THE TRAINING OF TRAINERS MANUAL

For Promoting Scientific and Technological Literacy (STL) for All

International Council of Associations for Science Education (ICASE)

Southeast Asian Ministers of Education Organization, Regional Centre for Education in Science and Mathematics (SEAMEO-RECSAM)

UNESCO Principal Regional Office for Asia and the Pacific (PROAP)

Bangkok, Thailand
February 2001

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FOREWORD

UNESCO-PROAP in collaboration with partners, the International Council of Associations for Science Education (ICASE) and the Southeast Asia Ministers of Education Organization Regional Centre for Education in Science and Mathematics (SEAMEO-RECSAM), is pleased that this "Training of Trainers Manual on Scientific and Technological Literacy for All" is completed. This is meant to be "a generic manual" which maybe translated and adapted in Member Countries. The aim of this Manual is for the continuous professional development of science educators, teacher trainers at pre-service and in-service levels, and those teachers who aspire to help other teachers in the promotion of scientific and technological literacy for all in the classroom, through the development and utilisation of supplemental teaching-learning materials which are relevant to the learners. Helping teachers could be through workshops organised by Universities and teacher training institutions, the Science Teacher's Associations, or in-school-based in-service training (INSET) activities.

The development of this Manual is within the framework of Project 2000+: Scientific and Technological Literacy for All, a project launched at the UNESCO Headquarters in Paris in 1993, following the recommendations of the World Conference on Education for All (Jomtien 1990), and in tune with the outcomes of the World Conference on Science (Budapest 1999), and the Global Forum on Education for All (Dakar 2000). It is hoped that this Manual will find its place in enhancing the capacity of teachers to cope with 'change' and to be more involved in bringing about a thorough infusion of the scientific and technological culture into society, as signified when Project 2000+ was launched.

UNESCO-PROAP would like to express a very special thanks to Mr. Jack B. Holbrook, Executive Secretary of ICASE for the preparation of the first draft, and the final editing of this training manual. The development of this Manual is under the Coordination of Mrs. Lucille C. Gregorio, Specialist in Science and Technology Education with the support of Mrs. Amporn Ratanavipak, and with the cooperation of Mr. Janchai Yingprayoon, ICASE Asian representative, Mr. Ong Eng Tek, Head of Science Division and Mr. Tan Khun, Director SEAMEO-RECSAM. We also gratefully acknowledge the contributions of our institutional partners and all the persons who provided professional and technical input and resources throughout the development process.

Zhou Nan Zhao
Acting Director, UNESCO-PROAP
31 January 2001

THE TRAINING OF TRAINERS MANUAL
For Promoting Scientific and Technological Literacy (STL) for All

Part 1: Background of the Development Process

Introduction

The Training of Trainers Manual, for the Asian region, to promote Scientific and Technological Literacy (STL) for All, aims to provide guidelines for teacher educators and teacher trainers to be able to learn and provide suitable continuous professional development for science teachers at the pre-service and in-service levels. It has been developed within the framework of "Project 2000+: Scientific and Technological Literacy for All" a project launched in 1993 by UNESCO and ICASE in Paris, in conjunction with a number of other international Non-Governmental Organisations (NGOs). It follows the recommendations of the World Conference on Education for All (Jomtien 1990), and is in tune with the outcomes from the World Conference on Science (Budapest 1999), and the Global Forum on Education For All (Dakar 2000).

The Regional Development Workshops

The development of this Manual was a direct response to the launching of Project 2000+. The first step for the Asian Region took place in Tokyo, Japan in 1994, where a regional workshop was organised by the National Institute of Educational Research (NIER), with fourteen countries participating. One of the recommendations was to "develop teaching-learning materials in science and technology education relevant in the 21st century". As a follow-up, UNESCO-PROAP in collaboration with ICASE, organised material development workshops in Lahore, Pakistan (1997), Manila, Philippines (1997), Kathmandu, Nepal (1998), SEAMEO-RECSAM, Penang, Malaysia (1999), and Langkawi, Malaysia (2000). UNESCO Delhi also organised a workshop in 1999, in collaboration with the Centre for Science Education of the University of Delhi and ICASE. During those workshops, participants from Member Countries of the region attempted to develop exemplar materials based on the criteria proposed and educational objectives suggested for developing supplementary teaching-learning materials, for STL for All.

Those workshops were envisaged as only the beginning of the developmental process, and led to this development of a systematic training manual for use by science educators and science teacher trainers. A growing trend has been to recognise the important role of teachers in many curriculum reforms. This has meant involving teachers in the curriculum development team, and besides providing financial incentives, recognising the teachers feeling of "ownership" and that their ideas and opinions were important and worthy of careful consideration. The expectation was that science teachers in schools were sufficiently capable of developing STL for All teaching-learning materials for their own classrooms once they understood and appreciated the needs for the underlying philosophy. The need for support for the training of trainers to prepare teachers for their role in the reform process was an important step.

Part 2: How to Use the Training Manual

Brief Description of the Sections of the Manual

The training manual is divided into 4 sections as follows:

Section 1:	Conceptualising Scientific and Technological Literacy (STL) for All
Section 2:	Operationalizing Scientific and Technological Literacy (STL) for All
Section 3:	Assessment of Students for STL for All
Section 4:	Creating and Implementing STL Teaching-Learning Materials

Section 1 introduces the idea that science educators and teacher trainers should recognise that the "goal of science teaching" is scientific and technological literacy for all. It leads to an understanding that the goals of education are "to prepare citizens who are empowered to lead productive lives and to enjoy the best possible quality of life." The section guides science educators and teacher trainers to promote a philosophy of STL and draw attention to different ways of developing STL for all. The rationale of Project 2000+ is explained, drawing attention to the concerns regarding the gap between science education as it is currently practiced, and the science and technology education expectations for know-how in the context of societal changes. The concerns are being addressed here.

Section 2 is intended to re-awaken in science educators and teacher trainers as well as in teachers and other educational providers the relevant teaching-learning practices in order to operationalise STL for All. It provides guidelines for the creation of educational programmes (formal and non-formal) with various partners performing complementary roles. The section tries to prepare science educators and teacher trainers to run training programmes for teachers in the way teachers gain STL skills to empower every member of society to initiate programmes for greater scientific and technological literacy for all, to satisfy basic needs and become productive members of the increasingly technological world.

Section 3 prepares science educators and teacher trainers to help pre- and in-service teachers to develop teacher-based formative and summative assessment strategies as a measure of student achievement in meeting the STL for All teaching objectives, thus ensuring that scientific and technological literacy goals are met.

Section 4 equips science educators and teacher trainers with skills and directions to guide their students in both pre-service and in-service teacher education programmes to develop their own teaching-learning materials which are relevant to the lives of the learners and the community members. It emphasises that one approach to guide science education towards greater relevance for the 21st century, is the use of supplementary teaching-learning materials which gives ownership to the teachers.

Other guidelines found in the Manual are as shown in the Table of Contents.

The Target Trainees

The Training of Trainer's Manual is targeted at science educators and teacher trainers. Such persons are seen as pre-service teacher trainers and also teachers who offer workshops for other teachers, often through membership of professional science teacher associations. The Manual is intended to offer help with the tasks of guiding the initial and continuous professional development towards the conceptualisation of STL and the manner in which it can be operationalised in the classroom. Helping teachers could be through courses organised by universities and teacher-training institutions, workshops ran by Science Teacher's Associations, or through school-based in-service training (INSET) activities.

Methods and Activities

Generally, each section starts with an introduction and the concerns, and puts forward ideas on science education towards the 21st century. There are activities and teaching learning resources for trainers to study and better appreciate STL by subsequently trying them out with trainees, and the sections end with a summary. Ideas are presented in an inter-disciplinary and holistic way, and developed by utilising the "Constructivist Practices," wherein the science educator/teacher trainer and hence the teacher learns based on the constructs, which they have already formed previously, often coming from the home or the society and are thus societal-based. The choice of methods, activities, and media is based on the concerns that it is expected science educators and teacher trainers can be expected to tackle, utilising participatory, learner-centred, and cooperative learning strategies. The teaching practice approach attempts to emphasise, for science educators/teacher trainers the problem-solving, decision-making and communication activities they need to undertake with the learners.

The Manual emphasizes to science educators and teacher trainers that they should not see the STL teaching-learning materials as replacements for the textbooks, nor recognize them as extensions of the textbooks, but to be aware that they are supplementary resources for teachers. Science educators and teacher trainers need to appreciate the materials are meant to be used by teachers as and when appropriate.

The Skills Required of the Trainers

The science educators/teacher trainers are expected to develop skills to facilitate the training activities. Such skills, required of the trainer, include:

- Ability to grasp and discuss the STL philosophy
- Ability to recognise and develop the range of educational objectives suitable for STL
- Ability to link STL learning objectives to activities, resources and assessment and evaluation
- Able to organize and operationalise effective training programmes for teachers developing STL skills
- Sensitivity to the needs of the trainees
- Ability to create participatory, active and cooperative learning opportunities
- Ability to encourage trainees to express their views and take 'ownership' of the STL philosophy
- Ability to counter resistance among the trainees and to motivate them to appreciate how they might overcome perceived constraints

Roles and Responsibilities of the Trainers

While the science educators and teacher trainers are considered as facilitators, their learning and taking responsibility for the planning, organizing, implementing, monitoring and evaluating the training activities is the major target of the guidebook. For this, it is expected the science educator and teacher trainers are able to:

- Put forward criteria to be used by the participants in developing teaching-learning materials
- Being knowledgeable about all sections of the Manual, paying particular attention to the training objectives, activities, resources, assessment and evaluation, references and other details related to the training
- Prepare all needed materials and equipment
- Be effective in demonstrating all training methods and strategies
- Guide the trainees to discuss and take ownership for the STL philosophy and approaches during the training period
- Plan the evaluation of the training program and the skills of the participants towards STL
- Report on the outcomes and impact of the training

Adaptation, Translation and Reproduction of the STL for All Training Manual

This Manual is meant to be a “generic training manual.” Institutions, organisations, associations, and other interest groups may adapt and translate the Manual, considering the policies on professional development of science teachers and other education providers, the availability of resources, the souci-economic and political environment, culture and traditions, and the partnerships within the teaching profession.

Specifically, the adaptation and translation would be expected to cover the following:

- Identification of relevant, but scientifically related issues and concerns
- Validation of the materials – the need for trials and pilot testing
- Design of relevant teaching-learning materials
- Utilization of Materials in the Classroom to achieve the intended objectives
- Identification of networks and partners
- Plan for continuous professional development
- Mobilization of technical and financial resources

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The Future

The continuous professional development of teachers is crucial if "Change" is desired in the way education is provided. Appropriately trained trainers of science teachers leading to relevant training of the teachers can ensure the effectiveness of the learning process. Teachers can be expected to be comfortable with change if they are provided with support to help them move forward in the right direction. Project 2000+ recognises the importance of professional development of teachers, and the importance of strengthening the skills of leaders, or science teacher educators.

Project 2000+ promotes two important facets of teaching: (i) the use of project work, and within this, the development of problem solving and communication skills; and (ii) teaching strategies that include relevant science education, and within this, the development of decision making skills related to social issues, where acquiring science knowledge is but one factor.

SECTION 1

CONCEPTUALISING SCIENTIFIC AND TECHNOLOGICAL LITERACY (STL) FOR ALL

1.1 Introduction

UNESCO's Director-General in his address during the launching of Project 2000+: Scientific and Technological Literacy for All (UNESCO, 1993), said:

> *"Just as education can no longer afford to assume that its essential purpose is to cater for the scholastically gifted, for future university entrants, for the Nobel laureates of tomorrow, so it can no longer afford to maintain the artificial distinction between those who are suited to the sciences and those who are predestined for the humanities. Efforts to achieve 'Education for All' must therefore be closely linked to a worldwide drive to raise levels of scientific and technological literacy. In practice, this means ensuring sound numeracy, a grasp of the fundamental concepts and methods of science together with the development of elementary problem-solving skills and associated decision-making capabilities. All are required in a world in which political, economic, social and ethical considerations have become inextricably linked with the consequences of scientific and technological advance. ….*
>
> *….in a world increasingly shaped by science and technology, scientific and technological literacy is a universal requirement, if people are not to be alienated in some degree from the society in which they live, they are not to be overwhelmed and demoralized by change, if they are to have the basic knowledge and understanding to make those multifarious political, environmental and ethical choices with which scientific discovery and its consequences are confronting us all."*

The statements reflect the concerns regarding the seriously increasing gap between science education as it is currently practised and the science and technology know-how and the skills that the general day to day living demands. They also reflect the anticipations of forthcoming changes in the years ahead. The concerns are now clear, but addressing these concerns and preparing science education towards making science and technology contextual to society still remains a challenging task. The first challenge is how to prepare existing educational institutions, their programmes, their staff and to take operational steps. This Manual is an effort towards taking that challenge.

1.2 The Concerns

Science curricula in many parts of the world are today still heavily characterised by their appeal to the more able students and their thrust towards 'doing as scientists do'.

This leads to the impression that those science subjects:

- are difficult in the eyes of students, compared with other subjects
- demand much intellectual thinking and are geared to the more able students

- consist of fundamental (often very abstract) ideas, which are considered necessary for the understanding as the first step
- consist of knowledge suitable for science related careers only

The above statements lead to some generalised views that school science is largely irrelevant to what society needs. What can science educators and teacher trainers do to guide teachers to combat these views?

As a first step, it is important to be able to establish what views participants on a training course or workshop might have in this direction.

Activity 1 -1: Participants' View

It will be useful to determine at a very early stage whether the participants support the point of view 'that school science is largely irrelevant to what society needs'. If so, and there is a strong conviction, then further ideas could be put forward. A checklist could be utilized. (Refer to Checklist: Participants' View Regarding Science Teaching, pg. 15)

If you, as the course workshop leader, are able to mention the STL view at the onset, then the meaning can be expounded (Refer to Resource 1C: Scientific and Technological Literacy for All, pg.20).

From the responses to the checklist, the following questions could guide the discussion:

What do you feel would be the current views of students about

- ***the learning of science concepts?***
- ***the value in learning science ?***
- ***the type of questions asked in science lessons ?***
- ***their attitude towards science ?***

(Refer to Resource 1A: General Student Views, pg.16)

1.3 Rethinking Science and Technology Education

Since science and technology are impinging more and more upon our day-to-day living, assuring literacy in these areas for today's youth must be a priority of educational reform (Shymansky and Kyle 1990).

If this is true, then it is critical that science education prepare our youth for an increasingly scientific and technological world where citizens will need to learn and apply knowledge to solve real-world problems. Unfortunately, our youths are not learning the nature of science or developing deep conceptual understandings of scientific concepts, nor do they find science interesting (Krajcik 1993).

1.4 The Purpose of Science Education

Activity 1 -2: The Purpose of Science E ducation

"Science education is so important that it must play its major role in covering the educational goals stipulated within a country."

If participants agree with above statement, you, as the course worlshop leader, need to identify the purpose of science and technology education. If not, you need to cope with a discussion on alternative ideas and try to counteract any claim that equates science education solely with the acquisition of science knowledge.

Do participants think it is possible to generalise th e purpose of science education for all students, in whatever class, or grade level or whatever year group within the school?

For this discussion session, all ideas are acceptable, and you, as the course or workshop leader, will be able to classify and analyse ideas put forward.

While there are differences in emphasis and complexity, it is suggested that the purpose of teaching science remains constant. Its purpose is to achieve scientific and technological literacy for all.

Two major categories for science education have been suggested by the Advisory Council for Applied Research and Development (ACARD 1986) as follows:

- Basic/fundamental science, which is driven by curiosity and speculation about the natural world without thought of possible application.

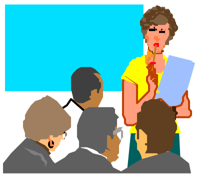
- Strategic Science, a body of scientific understanding which supports a generic (or enabling) area of technological knowledge, a reservoir of knowledge out of which many specific products and processes may emerge in the future.

A third category has been suggested by Levy (1989):

Mandated Science, the output from scientists and technologists in the context of legal bodies to make recommendations or decisions regarding policies. (e.g. regulatory agencies, standard setting organisations, expert commissions).

The above categories do not cover the humanistic component of science and technology, the values we have and the judgements we make as members of society. Here science and technology cannot be taken in isolation, but need to be considered alongside multi-disciplinary areas such as economics, environmental concerns, socio-cultural aspects and political considerations. A fourth category may be added.

Values science, which is the issues and concerns of society and how a study of science and technology can help to provide possible solutions to the identified concerns.



Activity 1 -3: The New Vision of Science Education

Ask participants to discuss all the 4 categories of science education.

The following case could be analysed.

Jenkins (1992) notes that much present day scientific effort in industry is directed to the production of the second and third of these categories. In contrast, the content of school science courses and the prevailing emphasi s in science education at all levels has been derived for the first category. Yet category 4 is also important. Ware (1992) points out in a World Bank report that an understanding of the utility of science is especially important in developing countries. Students need to learn that science does not exist in a vacuum. Society determines which scientific research is funded, Science and technology contributes to a better standard of living for the community through better health care, more nutritious diets, mo re effective land use, provision of a steady supply of energy, durable consumer goods, etc. Policy decisions involving the interaction of science and society must be made, not only by the scientific community, but also by informed members of that society, because this will determine the future of a country.

Of the 4 categories, participants should be asked to suggest which should be the current and future emphasis of science education.

From the above, a case can be made that even future scientists need a much broader education than they are currently receiving, if they are to function as responsible citizens.

1.4.1 Science Education for Citizenship

At this stage it is important that participants realise that "science for the citizen" is a requirement. And everyone is a citizen. There seems to be a growing realisation that science education is not simply about teaching science as recognised in the world of scientists. It is more than learning the processes that scientists undertake. Science education is also seen as interacting with the societal influences and concerns that surround the science, whether they be in the laboratory or in the home.

The current view of science education, and the close identity of science with technology, means that both the goals of science and technology education need to be examined. If science education is being redefined, its isolation from technology education also needs to be examined. The close link between science and technology is evident from the difficulty many have in distinguishing between the two, but this is not to distract from the fact that there are differences that can be magnified between them, particularly at the operational, rather than the theoretical level. Yet the technological skills needed for employment in the future are increasingly expected to be based on an understanding of science principles.

Activity 1 -4: Technology in Science Education Programmes

Guide participants to discuss whether there is a need to incorporate much more technology in science education programmes, both as a process as well as a product. Suggest participants to present their points for analysis leading to a common agreement.

The following case could serve as rationale for the follow -up discussion.

Today there is the recognition that the man -made world around us is based on technology. It is the technology that we see around us. The science is less visible. Yet to obtain a more technologically literate society, there is a need for people to receive a more relevant grounding in science. This grounding involves the technology surrounding them and the issues and conflicts that are related to the use of that technology in society (Holborn 1992a). Science education needs to encompass this technology.

Technological processes stemming from the use of technology hardware is clearly another aspect important in science. Operating a Bunsen burner is one such example. But the computer or a range of instrumentation can also be important as scientific aids.

Ask participants to give opinions on the above – do they agree or disagree on the points raised?

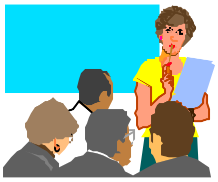
1.4.2 Science Education for the Future

Research proponents have argued that the study and understanding of the interactions and relationships of science-technology-society (STS) education need to become an integral part of contemporary and future science education for all (Bybee 1987; Fensham 1983; Solomon 1988; Waks & Parkash 1985; Yager 1985; Zoller 1987). Yager (1993) suggests that the basic aim of this approach is to engage students in problem-solving activities which they have identified and in which they have a personal stake. Students often work individually, but can also work in groups as investigatory teams. Students provide challenges for given conceptualisations, but the last confrontation or challenge is often the current conceptualisation of the scientific community. Instead of telling students what these ideas are and using the laboratory to verify the scientists' claims, the laboratory is used during the investigation as a further check and challenge. The attempt is always to use (and usually alter) the construct students have when they enter the classrooms.

However, Shamos (1993) states that basic to science education efforts is the production of an informed citizenry, capable of making crucial decisions about current problems and issues and taking personal actions as a result of these decisions. This means focusing on current issues and by attempting their resolution, prepare students for current and future citizenship roles. This means that students identify local, regional, national, and international problems, plan activities which address them, and move to actions designed to resolve the problem investigated. The emphasis is on responsible decision-making in the real world of the student within which science and technology are components.

Shamos continues that, by making science relevant to the students' everyday lives, they will take more interest in the subject and work harder to master it. Another argument is that by making science education relevant, it helps to create better citizens. An awareness of science-based societal issues, would also create greater interest in students, both in the science and in the related social issues.

Clearly, both problem-solving and decision-making in the context of science education for the future, and the high levels of critical thinking required on the part of both students and their teachers, are different. They are much more demanding than the exercise-solving process in ordinary science education (Keiny & Zoller 1991).



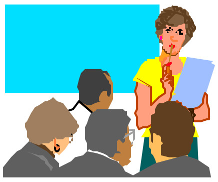
Activity 1 -5: What is science education for the future?

Based on the text above, you, as the course or workshop leader can, and you can suggest participants try, to find more evidences to support the issue. This could be presented and discussed.

1.4.3 The Objectives of Science Education

Goals and objectives are not only important for the teacher. Research carried out by Melton (1978) showed that 64% of students, who were aware of the educational objectives, achieved better results on acquiring teaching material essential to these objectives, but the remaining 36% however, did not suffer, neither achieving better results, nor doing badly. He explained that students achieve better results when:

- the objectives are explained
- teachers consider an understanding of the objectives essential
- the objectives are not too difficult to understand, or achieve
- the objectives relate to personal interests
- prior motivation in other directions is not too strong to allow students to meet the objectives



Activity 1 -6: Objectives of Science Education

Determine whether participants would agree with Melton?
How can teachers bring the educational objectives of science teaching to the attention of students ?
What are the objectives of Science Education?
(Refer to Resource 1B: Objectives of Science Education pg. 1 7)

1.5 Project 2000+: Scientific and Technological Literacy (STL) For All

Literacy in science and technology encompass a whole range of attributes needed to use and interact with issues that utilise components of science and technology. A level of scientific and technological literacy is important which leads to the recognition of problems, to considerations of how to solve problems, and to an ability to make decisions based on sound judgment and values inherent in the society. All this is in addition to the cognitive skills acquired through laboratory science teaching.

The relevant education for which we strive can be expressed as 'Scientific and Technological Literacy' (STL) for All. Unfortunately this is not a static target and also can also be achieved at various levels. And as a concept, there are no specific definitions, although the intention is to operationalise teaching in this direction and thus it is the target for science teaching.

Activity 1 -7: The Meaning of STL

At this stage it is useful [for you] to appreciate what is meant by STL. The following questions need to be discussed.

What is the meaning of STL ? Give examples
(Refer to Resource 1C: The Meaning of Scientific and Technological Literacy for All, pg.20)

You, as the course workshop leader could encourage participants to prepare concept maps on this, followed by discussions.

Activity 1 -8: The Scientifically Literate Person

To reinforce the concept of scientific literacy, it is appropriate at this stage to ask 'who is scientifically literate'? Prepare your description of a 'scientifically literate person.'

(Refer to Resource 1D: Who is Scientifically Literate pg.23 and Resource 1E: Background of Project 2000+, pg. 24)

1.6 Summary

Section 1 has illustrated the need for all science educators to move away from a narrow view of science and technology education as being that which duplicates what 'scientists' or 'technologists' does. In its place is suggested the need for a science education related to relevant concerns of individuals and the society.

In recognising that these needs and concerns change with time. As science and technology change and become increasingly important in our day-to-day lives, so must science education also change. The stress is on the promotion of scientific and technological literacy and that this is the only goal of science and technology education. Determining a way to operationalise the promotion of scientific and technological literacy within a society and in a specific cultural setting, is of crucial importance for all involved with science and technology education. This is a special challenge to those in developing countries where concerns about the importation of 'Western' science and technology are most strong. In meeting this challenge, it is of course important to realise that STL is not a 'have' or 'have not' situation. All students need to develop, over time and at greater levels of sophistication, conceptual understanding, positive attitudes and above all, a feeling of the value of science and technology in problem solving and decision-making.

In the development of science teaching materials it is important to recognise the change in the direction of science education. It is important that new teaching materials include objectives related to societal needs and concerns as well as addressing scientific processes and concepts. This is an important challenge.

Checklist : Participants' View Regarding Science Teaching

MESSAGE: WE TEACH STUDENTS, WE DO NOT TEACH SCIENCE

Direction: Write A- If you Agree; D – If you Disagree; and N – No Comments

- Science curricula are heavily content oriented
- The sequence in science curricula is first learning fundamental principles and then considering applications of the science in technological advances
- As scientists are involved in the development of science curricula, the curricula include much conceptual understanding of principles which lead to generalised theories to be verified experimentally
- Whilst not specifically intended, the teaching stresses the theoretical over the application
- The teaching isolates science from social issues
- Whilst science is presented in a logical fashion, building up generalised patterns, it is kept free from social values and the impact of economic or societal concerns
- Science answers all the ills of society
- Experiments can be fun, the observations easy, but the interpretation of the experiments relate to a unique observation
- Often the interpretation demands insights at a higher level beyond the comprehension of the students and as such interpretations are highly directed by the teacher
- Traditional teaching methods expect teachers to supply the answers to all questions raised by students

Resource 1A: General Students' Views

Yager and Roy, 1993

Yager and Roy (1993) grouped students' general views about science teaching into 4 areas, namely:

(1) with respect to Concepts

- sees science processes as abstract, glorified, unattainable skills
- the focus of the science class is on students learning concepts
- acquire concepts so as to do well on a test
- concepts are seen as the results of teaching

(2) with respect to Connections and Applications

- SEES no value or use for the material studied in science class
- SEES no value in science studies for resolving current societal problems
- recite information studied
- cannot relate the science studied to any current technology
- cannot relate science studies to daily lives

(3) with respect to Creativity

- exhibits a declining ability to question because questions raised, which do not conform to the course outline, are often ignored
- rarely feels the need to ask thought provoking questions
- ineffective in identifying possible causes and effects in specific situations
- does not have to have original ideas

(4) with respect to Attitude

- exhibits a declining interest in science at all grades levels
- curiosity about science seems to decrease
- SEES the science teacher as a purveyor of information
- SEES science as information to learn

Resource 1B: Objectiv es of Science Education
Holbrook and Rannikmae 1997

The major components that are needed in the development of the objectives of science education in line with STL are as follows:

1. Social value skills
2. Scientific method
3. Personal skills
4. Science knowledge

Each of these components is explained below.

1. Social Value Skills

This component illustrates that education is a societal demand. Science education has a duty to aid the development of persons able to integrate and gain skills to function within the society, e.g. science education in relation to cultural, environmental, political and societal understanding, awareness and values.

Although not unique to science teaching, very important components of STL teaching, are:

- the ability to recognise and discuss societal problems and issues,
- putting forward informed opinions and making that relate science concepts to economic, environmental, political and social considerations

Social skills also relate to being able to put forward points of view or procedures and being willing to reach consensus as a group. In being able to put forward opinions, students need to be guided to develop values and the ability to communicate these. STL teaching emphasises the need to substantiate points of view with evidence as appropriate to the circumstance and to exercise tolerance with others in putting forward views - appreciating moral views is crucial for social harmony. An STL goal must therefore, be to produce informed citizens prepared to deal responsibly with science and technology related issues.

2. Scientific Method

The second component encompasses the techniques of investigations, the required skills and activities of inquiry (observation, data collection, formulation of hypotheses, experimentation, etc.) and scientific attitudes (e.g. openness, recognition of errors). As this component exists among all sciences, it has been taken as fundamental for the integration in the different subject areas.

Within society, our concern is with the ability to solve problems connected with our daily lives and also the ability to make decisions. Solving problems require a scientific background and a knowledge of the scientific method. It is thus very fitting that science teaching should play an important thrust in this area alongside other subject areas. Solving problems begin from a recognition of the problem and usually the ability to transform the problem into one that can be answered scientifically. This is then followed by suggesting ways in which the problem can be tackled, the materials required for an investigation and the manner in which an investigation can be carried out for meaningful results and then an interpretation of the findings to see whether the problem has been solved.

The scientific method requires a background in handling process skills geared to scientific investigations. Such skills as observing, hypothesising, experimenting, analysing and drawing conclusions are important for science education as are handling equipment, controlling variables, measuring, calculating and planning procedures. 'Recipe following' when carrying out experimental procedures is **NOT** regarded as a STL target for scientific method.

3. Personal Skills

The third component recognises that students are individuals and that science education needs to play its part in helping individuals acquire a general education that is relevant to their development and in raising their awareness of career opportunities.

The need to educate the person is also of importance in science education. Students need to be able to utilise science for improving their own lives or health and coping with the changes taking place in our technologically advanced world. The ability to communicate is a major component here. Also of importance for personal skills is the attitude of the individual, especially towards science and technology. Developing an interest in science and the role it can play within society has much to do in promoting science learning in school.

The ability to understand scientific concepts, to recognise problems and to suggest methods of resolving such problems also relate to personal skills and of course follow on from an interest in the subject. Finally, personal skills gained from science learning should enable students to be more aware of the range of career possibilities that match their aptitude and interests.

4. Science knowledge

The fourth component includes facts, concepts, generalisations and conceptual schemes generated by scientists. It also includes abstract ways that knowledge may be organised and the functional applications of knowledge. This has all too often been taken as a major aim of science teaching with the canonical knowledge taught associated with the specific subject areas (chemistry, physics, biology).

In this context, knowledge covers the whole range of acquisition of science, from simple factual aspects, to higher order thinking skills. A conceptual error by many teachers is to assume that teaching must follow a sequence from simple knowledge, through understanding before the higher ability learning can take place, if higher ability thinking can be attained at all. STL learning does not recognise such linearity. It recognises that the real challenges are the higher order skills and that these should be introduced as soon as possible. Such skills are as much part of primary school teaching as they are in the upper levels of the secondary school.

Besides the four components above, another component to be stressed is Higher Order Thinking Skills.

5. Higher Order Thinking Skills

This is a major component for science learning. The ability of students to think, to solve problems, analyse situations, make predictions, evaluate or make judgements based on information available draw conclusions, are of importance to STL learning. STL learning is as much about understanding and utilising scientific concepts and principles as it is about relevance to everyday life. Whilst higher order thinking is usually linked with the manipulation of knowledge, they also apply to societal problem solving and decision-making.

Higher order thinking skills in science teaching have, in the past, tended to relate to 19th century science abstractions of academic principles and seen as having little to do with the critical thinking needed to relate to the science and technology involved in everyday life. This is serious omission if care for the environment is to be coupled with technological development as we aspire towards sustainability. Higher order thinking is crucial if important social problems are to be tackled seriously.

The reasons cited why teachers have not given much attention to higher order thinking skills are due to:

(a) their belief that higher order thinking skills are part of a hierarchy skills and cannot be acquired until lower order skills have been mastered

(b) their unwillingness to allow sufficient thinking time for students

Resource 1C: The Meaning of Scientific and Technological Literacy for All

Holbrook 1998

What Scientific and Technological Literacy means

STL is :

- 'Scientific', because most definitely science concepts and the manner in which problems are approached (scientific method) are very much relevant to an understanding of our world of today.
- 'Technological', because, for relevance, the processes of technology are heavily intertwined with those of science. It is probably fair to say that whenever you look around, it is the products from technology that you see; not the science. Yet the process by which the products are formed are likely to be based on scientific as well as technological know-how.
- 'Literacy', because it is not good having conceptual understanding if it can not be utilised. It is not good knowing science if it cannot be communicated to help solve problems or handle decision-making for concerns within the society. It is also not good if learning science does not contribute to the development of social values, personal interests, personal responsibilities and career enhancement. And finally, it is not good if learning science in schools does not prepare students for the world of tomorrow, able to face up to the multitude of changes and challenges. Science should teach students to cope with changes and learn to learn.

The Literacy Component

Acquiring 'Scientific Literacy' goes beyond learning from the textbooks. It is dependent on the vision of the teachers and the recognition of science education research findings that stress the advantages of student involvement, constructivist approaches and the role of the teacher as facilitator (rather than provider of knowledge). In some countries, the inadequacy of worksheets, unless used by teachers merely as support material, is of grave concern because they pay scant attention to the literacy dimension.

In fact, it is the literacy dimension that, on the one hand, suggests relevancy in science education curricula having uniformity across education systems around the world. The need to strive for conceptual understanding and the process of tackling problems in a scientific manner has worldwide applicability. But, on the other hand, relevance means curricula around the world need to reflect the concerns, priorities, customs and heritage of the society. In terms of relevancy, the context of the science curricula needs to be appropriate to the different societies.

All science teaching is geared to the educational objectives (although these objectives change in degrees of expectations at different stages of schooling). How far science education emphasises any specific general education goals will obviously depend on the overall learning environment, and especially the range of learning situations offered in addition to the science lessons. This in turn depends on the range of subjects offered within the total curriculum, the age of the students and the amount of teaching time allocated to science subjects.

STL is not a constant target but its promotion depends on the education received and the educational objectives within a specific country. This is a very important point to note in striving towards STL. In fact, it is important to realise that ALL students do achieve some degree of STL. But in putting forward STL as the teaching goal, it is STL that enables students to acquire educational objectives, to the degree intended by society that is important. And this will be more demanding the longer students remain in school. The Biological Science Curriculum Study (BSCS 1993), referring to biological literacy, suggests 4 levels of STL operating in schools, but only the fourth is seen as the real target.

The four levels of STL identified are as below:

1) Nominal STL literacy

Students identify terms and concepts as being scientific in nature, but they have misconceptions and can only provide naive explanations of scientific concepts.

2) Functional STL literacy

Students can describe a concept but with a limited understanding of it. School examinations are reknown for testing this level.

3) Structural STL literacy

Students develop personal relevance and are interested in the study of a scientific concept and construct appropriate meaning of the concept from experiences.

4) **Multi-dimensional STL literacy**

Students understand the place of science among other disciplines, know the history and nature of science, and understand the interactions between science and society. The multi-dimensional level of literacy cultivates and reinforces life-long learning in which individuals develop and retain the need to know, and have acquired the skills to ask and answer appropriate questions.

Notice it is only the multi -dimensional STL level that enables students to appreciate the place of science in their daily lives. It is at this level that students begin to see meaning in any formal science education. The goal is thus to raise the level of STL above the structural level and empowe r all students to lead productive lives by striving towards multi -dimensional STL.

What is STL?

A definition is not really helpful and certainly trainees may want to operationalise STL in the classroom rather than to be able to memorise a statement. But the following is put forward as a guide:

- STL is usually taken to mean developing the ability to utilise science knowledge creatively in everyday life, to solve problems, make decisions and hence improve the quality of life. This is based on acquiring educational skills at the intellectual, attitudinal, societal and interdisciplinary levels.

- If the above represents the target, then STL within formal schooling can be interpreted as 'science which is intended within the school curriculum such that science education can maximise its role in aiding students to acquire the goals of general education, as stipulated by society.' In other words, science is taught in schools, because it is seen as an important part of general education.

Resource 1D: "Who is scientifically literate?"
UNESCO, 1993

A general description might be:

A scientifically literate person

1. knows something of the role of science in society and appreciates the cultural conditions; knows the conceptual inventions and investigative procedures
2. understands the interrelationships of science and society, ethics, the nature of science, including basic concepts and the interrelationships of science and humanities
3. appreciates the role of science in a humanistic way, and feels comfortable when reading or talking with others about science at a non-technical level
4. curious about the how's and why's of materials and events - and genuinely interested in hearing and reading about things that claim the time and attention of scientists
5. may never create any ideas pertaining to science, but will be conversant with the ideas that are being considered

Resource 1E: Background of Project 2000+

Modification of UNESCO, 1994

UNESCO, together with its partners in Government and Non-Government Organizations (NGOs), especially the International Council of Association for Science Education (ICASE), launched Project 2000+ in 1993 in Paris. Project 2000+ attempts to mobilise worldwide support for action in which partners collaborate at the country level to achieve a greater degree of scientific and technological literacy for all (Holbrook 1992b; Holbrook 1994). Project 2000+ suggests a need to rethink the objectives of science and technology teaching and give more serious consideration to the nature of science, science-technology links and the importance of technological skills in science courses. It is important that science and technology are taught in a societal context and students learn to cope with a decision-making process in which a variety of factors (e.g. economic, environmental, ethical) may have some influence.

Project 2000+ recognises that, in many countries, basic education in schools includes little that will help students achieve such literacy, or feel confident either in applying their knowledge or in dealing with societal issues and the need for responsible actions. It is thus crucial to recognise that there is a need for this to change. There is a need to appreciate how this might change. There is a need to consider the steps required ensuring such a change can be initiated and developed. Project 2000+ is intended to make governments and NGOs aware of the changing world, the need for science and technology education to change with it, and how this might be attempted.

Project 2000+ is a movement asking each country, worldwide, to:

1. identify ways of promoting the development of science and technology education for all [THINK GLOBALLY]
2. put forward education programmes for regional and national consideration with an aim of satisfying basic needs of the population and enhancing productivity in an increasing technological society [HELPING TO SUPPORT LOCAL ACTION]
3. put forward guidelines for regional and national consideration of formal education needs of students and the needs of the adult community in the area of scientific and technological literacy [HELPING TO SUPPORT LOCAL ACTION]
4. support the development of a wide range of regional and national projects, evaluation studies, teacher education programmes and resource development [HELPING TO SUPPORT LOCAL ACTION]

SECTION 2

OPERATIONALISING SCIENTIFIC AND TECHNOLOGICAL LITERACY (STL) FOR ALL

2.1 Introduction

This section analyses the current teaching and learning practices, and examines the roles of science educators and teacher trainers in interacting with teachers, students, communities, as well as other concerned agencies, including non-governmental organisations (NGOs). It also discusses manner in which science educators and teacher trainers can enable teachers to gain the skills needed to perform these roles in an effective manner and identify teaching and learning strategies that are relevant for guiding students to increase their scientific and technological literacy. Most of the points made have always been relevant to teacher training and science teaching. They are not new. But they are important and STL teaching and learning will not happen without them. The section is intended to re-awaken the science educator, teacher trainer, and hence teachers and other people concerned with science education to the teaching and learning strategies that will need to be reflected in any STL material.

2.2 Problems in Current Instructional Practices

Research suggests that teacher trainers tell teachers how to teach but give little attention to interacting with teaching actually taking place in the classroom. There is usually little room for action research in any pre-service or in-service teacher education programme.

Further, Research suggests that traditional science teaching and learning usually involve a limited set of instructional strategies, which are used to teach a curriculum with overloaded facts. This in turn tends to lead the students into becoming passive learners. Research also indicates that many students at the primary, middle, and secondary school levels:

- do not understand fundamental science concepts
- do not relate science concepts to real phenomena
- memorise science terms without understanding
- memorise problem-solving steps

Common problems that have been identified with traditional science teaching are as follows:

- Poor involvement of students
- Barriers to change
- Teachers teach science contents, not students
- Poor classroom climate
- Lack of favourable social cultural factors

2.2.1 Poor involvement of students

Research has shown the importance of student involvement in science and technology education. According to Goodlad (1983), in the present context of science education, students are expected to do little more than memorise content knowledge or record observations.

2.2.2 Barriers to change

There are several barriers to change. Anderson et. al. (1992) draws attention to 10 barriers that science educators and teacher trainers have failed to remove when trying encourage changes to the manner in which a teacher teaches. These are:

(i) Reformers do not all agree on the type of reform and the strategies for reform [intention not clear]

(ii) Many teachers cannot use strategies proposed by new models of instruction [teaching deficiency]

(iii) Many teachers hold beliefs and priorities that are incompatible with envisioned changes [philosophical incompatibility]

(iv) Community members, administrators, and policy makers hold beliefs and priorities that interfere with change [management concerns]

(v) Students have expectations about learning that interfere with their ability to be full participants in new models of learning [poor teacher-student relationship]

(vi) New instructional, curricular and assessment materials are needed to support the changes in the learning environment [lack of resource materials]

(vii) Learning outcomes and expectations for all students are missing [intentions poorly conceived]

(viii) Systemic thinking about reform is often missing [poor implementation guidelines]

(ix) Cultural differences and their implications for how this change is handled are not considered [poor implementation guidelines]

(x) Mixed signals are given to teachers and students via mismatches among learning outcomes, assessment and curriculum [intentions poorly managed].

Activity 2 -1: Barriers to Change

You, as a course/workshop leader get participants to discuss the following question in groups.

"What constraints do you perceive as the most important barriers t o change?"

Discuss the issue and suggest alternative ways of overcoming the constraints.

2.2.3 Teachers Teach Science Contents, not Students

So far, approaches to incorporate the tremendous changes in modern technology have been for curriculum developers to design new curricula and teaching-learning materials, which includes topics such as biotechnology, plastics, electronics, laser, etc. This merely modernises the content, but does it cater to the needs of ordinary citizens? The ordinary school child will continue to be subjected to issues like pollution danger and health hazards in his/her everyday life. For instance, the term 'chemical' refers to something poisonous and definitely not to be found in the home. The average person continues to be ignorant to the fact that foodstuffs and the multitude of painkillers and other pharmaceuticals used at home are actually chemicals and even the petrol used in cars, or paints and other decorations of the home are chemicals.

Perhaps more than in any other subject area, science teachers perceive their task as teaching the subject matter (Aikenhead 1997). They see their task as imparting knowledge and understanding of the principles that underlie this knowledge (Romberg 1985). The feeling is so strong that 'completing the syllabus', as exemplified in the curriculum, is a common target for science teachers. Experimental investigations are given a low priority, especially if the external examination places little weight in this area. Assisting students to develop skills of problem solving is not taken seriously, unless this simply means tackling a variety of numerical problems. Time is certainly not set aside for students to (i) plan an investigation and then (ii) to carry out the plan, or to make decisions where the answer is not clear cut and a multitude of factors can influence the decision, such as economic, social, environmental, political, or ethical considerations.

It would seem that teachers continue to give greater attention to the content knowledge of the subject for a variety of reasons. One important factor is that textbooks, for the most part, tend to ignore non-conceptual areas. If the textbook includes applications within the society, it tends to be 'cases' quoted after a study of the science concepts (rather than an attempt to start from society's way of utilising science).

The textbook emphasis and approach are, of course, heavily influenced by the manner in which the curriculum is put together. For convenience, the curriculum is almost invariably put together based on science fundamentals, and science concepts are grouped together for scientific convenience. The curriculum rarely groups learning based on the way society makes use of science e.g. for solving issues/concerns in the kitchen, the bathroom, the local environment, industry and employment.

Teachers have not been able to initiate student-centred activities and therefore, students have not been able to grasp the content knowledge. Student activities that have the potential to increase content knowledge are avoided e.g. library searches, location of secondary information sources, because these could not be controlled easily by the teacher. As a consequence, science becomes impersonal and increasingly irrelevant; and in the hands of uninterested teachers, just a memory exercise. Utilising various teaching-learning strategies, such as brainstorming, role playing, small group discussions, and creative activities such as developing posters, composing letters to officials, raising environmental awareness and participating in debates, could be helpful.

2.2.4 Poor Classroom Climate

The classroom climate is governed by two crucial factors:

- the atmosphere, including changes in atmosphere, created by the teacher (and the students)
- the manner in which students are guided to learn within the classroom (or laboratory)

Activity 2 -2: Classroom Climate

Initiate a Debate on the following statements:

"Effective Teaching for scientific and technological literacy is strongly related to achieving the appropriate classroom climate for a given situation."

Do you agree with this statement? How important is the link between classroom climate and effective student learning?

Reflect on the agreements and disagreements.

In trying to suppress undesired behaviour, many teachers remove or severely limit classroom freedom. By doing so, teachers often inhibit intellectual freedom as well. Such teachers see simple, repetitive tasks as necessary for classroom control and hence generate a classroom climate with little intellectual stimulation and much boredom. Encouraging intellectual freedom to stimulate critical thinking, creativity, and communication, while restricting social freedom to that deemed necessary or desirable, requires that a teacher has a clear image of the desired classroom climate, a rationale to define and defend it, and above all, the professional competence to create it (Penick and Bonnstetter 1993).

Good and Brophy (1991) reported that all too often teachers:

- dominate communication
- overuse factual questions
- do little to motivate
- neglect to emphasise meaning

Activity 2 -3: Teacher Behaviour

Initiate a Debate on the following statement.

"The single most problematic teacher behaviour is that of dominating classroom communication by telling (giving information), or by the use of simple factual recall questions."

Whole class discussion should follow after the debate. The arguments could be presented for other participants to reflect upon.

Activity 2 -4: Do Teachers Create a Proper Atmosphere for STL?

Arrange for participants to Answer the following question, individually or in groups.

"Do you think there is the danger in using an STL classroom approach that teachers think they are creating an appropriate classroom atm osphere for student -centred learning, when in fact, an outsider would view it very differently?"

Answers should be defended, and argued with other members of the workshop.

2.2.5 Lack of Favourable Socio-Cultural Factors

Here are five predictors of socio-cultural influences in the teaching and learning of science in Nigeria of which STL teachers should take note (Jegede and Okebukola 1992).

(i) Authoritarianism

It is difficult to create an appropriate climate for STL teaching where the science teacher is a 'learner' because science teachers are usually seen as the 'elder' who 'knows all' in relation to scientific and technological literacy. The teacher's views are not to be challenged. In such an environment, whole class teaching and the enhancement of scientific and technological literacy could be very incompatible.

(ii) Goal Structure

The co-operative setting of Africa means the goal structure of individuals is directed to the same objective and there exists a high interdependence among the goal attainment of individuals. This aspect, if carefully nurtured, should be a valuable asset in developing a classroom climate for societal objectives.

(iii) Traditional Worldview

Challenges to the traditional beliefs and superstitions place students in positions of conflict with society, as they are expected to believe the traditional beliefs without question. Case studies and role playing activities may be important classroom strategies to help students in this situation.

(iv) Societal Expectations

Success of an individual within a community is interpreted by the way he/she interacts within a communal society. The behaviour of that individual is governed by the society. Without changing the society, attempts to change the individual become difficult and the classroom climate can become one of non-co-operation.

(v) Sacredness of Science

The learning of science is seen as incompatible to the thoughts of someone from a non-western society. Learning science is something special, requiring magical or weird explanations. It does not relate to societal concerns. A positive classroom climate could well be an essential factor in challenging this belief.

2.3 The Needs for Operationalising STL

Science educators and teacher trainers must be very conversant with the following and ensure teacher needs are met:

- The goals of science education
- Appropriate eaching skills for STL
- Creating a suitable learning environment for STL teaching
- Recognising teaching domains needed for change
- The Role of textbooks in STL teaching

2.3.1 The Goals of Science Education

Science educators and teacher trainers should be aware that Seven major goals have been identified which teachers wish students to attain, have been identified (Penick and Bonnstetter 1993). These are:

(i) Having a positive attitude towards science
(ii) Using knowledge learned to identify and solve problems
(iii) Developing creativity
(iv) Communicating science effectively
(v) Feeling that knowledge acquired is useful and applicable
(vi) Taking actions based on evidences and knowledge
(vii) Knowing how to learn science

To a large extent, science educators and teacher trainers need to recognise that the above goals are independent of the curriculum content, the textbook and the examination. But they are very dependent on the manner in which teachers see their professional role.

Activity 2 -5: Goals of Science Education

Allow participants to Discuss the seven goals in small groups and present your arguments.

Those in agreement will present strategies on how the goals could be achieved. Those who are in disagreement will als o present reasons why they do not agree to the goals. Posters or OHTs could be prepared for sharing with other members of the workshop.

Teachers, identified as teaching towards the 7 goals expressed above, are recognisable in that they tend to:

- Create new approaches to instruction
- Consistently tell students their goals
- Let students know that they, as teachers, are striving towards helping students attain these goals

These teachers have a well-developed, research-based rationale for teaching science and technology, which guides their classroom actions and their curriculum sequencing.

2.3.2 Teaching Skills and STL Teacher

Research also informs that, for too long, the perceived role of a teacher has been to behave like a **manager** - assigning lessons, starting and ending lessons, explaining rules and procedures, judging students, and maintaining order and control (Romberg 1985).

The many variables involved in teaching students who have different characteristics and curriculum demands, and react differently to examination pressures, to school policies, to relationships with colleagues and to parental wishes, can easily distract the teacher from the main scientific and technological literacy goals of teaching, and from adopting good teaching behaviour. Developing teacher skills to undertake A self-analysis of the classroom situation is important to evaluate their own teaching skills and their relevance to the classroom **(Please refer to Resource 2A: Teacher Self-Analysis, pg. 40).**

Activity 2 -6: Purpose of Teaching Science

Arrange for p articipants to Discuss the following statement :

"There is a real danger that teachers do not give enough attention to the purpose of teaching science and to making sure their teaching approaches are effective".

Prepare a report for presentation and furt her discussions.

We have seen that enabling student to make personal interactions (personalisation), encourage student participation, allow students freedom and encouragement to make decisions, stimulate student investigations, and a willingness to help others, are very important STL teaching attributes.

Activity 2 -7: Individualised Classroom Environment Questionnaire

Allow the participants to Discuss in small groups to answer the following:

"Would you agree that the following questionnaire designed for students at the lower secondary school level, is able to ascertain Personalisation (first item in each block of 5); Participation (2nd item); Independence (3rd item); Investigation (4th item), and Differentiation (5th item)?"

Evaluate the questionnaire and provide reasons for your responses.

(Please refer to Resource 2B : Individualised Classroom Environment Questionnaire, pg. 41).

2.3.3 STL teaching and learning environment

Teachers do make a difference. But do teacher trainers? Some important considerations a science educator, teacher trainer or a teacher needs to take into account in achieving the type of classroom climate conducive to STL promotional put forward by Penick and Bonnstetter (1992). All are crucial for STL. They include:

(i) A stimulating teacher and a stimulating environment
(ii) Interacting with students
(iii) Feelings of high achievement expectation
(iv) Promotes active inquiry by example
(v) Expect students to question facts, the teachers, and the knowledge itself
(vi) Stress scientific and technological literacy and the application of knowledge
(vii) Do not view the classroom walls as a boundary
(viii) Are flexible in their time, schedule, and curriculumm
(ix) Put in far more than the minimal time

Activity 2 -8: A Teacher Can Create a Stimulating Environment

Allow participants to Brainstorm the following statement in pairs or in small groups.

"A teacher can create a stimulating environment".

An illustration regarding classroom atmosphere needed for STL teaching should be provided. This could be in the form of simulations, games, etc.

Other factors in this respect could also be listed.

(Please refer to Resource 2C: A Teacher Can Create a Stimulating Environment, pg. 43)

In order to create the classroom climate, the role of the science educator, teacher trainer or the teacher is crucial. Many of the characteristics of scientific and technological literacy require considerable intellectual freedom if they are to be achieved. Such intellectual freedom does not imply social freedom but focuses, instead, on:

- providing opportunities for raising issues and questions
- trying out solutions
- communicating with others

Intellectual freedom requires a safe environment where the student feels comfortable suggesting possibilities, asking questions without fear of humiliation and of initiating actions to test personal ideas. An intellectually safe classroom also provides multiple opportunities to interact with others. This is the same classroom climate advocated by most current leading educational thinkers, even when they speak of the arts, social sciences, or the humanities.

Activity 2 -9: Cultural Challenges to STL Teaching

Allow participants to Discuss the following question in groups. Illustrations can be provided based on their experiences in their classroom.

"Do you perceive any cultural challenges for STL teaching of which you should be aware? What are these challenges?

Ask them to Note down their responses, discuss wi th their neighbour and argue on the points raised.

2.3.4 Recognising Teaching Domains Needed for Change

Science educators and teacher trainers need to recognise that The views of what is appropriate science for all learners have been broadened. Instilling in teachers an appropriate view is intended to form a basis for determining goals, curriculum strands, instruction and assessment for science and technology education.

Yager and McCormack (1989) have identified 5 domains that are important in science teaching:

(i) Concept Domain
(ii) Process Domain
(iii) Creativity Domain
(iv) Attitudinal Domain
(v) Application and Connection Domains

(Please refer to Resource 2D: Domains in the Teaching of Science, pg. 45)

Activity 2 -10: Sequencing of Lessons

Guide participants to Discuss the following que stion in small groups , and prepare to present their views.

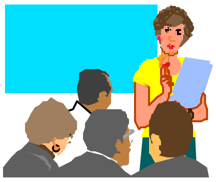
"What domains of learning would you suggest are needed to broaden the view of appropriate science for all and enable teachers to reflect on how to sequence their lesson plans."

"Would you wish to argue for a sixth domain on social values?"

(Please refer to Resource 2E: Review of the Curriculum Sequence, pg. 47)

2.3.5 The Role of Textbooks in STL Teaching

A major support for teachers, even during the present time, has been the textbook. Teachers have relied on textbooks all along. Research has shown that the textbook dictates the direction and pace of the lesson. But scientific and technological literacy is a problem if textbooks concentrate on factual knowledge and conceptual understanding and pay little more than lip service to the wider goals of science and technology education. Unfortunately most current textbooks, and even student workbooks, are weak in meeting objectives such as developing problem solving, decision making and communication skills. Textbooks are often geared to the assessment emphasis of examinations and based on an examination syllabus, sequenced on scientific fundamentals. This promotes conceptual goals but textbooks are not guiding for attitudinal gains.



Activity 2 -11: Textbooks for Science Teaching

Ask participants to Discuss the following question in groups.

"As teachers, how much do you make use of the textbook for teaching. Do you perceive any problems in placing too much emphasis on the textbook as an 'approach to teaching'?"

Responses should be r ecorded and shared with other members of the workshop.

It is logical to expect that the textbook covers ALL the objectives that are included in the curriculum guide and to expect the emphases to be similar. There is a very strong match between content designated in the curriculum guide and the textbook. However, there can be, unfortunately, a large mismatch when it comes to skills of problem solving, decision making and the various forms of communication skills. This is a concern that needs much more research.

Where teachers have confidence in their teaching and are highly motivated, it is probable such teachers make little direct use of the textbook. Students are encouraged to use the textbook as a resource to support their learning. The mismatch indicated in the previous paragraph is not a problem, as the textbook is used in a reference mode. But the textbook can also be used in a teaching mode. Teachers who are not confident, or who are poorly motivated, are likely to depend heavily on the textbook for their day to day teaching. This is where the problem arises. This is a problem that science educators and teacher trainers should ensure is not faced by teachers.

2.4 STL Approaches/Strategies

Creating the right environment for the promotion of STL would need effective classroom approaches/strategies. In guiding teachers to consider the implementation of the curriculum, science educators and teacher trainers should be aware that one decision that has to be made by the teacher is the manner in which the content and the science concepts are approached. Is it the science discipline, the needs of society, or other factors such as the environment that sets the direction?

Science educators and teacher trainers will recognise that usually, the curriculum developers set the direction, but that in developing teaching materials, teachers also need to face the issue of how best to approach the learning.

Activity 2 -12: Approaches for STL Teaching and Learning

Participants should be asked to Identify or suggest approaches which they will utilise in their classrooms for effective STL teaching and learning.

It is important to give reasons for the preferences identified, and if necessary, to describe what is meant by the approach. Recording the discussion and sharing with members of the workshop would be a ver y useful learning exercise.

(Please refer to Resource 2F: STL approaches, pg. 4 8 for further explanation).

Activity 2 -13: Strategies for Teaching and Learning

Guide participants to Work individually, in pairs or in groups, and suggest or identify effective strategies for STL teaching and learn ing. The list could be shared between the pairs or in the class discussion. (Please refer to Resource 2G: Other useful strategies for STL teaching and learning, pg. 50)

What do you and participants expect students to do in STL classrooms?

Educational activities take place not only in schools, in a formal setting, but also in non-formal programmes, and in in-formal settings. Some of the examples of non-formal programmes are activities of hobby clubs, science fairs, short-term training and workshops. Learning also takes place in in-formal settings, such as visit to shops, TV programmes, and listening to radio programmes.

In the present context of high technological advancement, a large variety of sources for information are available. Therefore, STL teaching and learning by a particular approach or source would be too limiting. Students should always be prepared to learn new information and ways. STL approaches should prepare students to use all possible means - formal, non-formal and in-formal. Formal learning could be more rigour-based, objective and capable of being evaluated. Non-formal approaches could be related to day-to-day needs or interest-based educational activities. In-formal teaching and learning should be focused to prepare students to use all available opportunities for STL learning.

One specific example is the activities of the China Association for Science and Technology (CAST). The organisation works closely with the Ministry of Education in China to promote the creative capabilities and scientific thinking among Chinese primary and secondary students. They sponsor the National Invention and Creation Contest and Science Symposium for Young People every other year (a non-formal approach), which attracts more than 10 million students. The root of this non-formal activity can be traced not only from the school science classes and after-school science clubs (formal education), but also from the training programmes organised by Children's Palaces and Science Museums (non-formal education). The instructors of these activities are not only science teachers in schools, but also many volunteer scientists and engineers.

2.4.1 The Role of Teachers

Science educators and teacher trainers in preparing teachers to talk to students, expect teachers to anticipate the questions and responses of their students. Yet, educators and trainers need to recognise that this is the beginning of a good conversation, not the end. In a true adult conversation, one person's response becomes the others' stimulus, leading to interplay of ideas, thoughts, and even more questions. To create this type of dialogue, a teacher needs to follow up on a student's response by asking for clarification or by using the response in another question. For instance, if a student says that the greenhouse effect can be a problem in tropical countries, it is logical to ask, "What do you mean by 'the greenhouse effect'?" or using the response itself, the teacher could ask, "What type of problems?" In either instance, the response continues the dialogue, allowing the teacher to deal deeper into the student's understanding. Knowing this, the teacher is in a better position to structure the learning environment for maximal student success. The cycle is much like adult conversation where one person's response leads to a response from the other, causing a continuing conversation which may turn in various ways, but will hold the interest of both parties.

Activity 2-14: Teacher Behaviour in STL Teaching and

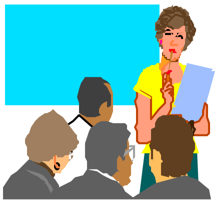
Ask participants to Discuss the different approaches STL teachers would use. The following question could guide the discussion:

"Are you able to put forward other teacher behaviours that are not only essential in STL teaching, but are used by good teachers in any type of teaching?"

(Please refer to Resource 2H: Teacher Behaviour Essential in STL Teaching and Learning, pg.51)

2.4.2 The Role of Students

In traditional classrooms, the textbook, the teacher, or professional scientists define what students should know. Typically they are expected to read, listen, and repeat the desired information - this being called learning. However, this description of learning for scientific and technological literacy does not seem adequate. All individuals learn continuously, but rarely do students learn as teachers have in mind. Individuals construct personal meaning out of the events, ideas and objects around them.



Activity 2 -15: Student Involvement in STL Learning

Ask participants to Discuss in small groups the different ways of involving students in order to achieve STL learning.

Guide participants to Present their your views to other members of the workshop.

(Please refer to Resource 2 I: Students' Role in STL Learning, pg. 5 5)

2.4.3 Role of Community Resources

While discussing classroom approaches towards STL, science educators and teacher trainers one should also look for community resources that can be used to enhance and develop STL. For instance, local enterprises can provide learners, especially those in rural areas, more opportunities to be connected with technology tools and with the people who use those tools. In the process, they can also come to understand more about the impact of technology on social development. Spreading of modern agricultural technology, especially the eco-agriculture farms, are good examples for learners to understand the ecology theory in their science study. The temples in Thailand have played very important roles in science popularisation. The community groups in many developing countries, like Nepal, are very active and effective in providing technical support and information to farmers. Yet the resources available in these community organisations are normally not easily accessible to "educational institutions". The potential educational functions of such regional organisations need to be identified and encouraged to become available as educational resources by persons or organisations who have the foresight and out-reaching capability in organising and co-ordinating resources.

In the West District of Beijing, China, the local government agencies set up regular Co-ordination Meetings for community resources to support education. During those meetings, all the governmental and non-governmental institutions located in the community, such as enterprises, research institutes, libraries, and factories, will be asked to make their contributions to work with the local schools to provide a better environment for the young people.

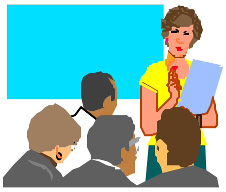
Activity 2 -16: STL Activities Using Community Resources

Show examples of STL activities utilising community resources. A bulletin board display could be set up, or exhibition utilising local resources.

Discuss with participants preparatory and post activities as a group.

2.5 The Need for STL Supplementary Teaching Materials

One resource, which can guide science education towards greater relevancy for the 21st century, is the use of STL supplementary teaching materials. These materials are not extensions of the textbook, but are additional resources for the teacher to call upon as required. As such they are optional materials and can be used as and when the teacher feels it appropriate. If the materials allow students to engage in activities relevant to STL, they enhance the learning situation and hence guide students to achieve the intended educational objectives.



Activity 2 -17: STL Supplementary T eaching Materials

Analyse the case below:

The major resources used by teachers and students are undoubtedly the curriculum guide (the syllabus) and the textbook, especially in developing countries. Changes in the curriculum and textbook can help to reflect new tendencies to some degree. The textbook can change to follow this sequence. Also, any moving from aca demic to thematic titles and by presenting the material through story lines rather than factual text, textbooks can reorient the manner in which the learning material is viewed.

But, course outlines, curriculum guides and most textbooks cause problems in promoting STL. For a start, they are out -of-date, having been produced before the latest advances and before the latest issues or concerns have merged within the society. Neither can they relate to a specific area, a specific school district or to the i ssues and concerns that reflect immediate school environments. And none can take advantage of 'connections' that may be unique to each person, school, science centre, local industry, or the community.

The textbook is even more limiting by its desire to i mpart knowledge. By stating the case and providing the necessary background, the textbook heavily inhibits the promotion of problem solving and decision -making skills. And, of course, it has already decided on the communication approach i.e. the written text, perhaps supported by diagrams, tables, or graphs. By placing too much reliance on the centralised curriculum and on curriculum developers, the most meaningful context for relevant learning that can only be exploited by the teacher is being undermine d. Teaching becomes stereotyped and in danger of being divorced from meaningful learning.

Suggested questions for discussion:

What issues can be identified from the case above?
As an experienced science educator or teacher trainer, how would you suggest teachers solve the issues?
How would you as a course/workshop leader relate your answers to the learning of STL?

Prepare a report for presentation to participants.

2.6 Summary

In many countries, new approaches will be required to meet the demands of a scientific and technological literacy teaching along the lines suggested. As the section has illustrated, this is no simple matter and it is crucial that science educators and science teachers guide teachers to pay attention to:

- The intention of the curriculum with respect to its place in the educational system as a whole
- The intended approach, the sub-dividing and sequencing of the curriculum so that it relates strongly to the underlying philosophy

- The implementation process to ensure that classroom practices do match the intentions and that teachers are able to sustain these practices in the face of possible constraints

Science educators and teacher trainers need also to pay Attention to the need to involve teachers in the development and implementation processes. Such teachers need to be carefully guided, however, as they need to embrace the new philosophy and be in a position to lead the implementation of the curriculum in the classroom during the essential field trials.

Resource 2A: Teacher Self -Analysis

Yager, 1993

A self-analysis scale can be used to judge the likelihood of a teacher being effective. Of course, it is virtually impossible to be perfect (right hand side of the spectrum) in all thirteen features. That is not even the point. What is does give a general picture of whether a teacher is likely to be considered as one using scientific and technological attributes.

"The scale is based on a Constructivist Learning Model as a part of a reform in science teaching" (Yager 1993). For questions 1-7, a four-point scale is used to indicate whether it is overwhelmingly the teacher who makes the decision, predominantly the teacher but with some student help, largely students guided by the teacher, or very strongly a student decision. Questions 8-13 solicit a definite no, largely a no, largely a yes, or a definite yes.

How would you rate yourself on each of the following questions?

The Self-Analysis Scale:

RATING SCALE

		1 - 2 - 3 - 4	
	The Teacher does	|----|----|----|----|	The Student does
(for questions 8-13)	No	|----|----|----|----|	Yes

Questions

1. Who identified the issue/topic?
2. Who is asking the questions in class?
3. Who identifies written and human resources?
4. Who locates written resources?
5. Who contacts human resources?
6. Who plans investigation and other activities?
7. Do students see issues as relevant?
8. Are varied evaluation techniques used?
9. Do students evaluate themselves?
10. Do students apply concepts and skills to new situations?
11. Do students take action following study?
12. Do science concepts/skills emerge because they are needed?
13. Are extensions of learning outside the school in evidence?

Add the scores for each question. We hope you managed to obtain a high score, well above 30.

But it is worth remembering – How far do answers to the above self-analysis reflect actual practice, rather than practice the teacher hopes to achieve? Sharp contrasts exist between what research and theory have established about effective learning of science, and the actual teaching practices observed in the vast majority of elementary, middle, and senior high schools (Boyer 1983; Goodlad 1984; Mullis & Jenkins 1988; National Assessment of Educational Progress 1979; Stake & Easley 1978; Weiss 1978).

Resource 2B: Individualised Classroom Environment Questionnaire (ICEQ)

Adapted from Thorpe, Burden and Fraser, 1994

Scale	Scale description
Personalisation	Emphases on opportunities for individual students to interact with the teacher and concern for the personal welfare and social growth of the individual
Participation	Extent to which students are encouraged to participate rather than be passive listeners
Independence	Extent to which students are allowed to make decisions and have control over their own learning and behaviour through problem solving and investigations
Investigation	Emphases on the skills and processes of inquiry and their use in problem solving and investigations
Differentiation	Emphases on the selective treatment of students on the basis of ability, learning styles, interests and rates of working

Individualised Classroom Environment Questionnaire

REMEMBER: You are rating what actually happens in the classroom.

KEY a = ALMOST NEVER; b= SELDOM; c = SOMETIMES; d = often; e= VERY OFTEN

Indicate a, b, c, d and e, before the statements.

1. The teacher talks with every student
2. Students give their opinions during discussion
3. The teacher decides where students sit
4. Students find out the answers to questions from textbooks rather than from investigations
5. Different students do different work
6. The teacher takes a personal interest in each student
7. The teacher lectures without students asking or answering questions
8. Students choose their partners for group work
9. Students carry out their investigations to test ideas
10. All students in the class do the same work at the same time
11. The teacher is unfriendly to students
12. Students' ideas and suggestions are used during classroom discussion
13. Students are told how to behave in the classroom
14. Students carry out investigations to answer questions coming from class discussions

15. Different students use different books, equipment and materials
16. The teacher helps each student who is having trouble with the work
17. Students ask the teacher questions
18. The teacher decides which students should work together
19. Students explain the meanings of statements, diagrams and graphs
20. Students who work faster than others move on to the next topic
21. The teacher considers students' feelings
22. There is classroom discussion
23. The teacher decides how much movement and talk there should be in the classroom
24. Students carry out investigations to answer questions, which puzzle them
25. The same teaching aid (e.g. blackboard or overhead projector) is used for all students in the class.

Resource 2C: Teacher Creating A Stimulating Environment

Penick and Bonnstetter, 1993

The following 5 aspects show how a teacher can create a stimulating environment.

(i) ***Caring***

Students must see the teacher as a caring helper working with individuals, not a judge dealing with the masses; they need to feel safe, to have success if they are to develop science literacy (Fisher et. al. 1980; Marlave & Filby 1985). The best classroom dialogue is similar to adult conversation. Adults rarely ask each other test questions (What is Avogadro's number?); instead, they ask each other questions to ascertain feelings, ideas, or to gain information not previously held or forgotten. No one likes being tested.

(ii) ***Friendly***

Students do best in a safe and friendly environment, supported by a rich variety of resources, and with many opportunities to initiate, plan, and take action (in the laboratory, library, or elsewhere). As students work in this rich and safe environment, the teacher observes, watching for clues to student understanding or moments where provided information or material might spur the student on, or allow new insights into the problem being investigated. At the same time, this teacher is carefully listening to students and asking open questions with the same goal in mind. In both cases, the teacher is trying to take actions that reveal the teacher's logic, a most critical step in communicating science and teaching students how to solve science and technology problems. This is what good, progressive teachers have always done.

(iii) ***Importance of effective questioning***

To help students, the teacher needs to gain feedback. Questioning can guide the teacher to the depth of the problem or the level of understanding possessed by the students.

A teacher's questions answered simply by "yes" or "no" are rarely suitable for science and technology teaching. They do not require deep thought, often encourage guessing and certainly encourage, if used in a whole class situation, students responding with a 'chorus' answer. They are of little use for STL.

Asking open questions, which you know the student can answer, is easy if you think of questions as a hierarchy. In this hierarchy, the lowest level questions are those relating to what the student has already done. Since they are part of the student's personal history, the student can answer them with ease. Now, with success at answering, the student feel more at ease while the teacher has multiple avenues on which to continue the conversation. Once the student has answered questions such as "What did you do first?" or "How did you do that?" you can ask questions which relate one aspect to another. For instance, "How does that compare to what happened the last time?" or "What did the other groups find?". These questions, like the historical ones, are not usually difficult to answer. And, if they are, these are questions where it is acceptable to not know. (Penick and Bonnstetter 1993).

Other higher order questions may follow these first two types. As students become more comfortable answering questions and comparing, it is possible to begin to ask questions that require application of ideas or knowledge. For example, “How could you use that idea to reduce the problem of rubbish disposal?” or “Where have you seen that idea in operation?” Application questions are very important in bringing student to understanding basic concepts. As students attempt to apply their knowledge, they often begin to see what they do or do not understand.

Application questions are often followed by speculation such as “What if we burned all our rubbish?” or “What might happen if we each had our own compost pile?” Again, much like the other questions, there is not a single right or wrong answer and students should be encouraged to make up an answer. At the end comes the questions, which the teacher would really like students to be able to answer; questions that focus on explanations. Requests for explanations are among the most difficult of questions and should be reserved for those rare occasions when students are ready for them.

(iv) ***Holding discussions***

Dillon (1981) noted that, to be considered a discussion, students must account for at least 40% of the total talk. Teachers allowing this are likely to be viewed as more patient and will be able to encourage multiple responses. Also, since the teacher does not know the students’ answers in advance, the teacher is in a learning situation (Rogers, 1969), a key factor in classrooms where the learning is exciting.

All too often teachers refer to holding discussions, when in practice it is not. Consider a class of 40 students, in which the lesson lasts for 40 minutes (a reasonable approximation) and in which the teacher takes half a minute to ask the questions to stimulate student ‘discussion’. In each case, a student takes half a minute to respond (again a reasonable approximation). In this scenario, it takes the whole lesson for all students to be involved. (As the teacher is teaching the whole class and communication skill can be considered one of the goals, it is reasonable to expect the teacher to want all students involved). So in this situation, the teacher is overtly involved for 20 minutes, whereas each student is limited to half a minute i.e. half a minute, in 40 minutes of time. A reasonable mathematical approximation is surely to say each student is involved for a negligible amount of time. Hence, in a situation such as this, it is not possible to say they were ‘discussing’! They were passive listeners most of the time. The actual activity is one of teacher talk, student listen. This can hardly be called a discussion. And this type of teaching must <u>not</u> dominate in the STL classroom.

(v) ***Developmental approach***

Elkind (1989) notes most classrooms emphasises a psychometric approach rather than a developmental one. The psychometric approach stresses achievement scores and acquisition of knowledge while the developmental approach seeks critical and creative thinkers. As the effective teacher encourages and wants critical thinking and creativity, the teacher needs to create a classroom climate that organises, stimulates, and makes readily available a wide range of resources and ideas and actions that encourage students to achieve the desired roles and goals.

Resource 2D: Domains in Science Teaching
Yager and McCormack, 1989

Five domains that are Important for Science for All

1. Concept domain

Science aims to categorise the observable universe into manageable units for study, and to describe physical and biological relationships. Ultimately, science aims to provide reasonable explanations for observed relationships. The Concept domain includes: facts, concepts, laws (principles), and existing hypotheses and theories being used by scientists. This entire vast amount of information is usually classified into such manageable topics as – matter, motion, animal behaviour, and plant development.

2. Process domain

Scientists use certain processes (skills). Being familiar with these processes concerning how scientists think and work is an important part of learning science. Some processes of science are – observing and describing, classifying and organising, measuring and charting, communicating, and understanding communication with others, predicting and inferring, hypothesising, hypothesis testing, identifying and controlling variables, interpreting data and constructing instruments, simple devices and physical models.

3. Creativity domain

Most science programmes see science as something to be done to students to help them learn a given body of information. Little formal attention has been given in science programmes to development of students' imagination and creative thinking. Some of the specific human abilities important in this domain are:

- Visualising – producing mental images, combining objects and ideas in new ways, offering explanations for objects and events encountered
- Questioning
- Producing alternate or unusual uses for objects
- Solving problems and puzzles
- Designing devices and machines
- Producing unusual ideas
- Devising tests for explanations

4. Attitudinal domain

Human feelings, values, and decision-making skills need to be addressed. This domain includes:

- Developing positive attitudes toward science in general, science in school, and science teachers
- Developing positive attitudes toward oneself (an 'I can do it attitude')
- Exploring human emotions
- Developing sensitivity to, and respect for, the feelings of other people

- Expressing personal feelings in a constructive way
- Making decisions about personal values
- Making decisions about social and environmental issues

5. Applications and connections domain

It seems inappropriate to divorce “pure” or academic science from technology. Students need to become sensitised t those experiences they encounter which reflect ideas they have learned in school science. Some dimensions of this domain include:

- Seeing instances of scientific concepts in everyday life experiences
- Applying learned science concepts and skills to everyday technological problems
- Understanding scientific and technological principles involved in household technological devices
- Using scientific processes in solving problems that occur in everyday life
- Understanding and evaluating mass media reports of scientific developments
- Making decisions related to personal health, nutrition, and life style based on knowledge of scientific concepts rather than on ‘hear-say’ or emotions
- Integrating science with other subjects

Resource 2E: A Review of the Curriculum Sequence

Yager and McCormack, 1989

An example of **STL Curriculum Sequence –** ***Our world and the inside story of matter***

Exploring differences between solids, liquids and gases *Our need to understand the effects of putting solids in water* *Why we need to know about molecules?* *Can solids, liquids and gases move through one another?* *Our lives and giving molecules energy* *The advantage of knowing what affects the evaporation of liquids?* *Heaviness and lightness: why the inside story is important* *Luckily for us, molecules can push?* *Molecules and air pressure– affecting more than the weather*

Comments on the context, teaching approach and the emphases in this curriculum modification.

The content above is not intended to be prescriptive. It merely tries to illustrate a different approach. The emphases is no longer on content only, but enhancing a range of skills through involving students in a variety of activities. It is much more geared to enabling students to strive for multi-dimensional STL.

Resource 2F: STL Approaches
Holbrook J.B., 1998

The decisions facing the teacher in achieving STL is whether the content should progress through:

1. Fundamental (science concepts) led Approach

In a fundamentals-first approach (Approach 1), the emphases is usually on a systematic study at the microscopic level. In initial chemistry courses, protons, neutrons, and electrons leading to atomic structure and bonding. Based on this, formulae and equations can be written and processes such as electrolysis and rusting can be explained. It is all very logical, very systematic, but it means there is much to study for little relationship (at least for much of the initial part of the course) with the world around us. This does not lead to STL teaching.

2. Societal (or issues) led Approach

The alternative approach (Approach 2) recognises the technology in society around us. It recognises the concerns of society, the skills required to deal with scientific issues in society, and the depth of understanding needed to gain some comprehension for problem solving. It begins with societal technology and in particular the concerns we have related to areas such as resources, health, food, the environment, energy problems, the need for industry and how we can communicate. This alternative approach uses more societal headings and approaches the science concepts through issues and concerns within society. It sees the society as the context for learning and the issues within society as the rationale for learning a particular aspect of science. The science is included on a 'need to know' basis which means that the depth of treatment of the science is dependent on the societal issues being studied, rather than by the scientists' view of conceptual compartmentalisation. Whilst the linking together of various topics in this way may not be scientifically logical, the curriculum can still be inherently logical from **the students' point of view.**

3. Environmental Education Emphases

Another approach is to consider an interdisciplinary area. This is really a variation of approach 2, where the environment is recognised as interdisciplinary and hence the teaching is not bound by conceptual ideas in any scientific discipline. It emphasises that environmental education is too important to leave to the well intentioned, but scientifically ill-informed. While the products of science and technology have caused many life-threatening environmental problems on this planet, these problems will only be solved by men and women who understand the nature – and limitations – of science and technology.

4. Thematic Emphases

In a constructivist idea, learning is contextual. New knowledge is highly dependent on its context and knowledge has different meanings in different contexts. School science and technology knowledge often has little meaning for students because it is presented in the abstract, independent of meaningful context. Concrete experiences such as those acquired in laboratory activities can provide some of this context. The overall framework of the discipline being studied and its major themes are other aspects of context. (Anderson, 1992).

In this approach the issues are not so much the primary focus as thematic areas, such as water, air or a balanced diet. This approach suffers from the fact that it can be conceived as Approach 1 or Approach 2 depending on the way the themes are developed. It is thus unclear whether a thematic approach will also be geared to STL teaching.

Resource 2G: Other Usefu l Strategies for STL Learning

UNESCO-SEAMEO RECSAM. 1999

Some strategies that are useful for STL teaching and learning are:

1. Individual work by students

Applicable to the development of individual problem solving or decision-making strategies and to all forms of written communication.

2. Brainstorming

Students are to present their ideas related to the topic under discussion. All ideas are collected and recorded, irrespective of their worth or correctness and without comment. This activity is designed to stimulate thinking and to call on students' background knowledge (and may be their misconceptions).

(A common approach is for the teacher to write student suggestions on the blackboard)

3. Role Playing

Students (or a group of students) undertake to play a specific role within a group debate or enactment of a scene. The student undertaking the role, tries to act according to the role assigned, putting forward points of view in line with the expected belief. The role playing exercises lend itself to decision making, whereby decisions can be made by a judge, a panel, or by a referendum of many people, based on the value placed on the various aspects within the scenario indicated.

4. Public Inquiry

This is similar to a role playing exercise wherein students create a courtroom and allow individual students to play the role of various figures in the enactment of a public inquiry. The bulk of the class acts as the jury and vote on the final decision. The teacher plays the role of the judge advising the 'Jury' as necessary.

5. Debate

A panel is set up (often of 3 speakers) that speak for the motion that is to be debated and are opposed by a similar number of speakers. Starting with the speaker for the motion and followed by a speaker from the opposition. The panel takes turn to present the points as forcefully as possible without duplicating a previous speaker, yet carefully refuting points put forward by the other side. The audience (or a panel) decides the winning team.

Resource 2H: Teacher Behaviour Essential in STL Teaching and Learning

Penick and Bonstetter, 1989

Here are some possibilities you may have mentioned.

1. Wait Time or Pausing

The time a teacher waits or a pause is also a key behaviour, essential for science and technology teaching. It is the time a teacher waits for a student response after asking a question. Without wait time, students quickly learn that the teacher does not really want a response. Plus, with a short wait time, only the brightest and quickest students respond (Rowe, 1986). Wait time, pausing after a student has responded, also leads to much more cross-talk, where students are challenging each other, offering additional ideas, and truly getting involved in the discussion. It appears that if teachers could learn to ask good questions and then wait, classroom teaching of all subjects and students' literacy in science and technology would be predicted to improve dramatically.

Research indicates that students respond more often, with more explanation, and with more self-confidence when the teacher makes effective use of wait-time or the pause. This is aided when the teacher:

- Asks questions clearly the first time, without dragging it out, undertaking rephrasing, or talking after the question
- Makes the pause overt. The teacher just asks the question, look at the student who is to respond, and waits patiently. Every time the teacher speaks, or looks away, the 'wait-time clock' starts all over again.

While pausing often feels very awkward, even embarrassing for the teacher, it ensures that students respond in desired ways. Once students come to recognise and expect wait-time, they will respond even better. In addition, as the teacher waits, this develops habits of good listening, and students also, become better listeners, with the result that their conversational partners are given more time without interruption. Wait-time is probably among the most influential of all teacher behaviours, leading to more active and involved students plus teachers who understand and teach them better.

2. Effective communication

Teachers and students not only communicate orally, facial expressions and the use of gestures with the hands, or with the whole body, can indicate willingness or reluctance to participate. This monograph is not the place to go into details on the use of facial expressions, but it is worth noting that a smiling tends to convey happiness and a relaxing atmosphere. Students like a teacher with a smiling face. On the other hand a facial expression showing determination, guides the students to concentrate. And few students like it when the teacher's expression conveys anger or disappointment, because the atmosphere prevailing in the classroom is not pleasant.

An effective teacher will make use of these attributes a great deal. A stiff, rigid and expressionless teacher can do little to stimulate the classroom atmosphere and hence control learning. The expression of the teacher can be particularly effective when one student is struggling to respond to a teacher question (facial expression can encourage) and teacher tries to maintain the concentration of the rest of the class (frowning on any undesirable behaviour).

But how do students see the facial expressions of the teacher? Clearly the closer the teacher moves to the students, the easier this becomes. Also the physical presence of the teacher near students gives a sense of encouragement, or being involved and thus helps students to participate more fully in the lesson.

3. Teacher positioning

Effective teachers do not stand behind the teacher's bench to talk to the whole class. Such teachers are too far away from the students. Effective teachers come closer to the students. If it becomes necessary for teachers to use the chalkboard, they move to the board for that specific purpose. Then as teachers do not spend more than a few moments writing (this is necessary if they want the whole class to pay attention), they are free to move closer to the students again.

The effective teacher moves as close to the students as possible and tries to find ways of being close to every student, some of the time. Or, alternatively, the effective teacher will move the students so that they are all equally as close to the teacher as possible (all students, not just the lucky few – the ideal arrangement is probably a semi-circle of seated students).

4. Feeling of high achievement expectations

Good teachers expect change. Change may be in learning, or attitude, or it may be resolution of a real problem. Teachers have different expectations for students as they recognise that students have varying potentials and interests. The effective teacher expects all students to achieve personal excellence through quality performance, but recognises this will be at different levels depending on the ability of the student. Evidence of high expectations is shown by their continual push to do more, gain more involvement, and see ore resolution. They are never contented with a status quo. Teachers with high expectations also see their roles as more than a teacher of a group of students. They see their role in a larger perspective in the community, and as a model of active inquiry.

Encouraging each student to participate in critical thinking and to learn is not easy in a whole class situation, unless individual work is demanded. A whole group, teacher-centred situation tends to encourage only 'good' students to respond. Whole class teaching has serious limitations for STL.

5. Promotes active inquiry by example

An inquiring teacher reads and explores widely, bringing this reading, action, and new knowledge visibly into the classroom. Students know this teacher is open to wonder, new ideas, and is innovative. Exemplary teachers bring inquiry alive by presenting themselves as students, eager and willing to learn new ideas, skills, and actions. By bringing new ideas to the class, by questioning and being open-minded, these teachers are clearly models to be followed. They also model the thoughtful and rational approach to problem identification and resolution by being interested, seeking information, asking for evidence, and by taking action themselves. In essence, they are making their thinking, feelings, and approach to learning highly visible.

6. Expect students to question facts, question the teachers, and question the knowledge itself

When teachers make their approach visible, students more easily see that science and technology involves a degree of skepticism. Not an assumption of being wrong, such a belief is a quest for evidence to support a fact, idea, or position. Teachers and students who have questions, seek answers, and who can provide evidence, may well become active citizens with the same attributes.

All too often students, in poor classroom climate conditions, have absolute belief in the correctness of the textbook and in the uniqueness of scientific solutions as expressed in the textbook. A discussion of the meaning of pure water may serve as an illustration. Depending on the situation, this can mean distilled water, de-ionised water, or simply water that does not contain sufficient bacteria to be harmful to man. Yet the textbook will, in all probability, only mention one of these.

7. Stress scientific and technological literacy and the application of knowledge

Teachers stress scientific and technological literacy by demanding a rational and independent approach to science and technology and its impact on society. Students are expected to seek, to question, to explain, and to apply their knowledge. Teachers are not content with students just knowing words or skills, they insist that words be used to justify, defend, or clarify larger concepts or actions. For many students, they must apply their knowledge before it truly becomes a part of them.

For many traditional teachers applying knowledge may be restricted to answering questions at the end of the chapter, but effective teachers are never contented with this alone. Calculating vectors in a pulley system does not have as much potential and is not, for most students, as problematic as making up a block and tackle. The same is true with societal applications where students, seeking justification for a new community water treatment plant, view their learning as vastly different from reading a standard text on the subject. In both instances, they can see their knowledge as it is being used, often outside the classroom.

8. Do not view the classroom walls as a boundary

Any learning that is real must, by definition, continue into the rest of the students' lives and world. Obviously, effective teachers see that both their students and their ideas have many opportunities to go beyond the classroom, via field trips, visits to resource persons and facilities, and using outside materials such as books, papers, and ideas. At the same time, teachers invite community experts in, offering new insights and perspective on existing problems and often raising new ones. Teachers also encourage going beyond by stressing issues and ideas from outside the school.

9. Flexible in their time, schedule and curriculum

An effective teacher takes advantage of opportunities, changing as occasions present themselves. A student learn but not always as the teacher anticipates or on the same schedule, but the stimulation, excitement, and involvement lead to many new avenues of motivation and learning – for the teachers as well as the student.

10. Put in far more than the minimal time

Scheduling, co-ordinating, developing materials and planning all require time. Exemplary teachers worry about time, but focus that worry on the finding of more time to devote to their classes and ideas. They complain that days are not long enough and as a result, such teachers devote time after school and on weekends, striving to make their teaching all it can be. For this, of course, the morale of the teachers needs to be high. Rarely are there any material rewards – the reward is simply the gains of their students as they strive for greater and greater degrees of scientific and technological literacy.

A common, negative cry from weaker teachers is that they do not have time to do extra tasks in the classroom. It is important that we finish the syllabus. It is crucial that STL teachers know better than to make such a statement. STL teachers know that the teacher finishing the syllabus has no meaning. It is not for the teacher to finish the syllabus, but for the students to acquire the knowledge and skills inherent in the curriculum.

STL teachers know that students learn better in an interesting, friendly atmosphere where there is also an element of challenge. It is the skill of the teacher to create such a situation. And once achieved, it is a powerful learning situation. Students learn how to learn. Students take responsibility for their learning.

11. Interacting with students

Teachers interact with students whenever it appears this would help students move towards the classroom goals. They begin the interaction cautiously. For instance, the teacher may watch students from a distance, observing what they are doing. Now, when the teacher approaches, rather than "What are you doing?" they already know that answer and can ask a more meaningful question. It is worth remembering that, if an individual or group were busy with a task in an adult setting, one would hesitate to interrupt. And, if this were necessary, one would begin with a polite amenity such as, "Excuse me". Yet, with students, teachers often barge in, asking questions as if only they matter. Often the end result is students who resent the teacher's intrusions and pay little attention to them. It is also worth bearing in mind that in a 'hands-on' curriculum, teacher interruptions take away activity time.

Although interactions at the student's level are important, they can lead to awkward situations. If teachers approach quickly, sit down, either to watch or interact, but unfortunately, the students do not want to interact, or for some reason consider it an inopportune moment, teachers have an embarrassing moment getting up and leaving. Much better would be for teachers to move toward the individual or group and, just like in an adult social setting, wait for the student or group to recognise their presence. Usually, at this point, it is obvious whether it is appropriate to ask a question. As teachers begin their conversation, they will soon know if this will be a minimal interchange or whether it is likely to turn into a real conversation. Rather than awkward or intrusive, the interaction between teacher and students becomes more natural and its value increased by the reduction of distance and the intimacy of the conversation.

Teachers anticipate that, in talking to students, they will obtain a response. Yet, this is the beginning, not the end, of a good conversation. IN a true, adult conversation one person's response becomes the others stimulus, leading to an interplay of ideas, thoughts, and even more questions. To create this type of dialogue, a teacher will follow up a student response by asking for clarification or by using the response in another question. For instance, if a student says that the greenhouse effect can be a problem in tropical countries, it is logical to ask, "What do you mean my 'greenhouse effect" or using the response itself, the teacher could ask, "What type of problems". In either instance, the response continues the dialogue, allowing the teacher to delve deeper into the student's understanding. Knowing this, the teacher is in a better position to structure the learning environment for maximal student success. The cycle is much like adult conversation where one person's response leads to a response from the other, causing a continuing conversation which may meander in various ways, but holds the interest of both parties.

Resource 2 I: Student's Role in STL Learning

Pennick and Bonstetter,,1993; Krajcik 1993; Mamalinga, 1993; Yager, 1993

Students play various roles in STL Learning. Some of these are:

1. Constructing Meaning

All individuals learn continuously, but rarely do students learn as teachers have in mind. Individuals construct personal meaning out of the events, ideas, and objects around them. Often, these constructed meanings have little congruence with the reality of professionals in the field. In addition, these self-constructed meanings are quite persistent, often surviving formal instruction about the same subject.

Successful learning often means replacing naï ve, prior conceptions with more sophisticated and thoughtful ideas. But, since each person develops meanings individually, imprinting the teacher's ideas directly onto the students cannot achieve such learning. Meaningful learning derives from being in an environment where the student experiments, reads, talks, listens, and, above all, thinks.

Constructivism differs from traditional science education in that science and culture are seen as inseparably linked. Constructivists view science in a cultural contact and that the cultural matrix of science education embedding science may not be widely shared by students (Cobern 1994). With knowledge of the way a student has constructed personal meaning, the teacher can make clear and rational decisions about how to interact with the cultural environment so the stud4ent can confront their own misunderstandings and rebuild an idea, and in the process come closer to the desired meaning.

Moving to Constructivist Practices

Constructivist practices result in students attaining more of the goals typically cited by teachers. Among these are:

- demonstrate mastery of basic concepts (in ways other than repeating or recognising standard definitions)
- use of basic process skills (again, in new situations ability to apply, interpret, and synthesise information)
- enhancement of creativity skills (questioning, proposing, predicting consequences)
- improved attitudes toward science study, school, teachers, and careers

Constructivist practices require teachers to:

- place students in more central positions in the whole instructional programme.
- question more and the questions must be used as the basis, for discussions, investigations, and actions in the classroom/laboratory
- propose solutions and offer explanations
- use the proposals in the classroom to form the basis for seeking and using information and for testing the validity of all the explanations offered

The above suggests a progression of involvement which starts with the student, moves to pairs and/or small groups of students for more questions and eventually consensus, then to the whole class for similar processing, and finally to the professional (scientific) community's views.

This progression is just the opposite of what typically happens in science classrooms.

2. Communicating

If students learn to communicate science effectively, they would be expected to read and write, converse in pairs or in small groups, or interact with the teacher. Sometimes a student could speak to a group or the whole class. Since communication involves comprehension, students could analyse and respond with questions, statements, actions, and feedback. Students would eventually be able to synthesise ideas and communicate with others.

As communication is a social activity, interactions occur. If education is for life and living, then effective and ambitious classrooms would expect students to carry out the activity beyond the classroom walls to where they live. For example, in a small town in Iowa, students began learning about problems with the ozone layer. As they studied, they became concerned with the impact on their own community. Several students contacted the mayor, asking, "What are you doing about the loss of ozone?" Contacting the mayor is usually considered a waste of time by many people, and few adults, much less children, ever go to this length to pursue their questions and issues. This is truly adult action, the kind that leads to knowledge, change, and a feeling of empowerment.

Encouraging interaction, communication, and conversation requires an appropriate and carefully designed classroom climate. In addition, since each goal implies overt action on the part of the student, the teacher must be prepared to encourage, support, and promote desired student initiatives and action. Teachers must recognise the difference between appropriate and inappropriate action on the part of students and themselves (Penick and Bonnstetter 1993).

3. Participation in Group Work

Science and technology students, working together in small groups (2-5 students) is common in schools and almost inevitable when students undertake any form of practical investigation. But there has been some concern that group work encourages students to agree on superficial and obvious features rather than abstract constructions (Mamalinga 1991). However, a Greek study, which requires students to solve problems through group work, showed no evidence that the range of ideas was reduced in the group context, or that the ideas were more superficial. As it happened, abstract ideas were few for both the group context or when students worked as individuals. In addition, it seemed possible to conclude that the group situation was a better learning situation, since wrong ideas seemed to be suppressed.

The manner in which group work functions, is likely to be enhanced strongly by the classroom climate. Teachers' handling of group work is perhaps one of the hardest area of science and technology teaching and it is perhaps a common sight to see groups of students left alone to cope with a worksheet, or other forms of instruction as best as they can. Worksheets cannot give students' feedback or even specific guidance should this be needed. This comes from the teacher's interaction with students as the teacher moves from group to group, or from teacher's intervention after observing groups in action from various advantage points.

The teacher's role is to provide the groups with the initial stimulus and to guide the students in their task. As part of the guidance, the teacher gains feedback from the groups, rather than 'interfering' with specific or isolated instructions (often given to the class as a whole without reference to the progress made within the groups and often without requesting the groups to temporarily stop their activity so that they can concentrate on the teacher's instructions).

Group work is applicable to experimental work in the laboratory and to such actions as: discussions of tasks, making decisions, role-playing exercises, playing games, participating in a debate and preparing for presentation of work to the whole class.

4. Gaining Other Skills

One of the greatest benefits of incorporating STL teaching approaches is the experience students gain in skills such as research, critical thinking, problem-solving, and integrating science concepts with their own experiences. With the need for an ever increasing emphases being placed on higher-level thinking skills, societal situations and issues provide excellent opportunities for students to expand their education beyond the traditional classroom offerings and meet the challenge of higher-level thinking.

In appropriate settings, students can begin to make connections between the coursework in science class and their work in other classes. In researching topics like deforestation, students are able to link their study of the biological issues present with concepts from other classes such as economics, mathematics and social studies. In addition, in effective communication and undertaking calculations or plotting graphs, students can draw upon skills learned in classes such as languages and mathematics (Kracjik 1993). Learning becomes an interdisciplinary affair.

Co-operative learning strategies are employed when students are involved with the following: field experiences, practical laboratory activities, case studies, simulations, role-playing, debates, library searches, brainstorming, panel discussions, individual or group projects, problem-solving, class discussions and presentations, displays, fairs and exhibitions, peer tutoring, designing and constructing equipment, models, and other learning aids, interviewing, audio-video recording, letter writing, surveys and decision-making. All these involve continuous planning and re-evaluation and may go on beyond the normal class time and extend outside the school hours (Yager 1993). Such strategies are crucial for the development of scientific and technological literacy.

SECTION 3

ASSESSMENT OF STUDENTS

3.1 Introduction

This section guides science educators and teacher trainers to develop an understanding of how assessment on learners studying with the STL materials should be and could be conducted. This focuses on the Training of Teachers to use criterion-based assessment as a means to better inform teachers as how well students have achieved for STL development.

Science educators and teacher trainers are expected to acquire a thorough understanding of these rationale and ideas. The following activity would provide an overview of one of the many ways to run training of trainers' workshop on student assessment.

Activity 3-1: Different Methods of Assessment

Guide participants to Discuss the different possible methods of assessment for students with respect to the purposes, strengths and weaknesses (Refer to Resource 3A: Possible Methods of Student pg. 69).

The discussion could then be extended to the "what, why and how" of criterion-based assessment, given a description of both general and pre-determined criteria in a 3-point achievement scale (Refer to Resource 3B: Criterion-based Assessment on a 3-point Achievement Scale pg. 70).

Examples could be illustrated using any of the following components:

- ***Social values***
- ***Problem solving***
- ***Decision making***
- ***Personal skills***
- ***Communication skills***
- ***Career awareness***
- ***Knowledge skills***

Allow participants to Report on the discussions and categorise the aforementioned components into 4 major areas:

(i) Social values
(ii) Science methods

(iii) Personal skills, and
(iv) Science concepts.

It is strongly proposed that the educational objectives in any STL unit should include some aspects in each of these 4 areas.

Activity 3-2: Assessment of an Exemplary Teaching Unit

Each group of participants is given an STL Unit devoid of the assessment component and group members are asked to work out the assessment component that reflects the achievement of the stipulated educational objectives. (Refer to Resource 3C: Exemplary STL Teaching Unit, pg. 71).

A graphic organizer or even a table could be prepared to serve as a guide for completing this activity. (Refer to Resource 3D: Guide for Assessing Achievement of Educational Objectives, pg. 76).

Other assessment strategies may be included and presented.

3.2 Assessment concerns

One important purpose of assessment is to improve student learning. However far too many teachers view assessment as merely a tool to document what children do not know and make no effort to provide remedial action (Bonnstetter 1991).

Activity 3-3: Assessment to Improve Student Learning

Assuming roles of recorder, timekeeper, facilitator and taskmaster within each group, participants take turns to comment on (a) and brainstorm for (b)

(a) Assessment as a means of improving student learning

(b) The dangers inherent in assessment, or in examinations in particular

Prepare to share the results of tasks at hand.

The conclusions on Assessment and Evaluation (UNESCO 1993) during the Project 2000+ International Forum in Paris were:

a) There is a danger of assessment defining the curriculum being taught in schools

b) Assessment must be an integral part of the teaching-learning event (formative), not an add-on at the end (summative), and must be consistent with all goals, priorities, and the context of the course

c) Assessment and evaluation should improve the quality of the teaching materials and methods of instruction. Students' views, rather than the 'correct' response, require more attention

d) Assessment and evaluation have traditionally focused on psychological aspects of learning, but STL relates to group activity by citizens, therefore, new methods of assessment and evaluation need to be developed within a sociological perspective on learning

e) STL must be operationally defined by good assessment practices

f) Knowledge, skills (including higher-order cognitive skills) and values to be assessed should be embedded in an everyday setting relevant and appropriate to the students

g) The element of assessment, which is an implicit part of teaching based on constructivist learning, must be made explicit. Steps must also be taken to improve reliability, for example, by moderation procedures, and by providing exemplification of students' actions and responses which have been assessed

h) Assessment and evaluation methods need to be developed for the skills of acquiring information, organising information, and using that information

i) Assessment and evaluation should focus on students' explicit behaviour, ethics and values, as evidenced in their everyday experiences

j) New curriculum projects must build into lessons an appropriately wide range of assessment and evaluation methods, indicating what students can do in a variety of contexts. Traditional formats must be expanded

k) Assessment modes may contain a gender bias, therefore, it is important for teachers and those responsible for generating assessment instruments to be aware of such gender effects and seek to avoid unnecessary bias

l) There should be assessment and evaluation of the capabilities of teachers to assess students in both formative and summative ways, as well as of the quality of instructional resource materials for STL

3.2.1 Are School Curricula for Educational Gains, or for Passing Examinations?

Activity 3-4: Why do Teachers Teach for the Examinations

Assuming roles of recorder, timekeeper, facilitator and taskmaster within each group, brainstorm on the following questions:

(a) Do teachers teach for the examination? Why?
(b) Is this seen as a problem? Why?

Write your opinion (yes or no) on a piece of paper when presented with question (a). Based on what you have written, move to either the YES or NO corner. In your respective corners, discuss the possible reasons to justify your stand. A member from each corner is picked at random to present.

Until science educators and teacher trainers guide teachers to make assessment procedures sufficiently valid and measure the objectives set for the course, there is always the danger that teachers will ignore the educational intentions of the curriculum and 'teach for the examination'.

Very able students, who develop learning skills of their own and acquire more than that delivered at school, have been able to cope with such a system, as is evident from past successes. But with education in science and technology encompassing a greater percentage of the population and the need to promote higher and higher levels of scientific and technological literacy among ALL students, limiting learning to that which is examinable by pencil and paper systems seems no longer sufficient.

3.2.2 Need for a Range of Assessment Procedure

Activity 3-5: Varied Forms of Assessment

The course/workshop leader should assign participants to groups with different roles and guide participants to discuss briefly the purposes, strengths and weaknesses for each of the possible methods of assessment. (Refer to Resource 3A: Possible Methods for Student Assessment, pg. 69).

Would you and the participants agree there is a need for more varied forms of assessment in science? Explain .

Each method of assessment has its own purpose, strengths and weaknesses. Educators must choose methods, which suit the purpose for which the assessment is intended - whether to provide feedback before and during instruction, summary of achievement after instruction, or to provide decision-makers with information needed for course planning, and improvement. It has been reported (Hildebrand 1991) that not all students perform best using any particular mode of assessment. It therefore, makes sense to include different ways of assessment to attain the desired learning achievement.

3.3 Assessment Research

Two research areas for assessment are examined. They are :

- the degree to which assessment can be undertaken by the teacher and
- the use of criteria on which to base assessments.

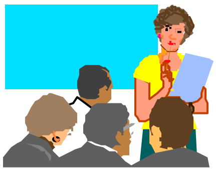
3.3.1 Assessment and the Teacher

Where the system does not demand that students take external examinations or be subject to a strict selection procedure, assessment by the teacher poses little problem. However this is not the case in most educational systems around the world, where competition between students for places in educational institutions, or to undertake specific courses, is often very fierce.

Science educators and teacher trainers should be aware that Any selection procedure based on assessment needs to be reliable. Reliability is emphasised by examination boards around the world. To have a reliable measure of students' achievement, there is a need to consider this with respect to the objectives of the course. Here the conflict with validity is clearly seen. Courses that emphasise attitudes and communication skills, soon find that the examination system can easily undermine these objectives. Without careful guidance by science educators and teacher trainers Teachers resort to concentrating on those aspects that are examinable under the current system.

3.3.2 Using Criteria to Assess Students

A growing trend is to try to assess students, not against one another, but against specific criteria. Once students have shown they can master the criteria, it is assumed they will retain this ability and can proceed to achieve other more demanding criteria. This does not mean that students are required to tackle one criteria at a time, but to suggest that students are given targets and through undertaking appropriate task or activities, students move towards the attainment of the required criteria. Assessment of their ability or progress towards mastering a skill can be determined continuously by the teacher as the students undertake the tasks set.



Activity 3-6: Analyses of Syllabus Statement

Ask participants to Analyse the syllabus statements in Resource 3E: Assessment Research, pg. 77. Ask them to Write their stand (yes or no) on a piece of paper when presented with the following question.

"How different are the pencil and paper examinations?"

Based on what participants have written, ask them to move to either the YES or NO corner. In their respective corners, ask participants to discuss the possible reasons to justify their stand and to present their ideas.

Trends in summative assessment (assessment undertaken at the end of a course) reflect a number of aspects that are becoming more common in schools. These aspects are:

- criteria based rather than norm based testing
- school based testing, moderated at national or state level
- teachers have flexibility to choose assessment activities which best suit their students' needs and reflect the goals of the teaching programme
- variety of assessment tasks
- students have more than one opportunity to demonstrate achievement of objectives
- assessment plans and procedures are freely available to students and parents
- students can be involved in the planning, timing and presentation of their work and thus take increasing responsibility for their own learning

3.4 Summative Assessments

It is usual to know what students have gained from instruction at school. Often there is a need to predict the likely success at a further stage of learning, especially if this is highly selective (e.g. tertiary education in many countries). The teacher, during teaching, could undertake this, but it is more usual that it is undertaken by some form of terminal assessment procedure, usually an examination. Nevertheless, science educators and teacher trainers need to realise that this external examination will not exclude the teacher's role and teachers need guidance in how to determine the progress of their students.

Activity 3-7: Criterion-based Assessment

Given Resource 3G: Using Criteria to Assess Students, pg. 80, ask participants to collaborate in respective groups to devise operational ideas in any small teaching unit as to how criterion-based assessment could be carried out.

Ask participants to Prepare to present a group report.

3.5 Formative Assessment

Science educators and teacher trainers should recognise the value of formative assessment procedures. Teacher involvement in assessment is inevitable when formative assessment (assessment during the learning process) takes place. In formative assessment, tasks can be used by teachers to help students learn and to help them understand and take part in the assessment process.

Activity 3.8: The Value of Formative Assessment

Present participants with Resource 3F: Formative Assessment, pg. 79, for a general overview. Ask them to Discuss the following two questions:

(i) What are your views on the value of formative assessment?
(ii) Do you consider it a useful form of assessment for STL?

Ask participants to Prepare their views for presentation.

3.6 Widening the Scope of Assessment

White and Gunstone (1992) contend that assessment in schools is often too narrow in range. They mentioned that oral and written questions that teachers ask in class are usually confined to requiring short answers for presentation or essay of various lengths. While there is nothing wrong with these tests, they are limited and provide a limited measure of understanding. They advocated the use of diverse probes of understanding as an effective means of promoting high quality learning which involve the use of concept mapping, prediction-observation-explanation, interviews about instances and events, word association, drawings, fortune lines, relational diagrams, and question production.

Activity 3-9: Assessment for Learning or Grading

Ask Groups to identify their respective opinions and support this with examples, given the following question:

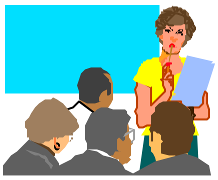
"Is assessment to gauge learning, or is it to grade the students?"

Ask participants to Consolidate their answers for presentation.

Science educators and teacher trainers need to be aware that The principles of assessment for learning differ from the principles of assessment for grading. When assessing for learning:

- it is not necessary to set all students the same task under the same conditions - the rules of fair competition do not apply. In fact, to explore the limits of their understanding, we need different tasks for different students
- wrong answers tell much about students' thinking. Assessing for grades counts right answers. Assessing for learning analyses all answers
- open questions give special insights into students' thinking. Students use their own words and make their own choices of the science to apply. Assessment for grading focuses on closed questions
- it does not matter if one student does well in projects and badly in quizzes, while others do well in quizzes and badly in projects: tasks do not have to yield the same ranking. It does not matter if all students score 10/10 on the quiz
- assessment for learning is integral to teaching. By contrast, assessment for grading is separated from teaching - we do not teach during a test, for fear of distorting the ranking.

3.7 Asessment of Student Achievement through the Use of STL Teaching Materials



Activity 3-10: Assessment Through STL Teaching Materials

Check that participants have understood the notion of criterion-based assessment, then ask them to work as a group to offer suggestions to the following question:

"How can teaching tasks be developed to assess specific criteria?

Ask participants to be prepared to present their group report.

The educational objectives put forward in STL learning need to be achieved. Teachers can thus be expected to assess the students on the various tasks put forward in the STL teaching-learning materials. After all, the tasks were introduced to help students achieve the educational objectives. However it is not quite than simple, because:

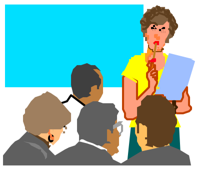
- a task can be given to students to achieve more than one educational objective
- achievement of an objective can be partial. A decision needs to be made whether this partial achievement is sufficient to meet the passing criteria
- the stated educational objectives are specific to the script - assessment is geared to the attainment of the general goals from which the educational objectives are derived.

There is also a further consideration. The achievement of an objective can be specified by indicating whether certain criteria have been reached. However, criteria can be considered at a number of levels. For example, students may not exhibit the achievement demanded. They will need help to raise their educational level. Also, some students may illustrate an acceptable level of performance, while others may be achieving far higher than the standard expected and need to be challenged to reach a higher level of literacy.

Formative assessment has the advantage that it can be carried out during the teaching process and it can give the teacher a picture of the various levels of achievement in each criterion by each student. Achievement of criteria can also be undertaken as a summative form of assessment (i.e. after the teaching). Written, tabular or graphical data form the major summative assessment components, but verbal presentations, supplemented by visual aids, can also be considered.

Irrespective of whether a formative or summative assessment approach is adopted, the following suggests a General Strategy for Assessment based on a 3-point achievement scale as given in Resource 3B, pg. 74.

Scale A	*represents an achievement above the standard and is the challenge posed for those students able to go beyond the standard level of achievement.*
Scale B	*represents an acceptable standard for the particular students in questions taking into account their age, experiences and previous background. This standard represents the target expected of ALL students in the class*
Scale C	*represents an unacceptable standard and more practice in this area is required.*

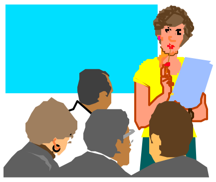


Activity 3-11: Assessing Objective Areas

Given the Resource 3H: Assessing Objective Areas, pg. 81, ask participants to work in their respective groups to understand and critique the criteria set for each of the objective areas before answering the following questions:

a) ***Do you consider this a feasible approach to be used in science classrooms?***
b) ***How are these objective areas related to the 4 areas of Education Components, viz. Social Skills, Science Methods, Personal Skills, and Science Concepts?***

Guide participants to Prepare to present their group report.



Activity 3-12: Other Assessment Techniques

Ask participants to brainstorm in groups, other assessment techniques that could be used to obtain attitudinal and other non-cognitive data during STL teaching.

Guide participants to Consolidate their ideas in groups, and prepare for presentation.

After the presentations have been made, refer to Resource 3 I: Other Assessment/Evaluation Strategies, pg. 84. The resource will serve as comparison between your "before views" and "after views".

3.8 Summary

While assessment reform is needed, there is a range of assessment procedures being suggested rather than reliance on pencil and paper examination. In many cases the assessment procedures involve the teacher and hence, the professionalism of the teacher is crucial for scientific and technological literacy development. Examples have been given of new directions in assessment as well as in recording a range of attributes and achievement, beyond those associated with factual recall and comprehension of the subject matter. Formative assessment can play a very valuable role in determining the development of the various attributes of STL teaching.

In conclusion, it is important to recognise the importance of assessment in guiding both teachers and students to the achievement of the educational objectives. STL teaching materials need to give careful attention to the assessment component, especially the formative assessment of the various educational attributes considered beyond scientific conceptual learning.

Resource 3A: Possible Methods for Student Assessment
Falvey P; Holbrook J B; and Conian D., 1994

These are possible methods for student assessment:

a) multiple choice items
b) open-ended assessment items
c) essay questions
d) written reports
e) group and individual presentations
f) interview individual or groups of students
g) technological design projects
h) student action plans and self evaluation
i) observations of students in role play and simulations
j) homework
k) student journals
l) standardized achievement tests
m) portfolios of student work
n) criterion-referenced tests
o) extended problem solving projects;
p) field investigations

Resource 3 B: Criterion-based Assessment on a 3-point Achievement Scale

Holbrook and Rannikmae. 1997

The following statements show the 3-point Achievement Scale on Social Values based on the general strategy or Assessment:

Scale √√	represents an achievement above the standard and is the challenge posed for those students able to go beyond the standard level of achievement
Scale √	represents an acceptable standard for the particular students in questions taking into account their age, experiences and previous background. This standard represents the target expected of ALL students in the class
Scale x	represents an unacceptable standard and more practice in this area is required

Assessing Students' Achievement on SOCIAL VALUES

The above involves, justifying a decision, taking into account social values, political considerations, environmental concerns and science and technology information.

Scale √√	A well-balanced justification taking into accounts the assessment of risk, the consequences of the decision and the sensitivities of the local people.
Scale √	Value position justified, but biased towards a predetermined point of view
Scale x	Decision not made, or if made not justified or justified based on a single criterion

Resource 3 C: Exemplary STL Teaching Unit
UNESCO Publication, 1998

SHOULD WE CONSTRUCT A WASTE POWER PLANT IN OUR TOWN?

Introduction

This is an activity to allow an individual or a group to make decisions about the value of constructing a waste power plant in a town. The activity is designed to reinforce students' reasoning and their ability to justify actions based on societal interest. The activity is also designed to lead children to overcome the kind of thinking "not in my backyard (NIMBY)" – which means that it is acceptable to cause pollution problems, as long as it is not where it affects me!

Educational Objectives

This script includes the following learning objectives:

1. Identifying and analysing the problems involved in the construction of a waste power plant.
2. Making a group decision on whether to construct a waste power plant
3. Putting forward reasonable justification for the decision made
4. Co-operating as member of a group to arrive at consensus on the issue
5. Communicating orally and in written format to put forward personal views on the problem
6. Detailing energy transfers taking place in relevant instances
7. Explaining the operation of a waste power plant

Scientific Concepts

Energy change takes place in burning household waste

Prior Knowledge

Emissions are given off by the combuster power
Waste power plants have advantages and disadvantages
Awareness of energy transfer and the ability to state energy transformations in a number of specific instances

Teaching-Learning Materials Needed

1. Newspaper reports on advantages and disadvantages of constructing a waste power plant.
2. Newspaper reports on how foreign countries manage their waste power plant.
3. Publications on the waste power plant made by the city government.

Student's Guide

Scenario

The City government plans to construct a waste power plant in the town. The waste power plant uses, as its fuel, flammable waste garbage mostly wastepaper, wood, rubber and fabrics, but also partly oil. The waste power plant supplies the town's electrical needs for heating and hot water for people's daily activities. The City government is not too sure how easy it will be to encourage residents to separate metals and glass from flammable waste. And it is very sure residents will not wish to separate plastics too. But according to environmentalists, the waste power plant will heavily pollute the air, especially in its immediate neighbourhood. This will be especially true with the burning of various types of plastics.

In some countries like Japan, they have waste power plants near residential areas. The Head of a waste power plant in Japan says that he can get electricity and hot water as well for heating houses and other living activities. At the same time, the waste power plant helps to diminish both oil consumption and the amount of garbage to be buried in the field to less than one tenth.

Your Task

1. List, collect and classify waste material that you know of. Use SMALL samples of different waste material and experiment to if they can burn. (You must do this out in the open because some waste materials give off harmful gases). Try to observe and compare how much energy is released and how much smoke or bad smell is given off. Obtain information from newspapers and other publications and identify problems and benefits from constructing a waste power plant.

2. Put forward ideas on the operation of a waste power plant in a brainstorming session.

3. List the energy transfers related to the power plant, taking into account each type of waste material that can be used as a source of energy transfer.

4. Discuss, in a group, the advantages and disadvantages of constructing such a plant, running on household waste.

5. Express your opinion and in so doing try to influence the rest of your group to form the same opinion regarding the appropriateness or inappropriateness of constructing a power plant in your town. In the discussion, attention needs to be given to what is best for the community as a whole and not simply on a localised view for a group of residents in a particular location.

6. A member of each group presents the group's opinion to the whole class. A whole class position is then determined.

7. Record the decision of the whole class and express its justification in the form of a letter to the City government.

Teacher's Guide

This activity relates to:

a) knowing the energy change that can take place on burning household waste and realising how far this can go to completion and how far waste in the form of ash is created;

b) awareness of the emissions given off by the combustion process and the effects of a limited air supply;

c) discussing, in groups, the advantages/disadvantages of waste power plants and the presentation of group arguments;

d) reflecting on positive community attitudes and how to combat attitudes signified by NIMBY (it is okay as long as it is good for my family and me).

Teaching Strategy

1. The lesson can begin with an initial brainstorming session on:

   "Why construct a waste power plant in our town?"

   Many ideas should be expressed at this time and the teacher can record these on the blackboard. Once these ideas are exhausted, the teacher needs to guide the class to collect together the ideas for future use in other sections of the lesson. These will cover (a) energy changes involved in burning rubbish – both partial and complete and (b) the advantages/disadvantages of a waste power plant.

2. The next part of the lesson is suggested as group-work to record as many possible energy transfers related with the power plant. During this time the teacher goes around the groups, checking the students written records and asking for explanations on any point that is not clear. It will not matter that students express obscure energy changes. The point is that this part of the lesson reinforces ideas on energy transfer covered in previous lessons.

3. In groups, students discuss the advantages and disadvantages of constructing a waste power plant in the town and come to a conclusion whether a waste power plant should be built. They can use the energy transfers listed, to guide their decision on the advantages e.g. getting rid of waste, producing heat energy, providing a source of carbon dioxide; and the disadvantages e.g. poisonous fumes, need for a supply of oxygen otherwise carbon monoxide produced, need for fuel such as oil to be added. But the important point is that students can come to a decision.

4. Each group presents their decisions and reasoning to the rest of the class. The whole class taking the most appropriate decision follows this. All students record this decision and the reasons for it.

5. The above decision was probably influenced by the burning process and disposal of waste, rather than the total social issue e.g. collection/delivery problems, where to put the power plant, pollution control, economics, where to dispose of the ash. It may also not reflect the need to view the matter on behalf of all residents and not just a vocal minority. The NIMBY thinking needs to be addressed here. In groups, students discuss how to overcome thinking like NIMBY. The group then try to present their thinking by constructing a letter on behalf of the class to the town council on whether a waste power plant should be built and how the council should take into account complaints that relate to the NIMBY thinking by residents.

Assessing Students' Learning with STL Teaching Unit

Trainers can use the 'Format of Assessment' as listed below to assess student learning.

Objective	This is achieved by
1. Analysing the problems involved in the construction of a waste power plant.	……………………………………………
2. Making a group decision on whether to construct a waste power plant.	……………………………………………
3. Putting forward reasonable justification for the decision made.	……………………………………………
4. Co-operating as member of a group to arrive at consensus on the issue.	……………………………………………
5. Communicating orally and in written format to put forward personal views on the problem.	……………………………………………
6. Detailing energy transfers taking place in relevant instances.	……………………………………………
7. Explaining the operation of a waste power plant.	……………………………………………

Formative Assessment Strategies

The following are examples of formative assessment strategies:

Able to give a Social Values grade (objectives 1 and 2)

A Able to make a rational decision and to put forward suitable public actions to make the power plant a welcome addition in any neighbourhood.

B Able to isolate the issues and to apply rational thought to make a decision.

C Repeat the opinions given in newspaper cuttings without giving any individual thought to the issues involved in constructing a waste power plant

Able to give a Science Method grade (objective 3)

A Able to put forward practicable suggestions to remove problems in operating a waste power plant and suggest how it could operate effectively.

B Recognises the combustion problems linked with a waste power plant and can put forward suggestions on how these might be overcome.

C Not really able to identify problems in operating neither a waste power plant nor put forward suggestions on how these might be overcome.

Able to give a Personal Skills grade (objectives 4 and 5)

A Willing to lead the discussion and to guide others towards a decision.

B Interested to take pat in the discussions and in formulating a letter to the City Government. Able to express opinion that is based on rational thought.

C Tales little pat in the discussions or in putting forward suggestions. Follows the opinion of others.

Able to give a Science Concept grade (objectives 6 and 7)

A Understands the energy transfer and steps that can be taken to ensure that exhaust gases are not toxic or contain particulate matter. Recognises the importance of 'scrubbing' gases and the use of an electrostatic precipitator.

B Understands the difference between complete and partial combustion and the release of toxic substances during combustion. Recognises the need for a good oxygen supply and a high temperature and how energy transfer occurs.

C Not able to explain the combustion of substances such as oil, wood, paper, plastics, or their likely products and does not appreciate the origins of toxic substances.

Resource 3D: Guide for Assessing Achievement of Educational Objectives

Holbrook and Rannikmae, 1997

OBJECTIVES	This is achieved by:

Assessment Criteria

1. **Social Values [Objective(s) ________]**
   √√
   √
   x

2. **Scientific Method/Skills [Objective(s) _______]**
   √√
   √
   x

3. **Personal Skills [Objective(s) _________]**
   √√
   √
   x

Resource 3 E: Assessment Research

Senior Secondary Assessment Board of South Australia, 1994

The syllabus statement of the Senior Secondary Assessment Board of South Australia, 1994, for the Year 12 Biology curriculum sets out its objectives in five domains:

- biological knowledge
- problem solving skills
- manipulative and observational skills
- social implications and personal relevance
- communication skills

Taking one area as an example - "social implications and personal relevance" domain, the guidelines state that students "should be able to apply the knowledge and skills obtained in the course to the understanding of biological problems and relevant social issues". For each content area in the syllabus, possible social issues are listed for the teacher, as follows:

Content Area	Possible Social Issues
Cells	Genetic Engineering, Cancer
Genetics and	Genetic diseases, Effects of the use of nuclear energy
Evolution/Energy	Greenhouse effect, Exercise; Alcohol, Deforestation and reforestation
The Human Body	Dietary disease' kidney disease, AIDS and the immune system, abortion, management of infertility, population control, birthing

The guidelines continue to indicate that "students are required to investigate at least 2 social issues. Each student must write at least one report for presentation at a group moderation meeting. The following aspects are suggested for structuring the report and can be used for assessing how well a student has fulfilled the objectives of the activity:

Why is this socially relevant? What forces have made this relevant?
Who or what does this issue affect? Individuals, communities, countries or the whole of humankind?
How are they affected? Living standards, lifestyle, personal freedoms, costs?
What are the benefits of the issue?
Financial, health? Do they allow new possibilities?
What are the costs of the issue?
An attempt to produce a balanced view of the subject should be made.
How can the phenomena be managed?
How can it be contained, treated, used, enhanced, made available to developing countries?"

It is suggested that students could achieve the objectives of the social implications and personal relevance domain by methods such as:

- writing a structured essay based on a specific issue
- writing a research assignment on a given topic
- reviewing a media item, newspaper or magazine article, or video programme, listening to a speaker, or attending an excursion
- presenting an oral report on any one of the above
- reviewing or reporting on a work experience or career option (e.g. physiotherapy, nursing)
- preparing and participating in a debate on one of a number of topics
- producing some form of visual or diagrammatic representation of data collected about an issue
- reporting on a survey of public opinion, analysed and evaluated
- discussing with other students
- role playing
- undertaking investigations of industrial processes using biological materials

Resource 3F: Formative Assessment

Black P.J., 1993; Fischer et.al., 1972; Malcolm, 1992; Gunstone, 1990

There has recently been a greater focus on formative assessment as a central requirement for effective teaching and learning. The key characteristic of formative assessment is that information from the assessment is used by teachers and students to help make their work more effective (Black, 1993). Formative assessment can take place during teaching and also before teaching begins (the latter is sometimes called initial assessment - Tisher, Power and Endean 1972). The "secret" of effective assessment is good observation combined with situations in which students reveal their beliefs, skills and self-assessments. From what students say and do, we have to infer what they understand, what they can do and how they think" (Malcolm 1992 p83).

Finding out what students think before, during and after teaching and learning is an important aspect of adapting a constructivist learning approach. The need to consider students' views about science is confirmed by the findings of numerous research studies. Gunstone (1990) reviewed relevant research and concluded that:

- learners have ideas and beliefs and attitudes about their world which are personal constructions
- these personal constructions have major impact upon science learning which the learner uses to (1) interpret (and perhaps reject) the ideas to be learned, and (ii) link ideas to be learned with what is already known and believed

Resource 3G: Using Criteria to Assess Students

Black P.J., 1993

Assessment by the teacher, based on criteria, can be based on a 2 point (can or cannot achieve) or a 3-point system (achieve at various levels of proficiency). Finer distinctions are possible if desired, but this would make the scheme more elaborate.

The following illustration relates to a 3-point scheme. The criteria, if aggregated, could lead to achievement at various levels. For example, it could lead to achievement at a foundation level for the minimum acceptance of achieving the criteria. It could lead to achievement at a credit level where the criteria have been well attained or a special level, where students have performed outstandingly and achieved the criteria in all aspects at an excellent level.

The scheme may seem sound, but the problem, of course, lies in the specification of the criteria in such a manner that it can be judged whether the criteria have or have not been achieved. This is relatively easy when science is treated as a factual subject, but becomes of immense difficulty when attitudinal scales are introduced and students need to work in cooperation with others, yet their contribution to the whole needs to be determined.

Resource 3 H: Assessing Objective Areas

Holbrook and Rannikmae, 1997

The educational objectives given in an STL teaching script relate to the 4 components of science education put forward in Section 1, namely Social Values, Science Methods, Personal Skills, and Science Concepts. However the components are too vague to indicate criteria. An attempt is made below to describe each component and indicate the scale of achievement geared to meet the criteria.

Social Values

Justifying a decision, taking into account social values, political considerations, environmental concerns and science and technology information

Scale ✓✓ A well-balanced justification taking into account the assessment of risk, the consequences of the decision and the sensitivities of the local people

Scale ✓ Value position justified, but biased towards a predetermined point of view

Scale x Decision not made, or if made not justified or justified based on a single criterion

Problem Solving

Recognition of the problem and putting forward a suitable plan to solve the problem

Scale ✓✓ Planning complete, detailed so that it is easy to follow the instructions and the apparatus needed is specified. Factors such as controlling variables are specified

Scale ✓ Planning is simple, sampling considerations are simple and one off; repeating for authentic data not included

Scale x Problem poorly conceived. Planning very vague or no plan

Decision-making

Recognition of an issue or concern, the factors involved, the acquisition of knowledge needed and making a decision

Scale ✓✓ Decision is made based on the concern, considering factors involved. Recognises the issue and knowledgeable on background information need to make an informed decision. An evaluation is given

Scale ✓ Decision is made based on the concern, but without considering all factors fully i.e. not fully conversant with the background information and thus making a decision based on incomplete information. No evaluation is given

Scale x Decision is made without considering different factors and without any analysis/synthesis of the situation. No links justifying the concern and the decision. No evaluation is given

Personal Skills

1. Exhibiting perseverance, creativity, initiative or ingenuity, leadership skills
2. Behaves cooperatively
3. Handles materials/apparatus safety; aware of and appropriately assesses the risks involved
4. Relates to ethical issues (takes a stance)

Scale ✓✓ Willing to participate in group work and take on a leadership role. Able to put forward ideas that exhibits both creativity and ingenuity. The student is able to handle materials and apparatus in a safe manner and be clear on the risks involved. The student takes a stance on ethical issues of persuading others of its virtue

Scale ✓ Willing to participate in group work and to play a significant role. Whilst leadership skills may not be highly development, the student is willing to persevere and put forward ideas that show some creativity and ingenuity. The student is able to handle materials as guided and show some attempt at assessing risks involved. The student is able to take a stance on ethical issues when specifically called upon to do so (may not exhibit this quality without being specifically requested)

Scale x Little attempt to participate in a cooperative activity and not able to take on a leadership role. Few signs of creativity exhibited

Communication skills

The interaction of ideas orally, in written, tabular, graphical formats or by utilising technology e.g. the computer

Scale ✓✓ Actively participates, putting forward ideas clearly, logically, emphasising the main points and being persuasive

Scale ✓ Participates and puts forward ideas, but is easily persuaded by others and adopts their ideas

Scale x Does not participate, or the contribution is poor, lacking in clarity

Career Awareness

1. Can recognise skills involved in a given scientifically oriented or scientifically associated career opportunity

2. Aware of educational achievement level needed for scientifically oriented or scientifically associated career opportunities

3. Appreciation of the job specification for different scientifically oriented or scientifically associated careers

Scale ✓✓	Is very aware of job specifications for a range of careers, the qualifications needed for acquiring such employment and the value that school work can have in meeting this targets
Scale ✓	Aware of educational achievement necessary for a range of career opportunities and sets sights on specific targets with this in mind
Scale x	Is not able to link school work to career possibilities

Knowledge

Factual information, understanding of scientific principles, application of scientific ideas and higher order thinking skills (analysis, synthesis, evaluation)

Scale ✓✓	Shows evidence of being able to analyse, synthesise and evaluate a situation with full understanding of the scientific principles involved and an ability to retrieve additional information from secondary sources. Is able to plan and carry out experimental work in a safe and secure manner
Scale ✓	Is capable of analysing, synthesising or evaluating a situation with guidance. Can undertake experimental work following plans developed during group work or supplied by the teacher
Scale x	Gives factual information with explanations copied or based on the textbook. Little evidence of higher order scientific thinking. Is only able to undertake experimental work when specific instructions are given

Resource 3 I: Other Assessment/ Evaluation Strategies

Ramsden J.M,1992; Gianello,1988; Malcolm,1992; Howe & Jones,1993

Some suggested techniques are:

1. Student Questionnaires

Teachers can obtain valuable feedback of students' perceptions about their learning by using oral discussion or having students complete a questionnaire that can then be used as a basis for discussion.

Questionnaire used by teachers during the trial of the Salters' Science course consist of two parts: the first part contains six statements to which pupils can respond on a 5-point scale (5-strongly agree, 1-strongly disagree) their agreement with each statement. The statements are:

- I enjoyed this unit
- I enjoyed the practical work in this topic
- I enjoyed the non-practical work in this topic
- I felt the ideas in this unit helped me to understand more about some everyday events and problems.
- I felt some of the things I learned in this unit would be useful in later life.
- I felt this unit made me more interested in science.

The second part of the questionnaire consist of a brief open-ended exercise in which pupils were asked to elaborate on their responses to the statements.

2. Checklists

Checklists can help teachers to plan and carry out observation of students. Checklists can assist teachers to:

- Sample all students
- Sample all aims
- Plan a schedule - this week I will focus on skills in group work; during the next month I will have a 3 minute interview with every student
- Record observations
- Impose a discipline (in time and attention) on our observation

Checklists can be used by teachers for self assessment and peer assessment. Checklists are important when introducing new skills (e.g. group work. It is important to note, however, that students will tire of checklists, if they are overused.

Five examples of different checklists are given below.

Example A - Simple checklist for students' drawings (Howe and Jones, 1993).

	A	B	Comments
Susan			
Andy			
Jose			
Jared			
Kelly			

A. Drawing is realistic rather than fanciful
B. Labels are complete and accurate

Example B - Checklist for Posters

A tick, a rating between 0-5, or a comment, can be written next to each aspect. The checklist can be used for self-assessment and peer assessment as well as teacher assessment.

Poster topic *Name*
Impact
Initiative
Ideas
Design
Clarity
Language
Originality
Scientific consistency

Example C - How I see myself as a group member
Code 0 - not at all; 1 - sometimes; 2 - a lot

Did I
1. .. listen to others?
2. .. talk to others?
3. .. ask questions?
4. .. offer suggestions?
5. .. explain science ideas?
6. .. organise the group ?
7. .. encourage others?
8. .. find mistakes?
9. .. do calculations?
10. .. take turns in speaking?

11. .. share worksheets/equipment ?
12. .. talk politely to group members?
13. .. concentrate on the task?
14. .. complete the task ?

Score

My role in the group today was ....

Example D - Self Assessment Checklist

Name:

I am able to do the following

a) light and operate a Bunsen burner
b) prepare a wet mount
c) measure liquids accurately using a measuring cylinder
d) use a microscope up to a magnification of x400

Example E - Checklist for a talk to the class

Negotiate the criteria for assessment of talks with the students and ensure each has a copy of the criteria before they begin work. All students fill out an assessment sheet for each group's presentation. This will help to focus their attention and develop their listening skills.
The students were asked to 'speak as a material' in a group situation. (A list was given to the group of things to be communicated. They could choose the method of communication, tell a story, sing a song, make up a play, put on a debate, give a factual presentation, etc). Flow of ideas, imagination and enjoyment are valued equally with science ideas.

Rate the following on a scale of 0-5, depending on how well the group conveys the following about the topic 'Material'.

Where it comes from?
What it is made of?
How it is produced?
What its properties are?
What it is used for?
The link between properties and uses
Imagination
Enjoyment
Flow of ideas

3. Portfolios and Profiles

A portfolio, or profile, is a systematic collection of evidence used to monitor the growth of a student's knowledge, process skills, attitudes and other relevant attributes. As such it is a tool that can help create a holistic view of learning. A portfolio is often viewed as more than a collection of marks or grades and may include samples of student's work, observations records, interviews, surveys, laboratory reports, etc. A profile, on the other hand, is a comprehensive set of achievements and attributes set out on a readable manner.

When assessing skills, attitudes and perhaps recording health data, punctuality, absenteeism and self-esteem, it makes little sense to combine marks or criteria levels. Whether the record is to be used by the student, the teacher, by parents or even future employers, the goal is to create something meaningful.

Two problems are apparent with the creation of a portfolio or profile:

- the type of profile to be designed and the qualities to be described in them
- the technical aspects of the educational measurement in which the profile is to be based, including validity and reliability

The type of portfolio or profile does in fact depend on the needs of the end-user. A teacher in developing a portfolio plan should take the following into consideration

- What kinds of assessment are currently used to assess student growth and performance in science? What do these assessment tell about student learning ?
- What are important aspects of student learning, performance and/or attributes that are not satisfactorily assessed with current practices ?
- What are the educational goals that teachers expect students to achieve and to be able to do when they leave ?
- What are the subject level curricula goals in relation to the overall school system goals?

An example of a profile covering aspects of character is given below. Relationship with fellow students:

- A leader/dominant personality
- Accepted member of student groups
- Likes to join with other students, a follower
- Independent, quite isolated, tends to be on his/her own

Ability to work with others

- Works well as a leader of a team
- Works well as a member of a team
- Prefers to work on his/her own
- Does not fit in well as a member of a team

Ability to profit from further training or education

- Should have further training or education from which much benefit would come
- Would follow an appropriate course of further training or education to advantage
- Further training or education probably not suitable

In conclusion, the move to develop scientifically and technologically literate students is well served by the adoption of portfolios or profiles for recording what students have achieved, what attributes have been developed and what attitudes prevail. But it is important to recognise that the criteria on which the portfolio or profile is developed are based on societal expectations and as such are referenced with respect to the aspirations of the norms of the society. These of course can change with time.

SECTION 4

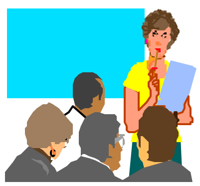
CREATING AND IMPLEMENTING STL TEACHING MATERIALS

4.1 Introduction

This section guides science educators and teacher trainers to help course/workshop participants to understand:

- how to use the criteria and create exemplary STL teaching materials
- approaches for implementing the STL materials
- different ways of evaluating the STL material.

You as a science educator or teacher trainer, are expected to acquire a thorough understanding of the above. To start, you may wish to adopt the approaches described in this section.



Activity 4 -1: Common Features of Exemplary Materials

Ask participants to work in groups and identify the common features in the 2 exemplary STL units. Refer to Resource 4A: Units 1 -3, pg. 99-106). Discuss the following areas:

- ***Format of scripts***
- ***Domains covered in educational objectives***
- ***The extent of students' participation***
- ***Acquisition of skills***
- ***Modes of assessment***
- ***Other distinctive features***

Participants should Prepare a report for presentation. In this they should High light the criteria for designing exemplary STL materials. Refer to Resource 4B, pg. 107 and features of exemplary STL materials in Resource 4C: pg. 108.

4.2 The Concern

UNESCO and ICASE proposed an innovation for teacher prepared STL teaching-learning materials. While the material is very appropriate for use in the classroom when prepared by the teacher for this purpose, the major aim of creating such material in the course/workshop is to give ownership of the philosophy and approach to the teachers. It is thus important for science educators and teacher trainers to be conversant with the philosophy so as to guide teachers in the creation of such materials. Teachers can also adopt or adapt the STL teaching learning materials developed by others.

This Manual is thus designed to assist science educators and teacher trainers appreciate the purpose of promoting STL teaching and learning and to suggest how courses/workshops might be conducted leading to the creation of exemplary STL teaching materials.

It is assumed that The goal of science teaching is to promote STL, which has a number of facets. These are not really 'new'; they mainly represent 'best practices' in science education, which in catering FOR ALL STUDENTS are suggested to be societally related learning materials. The focus of teaching materials for STL is on:

- problem solving
- decision making
- student-centred teaching
- cooperative learning
- recognition of the wider goals for science education
- importance of linking assessment with the achievement of objectives

For teachers to create STL teaching materials of their own, it is crucial that they appreciate the meaning of STL. Without this, the materials will not reflect the intentions of STL and will be just another teaching resource. Carefully conceived STL materials will, it is predicted, guide students to learn relevant science and technology covering the objectives of teaching. Appreciating the meaning of STL is not easy. It challenges many of the beliefs teachers have previously held e.g. learning science to become a scientist is <u>not a specific</u> goal for STL; School science is providing education through science from a societal point of view, not that of a scientist; technology driven science, or that coming from society, is of more relevance than accumulating textbook concepts; depth of treatment is governed by society needs not by a full coverage of the conceptual learning.

To create STL teaching materials, science educators and teacher trainers should guide teachers to recognise that they are not writing a textbook and what they will produce will serve as supplementary teaching materials. The materials can be used to "drive" teaching, but it is not designed to cover the full range of experiences needed by students to acquire scientific and technological concepts. When the materials are used, these are expected to enrich the students' learning experiences and play an important role in developing positive attitudes towards science and technology in society and the learning of science/technology at school.

Science educators and teacher trainers are thus guiding Teachers to create supplementary teaching materials that will be useful in presenting a wider version of science education and enabling students to be directly involved in these, more relevant, learning experiences. As such science educators and teacher trainers should recognise that these materials can follow a pattern of their own and emphasize aspects considered appropriate for STL. But, They should include strategies for best practices in the teaching and learning within the classroom.

4.3 Criteria for Exemplary STL Materials

The criteria being suggested for the creation of exemplary STL supplementary teaching materials (Holbrook 1997; Holbrook and Rannikmae 1997) are:

4.3.1 Promotes student achievement in a range of education goals

A wide range of education goals are stipulated and form the major focus of the material i.e. students are participating in the process of educational learning, appropriate for the goals of the country and their intellectual development. These goals are achieved through the objectives of science education which are expressed in 4 major areas, namely social values skills, science method, personal skills, and science concepts. These major areas are seen as related to the purposes of education and hence the intention is to ensure science education is playing a wider role in helping students meet educational objectives.

4.3.2 Starts from a concern or issue in society

The material needs to be relevant to the students. It is societally related and thus needs to draw on an issue or concern within the society. Students are familiar with the situation, can thus appreciate its relevance and are able to build on constructs already formed. The material is directly relevant in the eyes of the students. Creating materials on pressure, or bonding or photosynthesis are not, it is suggested, directly relevant because the relevance is not overt. Creating materials on the correct inflation of car tires, moisturising the skin, or the Amazon rain forests are relevant. The relevance is clear even though the conceptual science may not have changed.

4.3.3 Involves demanding (higher order) thinking skills

Undertaking the activity is an appropriate learning exercise for the learner as it provides intellectual challenge appropriate for the students. It utilises constructivist principles - moving from information and understanding already [in] possessed by students, to the new learning situation. It involves analytical or judgmental thought.

4.3.4 Student Participation

The teaching approach and activities are designed to be student-centred, whenever students are involved either individually or in groups for a considerable amount (>60%) of the teaching time. This does not necessary mean the teaching material is experimentally oriented (although this is considered important), but it does mean attention is paid to the incorporation of a variety of teaching approaches through which students can participate.

4.3.5 Includes communication skills

Due consideration should be given to enhancing a wide range of communication skills appropriate for the dissemination of scientific ideas and social values. The development of communication skills is part of the goals of education. In science education, students are expected to be able to communicate orally, mathematically, in creative writing and through the use of charts, diagrams, tables and symbols.

4.3.6 Relates to science concepts

Whilst the material links science teaching to societal issues, particularly by the scenario from which the material is developed, the teaching still contains a substantial component of 'standard' science. Students are given ample opportunities to acquire scientific concepts so as to better understand the scientific components related to the issue or concern and are able to make decisions and put forward suggested actions to be taken. The material is definitely education through science, not a social science add-on.

4.3.7 Includes a comprehensive teacher's guide

As problems, issues and concerns coming from society are often interdisciplinary in character, with the science ideas unfamiliar to the teacher, full explanations are needed to help teachers make use of the materials in a meaningful and interesting manner.

A comprehensive teacher's guide can be expected to include as much detail as possible with respect to:

- the objectives of teaching a unit
- the teaching strategy being suggested
- the manner in which the objectives can be achieved by the task given to the students
- guidelines on how best to assess whether the objectives are being achieved
- detailed information on background information relevant to the teaching

Teachers are used to develop teaching material for themselves, however, they seldom formalise the teaching approach, the organisational needs, the preparation of materials and the manner in which students will be assessed. All of these need to be developed in detail in the STL supplementary teaching material, if they are to achieve their purpose of being exemplary in guiding STL teaching.

4.4 Creating STL teaching materials

4.4.1 Making a Start

Science educators and teacher trainers can begin by guiding course/workshop participants to start creating STL material by recognizing an issue or concern that will be relevant to their students (or whatever they are curious about) and which is worthy of study in a science lesson. This could arise from a student question in class (often a situation at the primary school level), or from a topical concern recognized by students as something that affects, or may affect, them, their family or their community (perhaps something being expressed in the media - the newspaper, television, radio). Thus issues such as 'how to save energy in the home', 'how do we clean clothes?' can be considered as starting points. Students can appreciate the relevance to their lives. This contrasts with statements commonly found in science teaching material such as 'energy in the home', or the more scientific expression 'oxidation by chlorine'.

The major factors are that issues or concerns are seen as relevant in the eyes of the students. The following is a suggested sequence of importance related to how issues or concerns are identified:

(a) Best choice - the students identify the concern or issue
(b) Another choice - the teacher, taking the idea from a secondary source e.g. newspaper, TV.
(c) Last choice - the teacher, initiating the title artificially, from the textbook, etc.

4.4.2 Developing a Title for the Material

Whatever the source from which the idea for the teaching material is derived, it will need a title, supplied by the person creating the material.

Science educators and teacher trainers should recognise that it is important that course/workshop participants see the need to put forward titles that reflect the scenario and thus ensure relevance of the learning material in the eyes of the students. Often a tendency is to make the title reflect too large a topic (e.g. noise pollution, health care, energy for the home). It is more appropriate to gear the title to an area that can be taught in 2 or 3 lessons (e.g. the danger of loud noises to our health, recognising a balanced diet, transporting electricity to our homes). Having done this, it is worth guiding participants to check that the title does reflect a relevant issue or concern as seen from the students' point of view, and which does lead to the acquisition of science concepts that is part of the intended curriculum.

4.4.3 Understanding the Education Components

Teachers need to appreciate that A major recognition in STL education is that science teaching is about educating students. Teaching facts or even guiding students to acquire isolated scientific concepts is not enough. Science teaching must aspire to help students gain the total range of educational objectives put forward for schooling at the given age. Each script should indicate the educational objectives to be achieved in undertaking the activities proposed.

It is recommended that the science educator and teacher trainers guide course/workshop participants to sub-divide educational objectives into four areas as below so as to highlight different areas, but there needs to be no suggestion that these areas can be taught in isolation, or that the descriptors given below are unique and clearly reflect only one attribute. The descriptors merely need to point out that they are different aspects, which STL teaching materials should recognize and give some direction for tackling the attribute involved.

In creating the STL teaching material, it is proposed that science educators and teacher trainees require course/workshop participants to put forward objectives in each of these 4 areas i.e. at least one objective in each of the areas.

- social values — decision making with justification
- science method — science skills
- personal skills — especially communication and cooperative skills
- science concepts — science knowledge with respect to comprehension, application, and the range of higher order cognitive skills, e.g. analysis, evaluation, problem-solving

4.4.4 The Teaching

Science educators and teacher trainers should recognise that each exemplary material should encompass:

(a) A motivation component

Student motivation will be enhanced very strongly by the teaching style adopted by the teacher, who needs to:

- stress what constitutes the learning and its purpose
- relate the learning to students' needs.

It is suggested that science educators and teacher trainers prepare course/workshop participants to create a scenario for each script.. The scenario 'sets the scene' for the learning. For example, a newspaper cutting, a case study, a hypothetical situation, an experimental observation, toys, games etc. Its purpose is to give context to the learning and stimulate motivation.

(b) Student activities

The script must have student activities. The activities however, can be very varied and can include, for example:

- individual writing, drawing, or presenting
- group work for discussion
- undertaking experimental work
- developing a presentation
- formulating a point of view
- creating a questionnaire
- undertaking a library search
- brainstorming
- planning class actions
- writing letter to the community leaders
- poster for public awareness
- participating in a play, a class debate, or a simulation of a law court decision making process

Based on the topic chosen, the skill of the teacher will be to determine an activity (or activities) that can best help students to appreciate the concern or issues from a science educational perspective, what will lead to solving the problem or making a suitable decision. The activity(is) needs to help students gain the necessary scientific background, as well as provide adequate feedback to show them how far they have grasped the concepts and skills being introduced. Finally, the activity(is) needs to pay attention to the development of personal skills, such as cooperative and communication skills, relevant to the teaching situation.

4.4.5 Teaching Strategies

Science educators and teacher trainers should guide course/workshop participants to appreciate that the manner in which the learning will proceed must also be made clear in the teaching material being created. This is best illustrated by suggesting teaching strategies that elaborate the progress of the lesson and detail the actions undertaken to ensure the student activities run smoothly and achieve the objectives.

It is recommended that science educators and teacher trainers guide course/workshop participants to give teaching strategies in sequence, starting from the beginning of the lesson and proceeding through the various tasks undertaken by the students.

The role of the teacher, whether watching, listening, talking to small groups or assessing students needs to be made clear by the details given when elaborating the teaching strategy.

It is recommended that each step in the suggested teaching strategy is numbered and that each number relates to a different strategy adopted by the teacher within the lesson.

4.4.6 Linking Student Tasks and Educational Objectives

It is recommended that science educators and teacher trainers ensure that The relationship between the student tasks and the objectives to be achieved should be clearly stated in a tabular format within the teacher's guide section of the material. This helps teachers recognise that their target to help students achieve the objectives, rather than simply to understand the tasks.

4.4.7 Determining Student Achievement

Science educators and teacher trainers should help course/workshop participants that The most important aspect for the teacher is to determine whether the students have achieved the objectives to the level desired.

The assessment component enables the teacher to ascertain whether the students have achieved the various social values, science method, personal skills and science concepts objectives. The manner in which the teacher is guided to determine these, either by formative or summative assessment procedures, needs to be given clearly.

4.4.8 Finalising the Teaching Material

The guidelines given above should enable the major components of the teaching material to be completed. Science educators and teacher trainers may wish to reflect on Other aspects which can be added, such as:

- List of science concepts covered

This enables teachers to recognize the most appropriate area of the curriculum to which the material relates.

- Handouts to the students

The inclusion of handouts enables the teachers to be clearly aware of material that can be used to guide the students during the teaching process.

- Background information

Teachers appreciate more information on the science background, especially where this is not easily available from books. Many of the more social aspects of science are rarely found in the standard textbooks and teachers often have little confidence in their knowledge in this area.

4.5 Implementing STL Teaching Materials

4.5.1 Classroom Implementation

The teacher, knowing the students in the class and their aptitudes and needs, should be expected to select the appropriate teaching material and the point in time when it should be introduced. Having done this, science educators and teacher trainers need to ensure course/workshop participants to recognise that:

- The teacher will need to be conversant with the material and be prepared for the teaching by making sure all support materials are available. In particular students will need a copy of the Introductory Page and the Students' Guide. Preferably this should be made available for each student as an individual script, but students can also share the scripts and work in groups. (This may be prepared as wordcards if desired). In a more sophisticated situation, it may be appropriate that students download the instructions from e-mail.

- Teachers need to read carefully the teaching strategy being proposed. This has been carefully developed to enable the student activities to be linked to the educational objectives. However, teaching materials cannot be expected to take over the expertise of the teacher. The teaching strategy in the materials must remain a suggestion and teachers must have the freedom to modify as appropriate, in the light of circumstances.

- Where teachers do modify the strategy, they should be careful to ensure the educational objectives remain the sole purpose of the lesson. Unfortunately, the usual reason for modification is that there is insufficient time to complete all the activities. This tends to mean student activities are reduced. Teachers will need to be vigilant during the assessment component to ensure that learning is actually taking place.

4.5.2 Evaluation of Teaching using the STL materials

Clearly, teaching materials of this nature are of little worth if they do not fulfill their expectations. If they are not interesting to the students, then they are not likely to be motivational and a major educational stimulus is not available. If the objectives cannot be achieved by the activities stipulated, then there is basically no learning and the students are wasting their time. And if the assessment by the teacher shows that the students are not gaining from the experiences, then it is important that the teacher takes appropriate remedial action.

Science educators and teacher trainers should recognise that All of the above points to the necessity of piloting teaching materials. If this is undertaken by a number of teachers then the results of their experiences can be utilised to modify the material with the view to making it a better teaching resource.

A problem with this approach is that teachers are often very poor at helping other teachers. Once they have perceived how to handle a situation themselves, they assume other teachers will also appreciate the manner in which the situation should be handled. Of course this is a fallacy. But it does mean that teachers do not find it easy to explain what is wrong with the material or how the materials could best be modified.

To help overcome this situation, Science educators and teacher trainers can create an evaluation form that guides teachers to put forward their points of view. Such an evaluation form is indicated in Resource 4C: Features of Exemplary STL Materials, pg.108.

4.6 Research

The activities suggested for the teaching materials mean that teachers are automatically involved in educational research. This is a very positive step as it means that the practitioner (the teacher) is actively involved in shaping the materials to be used and in determining their effectiveness.

The assessment strategies suggested for the teacher and the evaluation of the teaching materials as suggested by the completion of the evaluation form can both be considered components of educational research. They can determine the value of the activities as to their appropriateness in achieving the desired goals of 'STL for All.' Both strategies simply formalise activities that teachers tend to perform on an on-going basis, without realising the research implications of their actions. Science educators and teacher trainers need to recognise that **action research** is crucial for the development of STL for All.

For STL teachers, student gains are the most important aspect. Finishing the syllabus, or completing the curriculum are seen as statements of little worth. Helping students achieve the educational objectives to the level considered appropriate and determining that this is being achieved through appropriate feedback (assessment strategies), must be the only goal of teaching. And this is governed by the skill of the teacher in teaching students, not by the contents of a textbook. Gearing future teaching to student gains and motivation reflects the teacher's skill. It is a social phenomena governed by feedback (action research).

Without a mechanism for determining student achievement of all educational objectives based on action research, STL is seriously inhibited. It is inhibited by a lack of student involvement. It is inhibited by insufficient action research. It is definitely inhibited by attempting to carry out these activities with a class size where action research is not meaningful.

Science educators and teacher trainers may wish to know that Most of the data collected so far has been where the class sizes are between 20-30 students. Classes larger than this will seriously inhibit student activity and the ability of the teacher to assess the objectives are achieved.

Where classes are larger, then the strategies below are suggested to science educators and teacher trainers so that teachers can try to cope with this constraint:

- one approach is to use an additional teacher, but not through the normal teaching-learning pattern in most schools.

- an expected approach is to sub-divide the class into units of 20-30 and to handle them as separately as is feasible. If it is possible, teach the units at different times, this is the most desired choice, even though it gives the teacher much extra work. If it is not possible (or the teacher is unwilling to teach units at different times), then the different units need a team leader who will guide the use of the material. It will also require the teacher to prepare:

  (a) written instructions for the team leader for introducing the teaching-learning materials
  (b) assessment strategies to be undertaken by the team leader when using the teaching materials (the team leader must assess, otherwise there is no feedback to the teacher)

Activity 4.2 : Creating STL Materials

Prepare participants to Work in groups and develop an STL Unit. Suggest that they begin with a brainstorming session on concerns and issues, following the strategies as d escribed in this section. Ask Groups to report in plenary the progress of their work, and to obtain feedback for improving their work.

When all the groups are ready, ask for presentations to be made of the whole Unit.

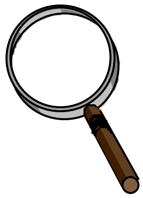
4.7 Summary

Teaching materials can only be considered as STL if they promote the science learning. Science educators and teacher trainers need to guide course/workshop participants to realise that The use of STL teaching material in the classroom also requires best practice teaching-learning approaches and assessment techniques.

The crucial steps involved in developing STL teaching materials are creating:

- a title that reflects a relevant issue or concern
- educational objectives covering the STL range of skills
- a student's guide that includes a scenario and student tasks
- a teacher's guide that details best practice teaching strategies, tabulates the relationship between educational objectives and student tasks, and specifies the assessment strategies to determine how far students have achieved the objectives

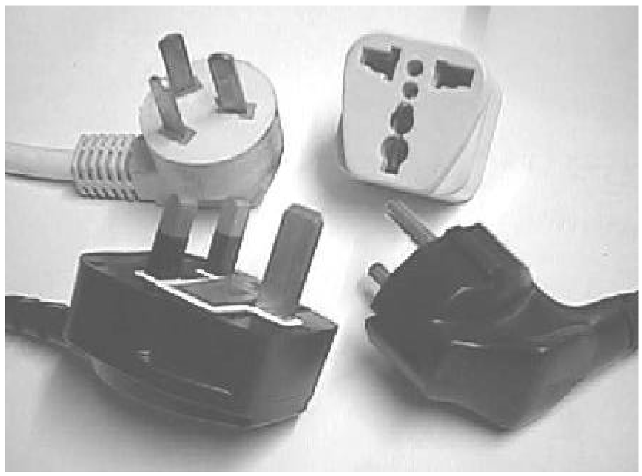
  Additional components can be added such a list of science concepts, resources required and additional notes for the teacher giving background information.



Resource 4A: Exemplary STL Units

Exemplar 1: Should the 3-pin Plug be our Only Choice?

(Source: Hongkong Assoc. for Science and Mathematics Education (HKASME) Workshop, 1998)



Introduction

This script describes an activity exploring the pros and cons of the enforcement of a regulation that limits consumer choice. Students are asked to make up their mind, with justification, as to whether they agree with the regulation. The exercise requires ideas about electrical power, safety and consumer's rights. It also focuses on practical skills, such as wiring up a 3-pin plug. Students need to apply their knowledge on electrical safety to evaluate the safety features of different types of plugs and adaptors. They need to consider the problem with reference to consumer benefits and public safety in addition to scientific points of view.

Educational Objectives

Students are expected to achieve the following:

1. Decide, with justification, whether they agree with the enforcement of the regulation
2. Appreciate the economic and political implications in enforcing the Electrical Product Safety Regulation (EPSR)
3. Develop practical and safe skills of wiring up a 3-pin plug
4. Develop presentation skills and the ability to communicate with others during in group work
5. Identify the electrical properties and safety features of plugs and adapters
6. Have an understanding of the safe use of electrical plugs and its links to consumer rights.

Scientific Concepts
Electrical safety
Short circuit
Fuse
Earthing

Students' Guide

Scenario

The Government of Hong Kong recently passed the Electrical Products (Safety) Regulation (EPSR) to provide statutory control over the safety of all household electrical products supplied in Hong Kong. Under this regulation, electrical accessory providers cannot sell plugs, sockets and adaptors that do not comply with the safety standard. The regulation stipulates that

- All plugs should be 3-pin, either sleeved or flattened, and clearly marked with voltage and current rating

- All adaptors should be designed to adapt 3-pin plugs and to fit for plugs of a definite pin type only, fused and clearly marked with voltage and current rating.

Your Task

1. Based on your previous knowledge, wire up a 3-pin plug. Be prepared to state the potential dangers that may happen due to improper wiring of a variety of plugs and sockets commonly used in different countries around the world.
2. Examine the plugs and sockets to identify the safety features. Discuss the advantages and disadvantages of the various designs in terms of safety, production costs and convenience of use.
3. Decide whether you agree with the enforcement of EPSR. Write a letter to the newspaper to express your views.

Teacher's Guide

This is an exercise on decision-making. The students are expected to have knowledge of 3-pin plugs and electrical safety. Through the activities, it is intended that students consider other factors that affect their decisions, e.g. the cost of production and convenience of use. In addition, students should be aware of societal concern about consumer rights.

Teaching Strategy

1. Students read the scenario individually
2. Students wire up a 3-pin plug based on the knowledge they have learned

3. After wiring up the plug, the teacher leads a whole class discussion on whether there are any potential dangers that may occur if the plug is wired incorrectly. Through this activity, students are guided to think about whether a 3-pin plug is always a safer choice than other types of plugs

4. Students, in groups, examine other types of plugs to identify the safety features and make a comparison with the 3-pin plug. The groups discuss the advantages and disadvantages of the various designs in terms of safety, production costs and convenience of use. This is seen as an important part of the lesson and the teacher will need to move around the groups ensuring that all students are involved in the discussions

5. The teacher conducts a whole class discussion to allow students to voice out the results of their discussions. This is seen as important because the findings form the basis for making a judicious decision later

6. Students, in groups, discuss and list the pros and cons of enforcing EPSR. The teacher moves around the groups helping and interjecting suitable questions (without giving answers) to stimulate wider and in-depth thinking

7. Several students can then present their decisions and reasoning to the whole class. Following each presentation, other students can give their comments and ask further questions. The teacher can also comment on the content and performance of the presentation

8. Students write out individually their opinions on enforcing EPSR

9. Students, in groups, write a letter to the newspaper to voice out their views as a consumer

Achieving the Objectives

Objectives	This is achieved by
1. Taking a position on whether to agree with the enforcement of the regulation	students discussing the issue in their groups and writing up their opinions, justifying their position
2. Appreciate the economic and political implications of enforcing EPSR Groupwork in which students consider all factors involved	students should have knowledge and the skills to solve this societal problem
3. Develop the practical and safe skill of wiring a 3-pin plug	students wiring up a 3-pin plug
4. Develop presentation skills and skills of cooperation with members of a group	students take turn to express their ideas in group discussion and cooperating as a member of a team
5. Identify the electrical properties and safety features of some plugs and sockets	students working together to examine and identify various types of plugs and sockets
6. Have an understanding of the safe use of plugs linked to consumer rights	students write at least 3 safety features of a 3-pin plug Students express through letters, their views on using any 3-pin plug

Assessment

Formative assessment strategies

Able to award a social value grade (objective 1 and 2)

x Not able to discuss the EPSR regulations and consumer rights.
✓ Able to take up a position on the enforcement of EPSR.
✓✓ Able to justify a position concerning the enforcement of EPSR and to relate this to consumer rights in a meaningful way.

Able to award a scientific method/skills grade (objective 3)

x Not able to wire up the 3-pin plug.
✓ Able to successfully wire up the 3-pin plug
✓✓ Able to identify and utilise safety aspects when wiring up the 3-pin plug.

Award a personal skills grade (objective 4)

x No meaningful contribution given to the discussions.
✓ Able to participate in the discussions and make a decision on social concerns.
✓✓ Able to play a significant role in the discussions and lead the group to reflect on particular viewpoints.

Able to award a science concept grade (objectives 5 and 6)

x Not able to identify the electrical properties and safety features of plugs and sockets.
✓ Able to identify the electrical properties and safety features of plugs and sockets.
✓✓ Students understand the safety features of plugs and sockets and the implications of the dangers associated with not protecting the consumer.

No summative assessment recommended

Information sheet

Further information that would give answers to the questions below:

1. Why are the plugs and sockets stipulated by the regulations considered safe? Are they always safer than the other designs?

2. Before the enforcement of the regulations, many households are still using various types of plugs and sockets. What problems will arise when the regulations come into force?

Exemplar 2: Using Iodized Salt to Prevent Goitre
(Source: STL Manila Workshop 1997)

Grade Level: Grade 5 or 6

Introduction

Goitre is a disease physically shown by the enlargement of the neck of humans. It maybe due to a total or partial enlargement of the thyroid gland. One of its causes is hormonal dysfunction. Endemic or simple goitre is a result of prolonged iodine deficiency. This kind of goitre is quite common, especially among the poor people.

Educational Objectives

This script includes the following learning objectives:

1. Decide how a community can eliminate goitre
2. Involve the learners in creating and transmitting messages to the community regarding the consequences of iodine deficiency
3. Cooperate as a member of the group
4. Communicate ideas orally within a group by creating publicity materials
5. Explain the consequences of iodine deficiency in human beings
6. Understand the role of iodine in goitre prevention

Scientific Concepts

- Goitre is physically manifested by the enlargement of the neck in humans
- Enlargement of the neck maybe due to the enlargement of the thyroid gland
- Endemic or simple goitre is a result of iodine deficiency
- Adding iodized salt to food could prevent goitre

Previous Knowledge Assumed

Parts of the body
Functions of glands and hormones

Materials Needed

Pictures of people with goitre
Iodized Salt
Community data on goitre problems
Poster paper, pens

Student's Guide

Scenario

A picture of a person with goitre is shown to the class. Such endemic goitre is endemic to some pockets of population. For example, in Jamalpur Bangladesh, there is a high report of goitre among the people. What causes this problem? Can students do something to alleviate the problem?

Your Tasks

The activities are summarized as follows:

1. In small groups, brainstorm your ideas about goitre, the consequences of iodine deficiency and whether this is a problem in one specific community.
2. Report the discussions of your brainstorming session to the class, further discussions will follow.
3. Make a survey of the number of goitre patients in the community – or obtain the data available from the health centre. The data is analysed, then finding out the dietary habits of members of a family affected with goitre.
4. Call a resource person to discuss about the possible causes and consequence of goitre.
5. Compare the properties of iodized salt with non-iodized salt.
6. Recommend to family members the use of iodized salt to prevent goitre
7. Design a poster to make people aware that goitre could be prevented

Teacher's Guide

This activity relates to:

- An awareness of the causes of goitre and how this can be prevented
- Acceptance of the Use of iodized salt to prevent goitre
- Public awareness that goitre can be prevented

Teaching Strategy

1. The teacher can begin the lesson by a brainstorming session in which the students put forward their ideas on the problem of enlarged thyroid gland and whether this is a problem in the community. In this session, students put forward any idea they have, and the teacher records this on the board. All ideas are written down.
2. Follow the brain storming session with students discussing in small groups, to address the issue whether action is needed in their community to counteract the problem of enlarged thyroid glands. Where action is required, students put forward suggestions of how this can be undertaken.
3. In their small groups, students develop questions about the problem, which they can pose to a visiting health worker, to find out more about the disease, and how it can be prevented.

4. Teacher invites a health professional to discuss with the class the problems about goitre. Each group is permitted to ask questions. The teacher writes the questions on the board, so that other groups would not ask similar questions. When all groups have asked the questions, answers are presented and discussed by both health worker and the teacher, a short written quiz is given. Students exchange papers and mark the papers based on the right answers.
5. An activity follows: samples of iodized and non-iodized salt are examined. Students observe, and describe the properties of the samples. Discussion follows on the value of iodized salt.
6. Posters are then prepared on the following: how the people in the community can prevent goitre, the advantages of iodized salt, and ways to determine iodized salt as compared to non-iodized salt.

Achieving the Objectives

Objective	This is achieved by
1. Decide how a community can eliminate goitre.	Group discussion on the causes of goitre and its prevention
2. Involve the learners in creating and transmitting messages to the community of the consequences of iodine deficiency.	Designing a poster to publicise the problem of iodine deficiency and how it can be overcome. Put forward plans for displaying the poster in the community
3. Cooperate as a member of a group.	Working with the group so that all are involved and arriving at a common agreement for action
4. Communicating ideas orally within the group and by creating publicity material.	Taking an active part in group discussion and in the creation of the poster
5. Explain the consequence of iodine deficiency in humans.	Interacting with a professional who can explain the problems of iodine deficiency and record this. Be prepared to present your explanation to the whole class
6. Understanding the role of iodine in goitre prevention.	Creating a poster to explain actions needed by the community to prevent goitre

Assessment

Able to give a social value grade (Objective 1)

x Not able to suggest ways in which a society can eliminate goitre

✓ Able to put forward ways of eliminating goitre and the manner in which this should be tackled

✓✓ Able to appreciate the importance of eliminating goitre as well as indicating ways of doing this

Able to give a science method grade (Objective 2)

x Not able to develop a questionnaire, relies on the work of others

✓ Able to make a positive contribution to the development of a questionnaire on goitre

✓✓ Able to guide others to create a questionnaire that show insight into the causes of goitre and the manner in which it can be eliminated

Able to give a personal skill grade (Objectives 3 and 4)

x Not able to work with others to resolve and communicate ideas
✓ Able to work with others to make a common decision
✓✓ Able to actively participate and convince others to support the idea put forward in the discussion

Able to give a science concept grade (Objectives 5 and 6)

x Neither able to explain goitre, nor suggest how this can be prevented
✓ Able to explain the causes of goitre and put forward ways in which this can be prevented
✓✓ Aware of the causes of goitre and how to eliminate it by understanding the make-up and function of the thyroid gland

Summative Assessment Strategies

Able to give a personal skills grade (Objectives 3 and 4)

x Not able to design a poster for educating the general public
✓ Able to design and create a poster that informs the public about goitre and its prevention
✓✓ Able to create an attractive poster that gives a positive image to the general public concerning the need to take preventive measures against goitre

Resource 4 B: Criteria for Designing Exemplary STL Materials

Holbrook J.B., 1998

a) Promotes student achievement in a range of education goals
b) Starts from a concern or issue in society
c) Involves demanding (higher order) thinking skills
d) Student participatory
e) Includes a communication skill component
f) Relates to science education
g) Includes a comprehensive teacher's guide

Resource 4C: Features of Exemplary STL Materials
Holbrook and Rannikmae, 1997

Introduction

Educational Objectives

Scientific Concepts

Students' Guide

- Scenario
- Your Task

Teacher's Guide

- Teaching Strategy
- Achieving the Objectives
- Assessment
- Information Sheet

Resource 4D : Evaluation Form for Piloting STL Supplementary Teaching Materials

UNESCO, 1997

(To be completed by teachers using the STL materials in their classrooms)

THANK YOU FOR TRYING OUT THE MATERIAL. PLEASE CAN WE INVITE YOU TO COMPLETE THE FOLLOWING QUESTIONNAIRE.

This questionnaire is designed to determine how teachers utilize STL materials in their classrooms and how far the STL materials meet the criteria specified.

In the questionnaire the term

TOPIC refers to the subject being taught as per the curriculum
SCRIPT refers to one specific STL material as supplied

Part A General Information (please complete)

NAME OF SCHOOL =
NAME OF TEACHER =
TITLE OF SCRIPT =
Date of piloting =

Type of School		....
Students involved	Grade level	....
Age range of students		....
Student ability (if streamed)		above av./av./below av.
or	(not streamed)	mixed ability
No. of students in the class		....
Total no. of lessons involved		....

Part B Teacher Comments (circle the best choice and complete any blanks. Please add additional comments at the end if appropriate)

For **each** lesson in which all, or part of a STL script was used, please answer the following

1. Which script did you use for this lesson ?

   Title ....

   Part(s) ....

[Against 'Part(s)' write ALL, if you used the whole script. If only part of a script was used please indicate with reference to numbers from Your Task in the Students' Guide, or sub headings].

2. Into what teaching topic from your syllabus (curriculum) was the materials introduced? (Use the topic heading as per the syllabus/curriculum guide)

....

3. Was the total script used for

A.	one complete lesson	No. of minutes	=	____
B.	less than one whole lesson	No. of minutes	=	____
C.	more than one lesson	Total No. of minutes	=	____

1. If your answer to 3 is (B), please further indicate whether the script was used

A. at the beginning of the lesson
B. in the middle of the lesson
C. at the end of the lesson.
D. some other combination (please specify)

5. If your answer to 3 is (C), please further indicate which parts (based on the Your Task in the Students' Guide) that were used in each lesson

Lesson 1	parts included	....
Lesson 2	parts included	....
Lesson 3	parts included	....

6. List key scientific concepts, which you think, were particularly well covered in the materials you used in your lesson.

6. List any scientific concepts introduced in the script which students found difficult.

8. For which of the following was the Teacher's Guide and/or Additional Notes not sufficient

A. giving background scientific knowledge ?
B. providing answers to be expected to questions in the students' sheets ?
C. putting forward ways of organizing and managing the activities ?
D. the teaching strategy recommended ?
E. illustrating assessment procedures

9. What societal situation/concern is illustrated in the script?

10. Did you consider the societal situation (see question 7) was

A. very appropriate for learning needs of your students
B. only adequately useful for developing learning opportunities
C. poor at providing a learning situation
D. I omitted the social learning activity (please explain)

In using the script in your lesson, did you

A. encourage extensive student participation (more than 70% of teaching time)
B. manage only part student participation (30-70% of teaching time)
C. included very low student participation (0-30% of teaching time)

If your answer to question 9 was (C), please continue to question 11.

If your response to question 9 was A or B, please indicate how well the students became actively involved in (answer for all parts that are applicable)

ACTIVITY	Very Well	Well	Poorly	Very Poorly
1. solving numerical problems				
2. discussing issues				
3. planning procedures				
4. doing practical work				
5. making decisions				
6. communicating orally				
7. communicating in written form				
8. working cooperatively				
9. handling data				
10. searching for data				
11. interpreting data				

11. Did you consider the language level of the unit
A. very suitable ?
B. suitable ?
C. unsuitable ?

12. Did you consider the layout, diagrams, photographs, type font size

A. very suitable ?
B. suitable ?
C. unsuitable ?

13. How well did you consider the STL script met the educational objectives specified

A. very well - students generally acquired the learning skills ?
B. provided good practice and review of existing skills ?
C. lacked adequate attention to one or more objective ?

14. Did you consider the script enhanced the development of scientific and technological literacy (see the guidebook, section 2, for more information on a possible interpretation of STL)?

A. Yes, because...
B. No

15. Based on feedback obtained from student responses, please indicate whether the script was

A. interesting and motivational
B. interesting
C. not considered enjoyable

16. Did you, as a teacher, enjoy using this script in your teaching ?

A. Yes
B. No. Why was this ? ....

17. Would you use the materials again ?

A. Yes
B. No. Why is this ? ....

If so, would you use it

A. unchanged
B. with modifications (please give an indication of the type of modifications you have in mind)……………………………………………………………….

18 Further comments (please complete as appropriate)
[e.g. Other modifications; New teaching aids]

Part C *Comments by students*
(Please give reactions by students to the tasks suggested in this script on a separate sheet)

Training of Trainers for Promoting Scientific and Technological Literacy (STL) for All

Suggested Evaluation Form

Date of Training______________________

Venue of Training______________________

Direction: **Please answer the questions or put a tick (Ö) where appropriate.**

1. Objectives

The objectives of the training were for trainers to:

1.1 Acquire an understanding of the meaning of STL for All
1.2 Analyse the current teaching-learning practices and examine the roles of various partners in operationalising STL for All
1.3 Gain experience in the development of teacher-based formative and summative assessment strategies to ensure that STL for All goals are met
1.4 Strengthen skills to create STL for All teaching-learning materials relevant to the lives of the learners

In your opinion, to what extent were the above objectives achieved?

Objectives	Excellent	Very Good	Good	Satisfactory
1.1.				
1.2.				
1.3.				
1.4				

State your comments regarding the attainment of training objectives.

____
____
____

2. Elements in the Training Manual

In your opinion, how **useful** was the Training Manual in terms of:

Elements	Very Useful	Quite Useful	Not Useful
2.1 Presentation of the Text			
2.2 Activities Suggested			
2.3 Use of Resources			
2.4 Examples Presented			
2.5 Training Strategies			

If you think any of the above elements is not useful, please write below your suggestions on how to improve the different training elements.

Suggestions____

____

____

3. Conduct of the Training

How would you rate the conduct of the training in terms of:

	Excellent	Very Good	Good	Satisfactory
3.1 Trainer's Preparation				
3.2 Trainer's Presentation				
3.3 Use of Technology				
3.4 Use of Various Training Techniques				
3.5 Use of Other Resources				

If you think any of the above elements could be improved, please write below your suggestions on how to improve the conduct of the training.

Suggestions____

____

____

4. **Would you wish to introduce more skills-based components in future training?**

____ Yes Please suggest which skills should be addressed:

Problem-solving___________
Teaching Techniques_______
Communicating _____
Use of New Technologies___
Others (please identify) _____

_____ No Explain why not?
____
____
____

5. **Presentation and Group Work**

In your opinion, were the group work and presentations useful?

_____Very Useful _____Quite Useful ______ Not Useful

Please suggest ways how the presentations and group works might be improved
____
____
____

6. **Suggestions for the Organization of future Training Activities in terms of:**

6.1 Venue________________________________
6.2 Timing and Duration__________________
6.3 Choice of Trainers____________________
6.4 Others________________________________

7. **In general how would you evaluate the training?**

_____ Excellent
_____ Very Good
_____ Good
_____ Satisfactory

8. **General Comments and Suggestions**
____
____
____

Thank You

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SEAMED-RECSAM

RECSAM, the Regional Centre for Education in Science and Mathematics, is one of the ten members of the Southeast Asian Ministers of Education Organization (SEAMED), an intergovernmental organization established in 1965 among governments of Southeast Asian countries to promote cooperation in education, science and culture in the region. The SEAMED Member Countries are: Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam. Based in Penang, Malaysia, RECSAM has been mandated to fulfil the mission of nurturing and enhancing the quality of science, mathematics and technology education in Member Countries and beyond. In line with its mission, the Centre constantly strives to design and to conduct innovative and challenging training programmes as well as activities that address the needs of science and mathematics teachers and teacher educators in the region.

ICASE

The International Council of Associations for Science Education (ICASE) was created in 1973 with the help of UNESCO to provide an umbrella and a support for voluntary science teacher associations and other professional groups interested in the promoting of science education at the primary and secondary levels. Its members are Science Teacher's Associations (STAS), Science Centers, Institutions and even Scientific Companies who share an interest in science education. By means of a quarterly journal, a primary science newsletter, regional symposia and specialist conferences and workshops, ICASE endeavours, in conjunction with its member organisations, to help teachers through the sharing of experiences and ideas. ICASE also tries to bridge the gap between research findings in the field of science education and the manner in which these can be made operational for the teacher in the classroom. This Manual is an attempt to assist those pre-service teacher educators or experienced teachers to offer professional help to trainees/teachers in the developing area of Scientific and Technological Literacy (STL) for All.

UNESCO-PROAP

The United Nations Educational, Scientific and Cultural Organization, Principal Regional Office for Asia and the Pacific (UNESCO-PROAP), in partnership with ICASE and SEAMED-RECSAM prepared this Training of Trainers Manual for Promoting Scientific and Technological Literacy For All. The development went through a long process, following the recommendations of the World Conference on Education for All (Jomtien 1990); the Project 2000+: Scientific and Technological Literacy for All (Paris 1992); and the World Conference on Science (Budapest, 1999). The Manual aims to provide a systematic training for teacher trainers and science teachers guiding others to help teachers to develop their own STL-oriented teaching-learning materials, to supplement existing textbooks and other learning resources. All relevant science educators are encouraged to translate, adapt, and utilize this in their teacher training programmes.

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