student projects and may suggest ways to improve teaching methods and increase the quality of learning for future wind projects.

Theory
The conventional wisdom that staff discipline-based research benefits teaching and learning is not supported by statistical evidence (Ramsden and Moses, 1992; Astin, 1993). Further, there is evidence of students' concerns that a teacher's individual research interests should not dominate at the expense of the aims of the course (Neumann, 1994; Jenkins, Blackman, Lindsay, & Paton-Saltzberg, 1998). More recent studies (Barnett, 2000; Jenkins, 2000) however have questioned the methodologies of these traditional correlation studies, which have treated teaching and research as more or less discrete entities. Educational research has been a starting point for discussion of new ways of thinking about the relationship between research and teaching. Brew (2006) postulates an integrated model of research-enhanced learning with greater involvement of students with academics in scholarly communities. Pascarella and Terinzini (1991) noted that the greater the students' involvement in academic work, the greater the knowledge acquisition and cognitive development. Brew (2006) argues that not only can research benefit teaching but teaching can stimulate academic learning. Student participation in academic work may help the academic to overcome the isolation of individual research and can generate research ideas through questions posed by students.

The notion of research-enhanced teaching forms the main theoretical context for this paper but the very nature of the research makes connections with a number of teaching and learning concepts. The research gives the academic the experience of the process of constructive learning (Biggs, 2003) which can then be communicated to the students in the classroom. In addition, the sort of two way exchanges between academia and industry as related in this paper falls under the idea of a scholarship of engagement (Holland, 2005; Ramaley, 2005) and has the ability to raise the research profile of the university and build the opportunity for students to better prepare for the workforce. In addition the multidisciplinary nature of the research is allied with student learning outcomes, in particular developing employability through the formation of the types of skill sets valued by employers and identified by Kubler and Forbes (2005).

Design and procedure

Since Energy Studies students are from different disciplinary backgrounds and have a wide difference in their learning needs and knowledge base, diagnostic testing of all undergraduate and postgraduate students on wind energy concepts is planned for the start of their respective courses. During their course an undergraduate student's contact with the RISE wind projects may occur through honours projects and independent study contracts while a postgraduate student's contact with the RISE wind projects may occur through small research projects in elective units, Masters by coursework dissertation projects and higher degree research. In addition, postgraduate students from other universities may have contact with the wind projects through undertaking a practical traineeship with RISE.

To test the impact that involvement with wind energy technology and wind data has on a student's understanding of wind energy concepts, further diagnostic testing is planned for undergraduates and postgraduates at the end of their respective courses. The test results from those students involved in the RISE wind projects will be compared to the results of their cohorts who were not involved in the RISE wind projects. To test for the impact of the wind projects on deep learning and employability, students involved in the RISE wind projects will be surveyed during their project and then surveyed again a number of years later as part of a focus group of former students. The survey questions aim to uncover the student's experience of the effect that the RISE wind projects have had on their education, employability skill sets and career choices.

Findings

Preliminary findings have involved informal feedback from a focus group of eleven former postgraduate students who were involved with the RISE wind projects during their studies at Murdoch University over a period from 2003 to 2006. The focus group were asked for their general comments about their experience with the wind project and its contribution to their education and future careers. The feedback from the group was extremely positive with two members identifying the wind project as the "… most interesting unit of the entire course" and the "… high point of my university study…"

Some comments made by the focus group suggested that involvement in the wind projects resulted in a process of constructive learning by the student. Examples of these comments are that "… the work on the turbine deepened my knowledge …", that the work was "… beyond the coverage of the topic in the coursework ..." and that the project "… took me well beyond the limits of any previous studies …" Other members of the focus group pointed out the context of the environment in which this constructive learning occurred in that it " … gave me the opportunity to apply some of the skills and techniques I had learned … in a real-world, industrial context" and it "… allowed me to gain some practical experience within a commercial framework".

One member gives insight that supports the notion of the industry-academia exchange on the wind projects as an example of scholarship of engagement. They state "Another new and absolutely positive experience for me was to actively participate in the meetings (with industry). It was very instructive to be responsible for the preparation and presentation of results (at the meeting) as well as give further details and to answer questions".

Finally a number of the focus group address the impact of the wind projects on their employability. Some statements refer to the potential impact such as "I've talked it up in all interviews and I'm sure its well regarded" and "…will be regarded favourably by potential employers" while others recognise a direct impact in that the project "… was very helpful in getting my current position …" and "has directly contributed to my current employment in a wind engineering capacity…" Interestingly, members of the focus group not working in wind energy still recognised the contribution that the wind projects had made to their careers in terms of the ability to think analytically, to communicate, write reports and give presentations.

The preliminary findings support the idea that the RISE wind projects promote the teaching and learning concepts of constructive learning, scholarship of engagement and student employability. A more formal study is planned involving diagnostic testing of students as outlined in the Design and Procedure. In addition a new unit is planned which will promote undergraduate involvement in the RISE wind projects and increase the exposure of undergraduate students to research-enhanced teaching at Murdoch University.

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