

Learning Physical Science in a Rural South African School: A Case Study of Student Perceptions of the Value of Computer-assisted Learning

M.S. HARTLEY (hartleys@cput.ac.za), Cape Peninsula University of Technology, South Africa and
D.F. TREAGUST (D.F.Treagust@curtin.edu.au), Curtin University of Technology, Australia

ABSTRACT *This paper investigates the introduction of computers in the physical science classroom of Grade 12 learners in a rural school in the Western Cape Province of South Africa and explores the perceptions held by these students given their limited exposure and experience of working with computers. The perceptions were collected by interviews conducted with both individual students and groups, and an instrument, called the Computer-Assisted Learning Environment Questionnaire (CALEQ), that was specifically developed for the school's context. The learners' responses indicated that they considered the inclusion of computers as improving their learning, whilst clearly articulating the importance of including the computers for teaching and learning from earlier grades. A need for more computers to create opportunities to work individually was also strongly indicated.*

KEY WORDS: *Computer-assisted learning, student perceptions, South Africa.*

Introduction

The need to transform the South African education system has been a subject of intense debate and discussion dating back many decades. The most striking feature of education in South Africa was the legacy of the previous government's policy of differential development of education based on racial groups. Many studies and policy documents argued that the past provision of science education was of poor quality and was wasteful, because the *black* African students, who were in the majority, were denied access to fully engage in the study of science (Department of Arts, Culture, Science and Technology (DACST), 1996; Department of Education, 2001; International Development Research Centre (IDRC), Mission Report, 1993; Mkhathshwa, 1999). The education policy of the apartheid government resulted in many schools designated for *black* students not having electricity, water, infra-structure, textbooks, and other teaching and learning resources, as well as having under-qualified teachers and teacher-student ratios sometimes exceeding 1:100 (teacher per students), especially in primary schools.

The demise of apartheid and the change to a democratic dispensation in South Africa in 1994 provided the new government with the much-needed opportunity to bring the education system in line with principles of democracy, equality, and justice. The new government was faced with the unequal distribution of its human resources especially in Science, Engineering and Technology (SET). SET has criti-

cal implications for human resource development, education, and training policy in general, and SET education in particular for South Africa (Lewin, 1995). This inequality in SET participation created new challenges with regard to SET interventions that would empower and enable marginalised communities to make informed decisions about their future. The new government recognised the importance and the role of SET education in developing the country's human resource capacity (Department of Arts, Culture, Science and Technology, 1996). It was generally agreed that if South Africa was going to reduce poverty and unemployment and all their negative side effects, it must become competitive in the global economy. The White Paper on Science and Technology (Department of Arts, Culture, Science and Technology, 1996) argued that government:

has a responsibility to promote science culture, science education and literacy amongst both children and adults, and influence the attainment of equity by providing incentives for disadvantaged groups to study mathematics and science and achieve computer literacy (p. 41).

Arnott, Kubeka, Rice and Hall (1997) compiled an extensive report for the Department of Education and Training and the Department of Arts, Culture, Science, and Technology about the status of mathematics and science teachers in South Africa. They looked at the qualifications and experience profiles of mathematics and physical science teachers in schools, their utilisation and the type of training they received in colleges of education. In addition, they compared the output of teachers from colleges of education, technikons (tertiary institutions that provided technical training), and universities in these subjects with the number of teachers needed in terms of projected student enrolment. This report provided a startling overview of the difficulty the Department of Education was facing in mathematics and physical science. The dismal performance of South African learners in the 1995 and 1999 TIMSS tests (Howie, 1997, 2001) intensified this difficulty. A decline in the number of those achieving matriculation exemption in the Senior Certificate Examination was a further concern. Independent confirmation of the serious shortcomings in science and mathematics education found in the Presidential Education Initiative Research Report (Department of Education, 1999) also prompted the President of South Africa to emphasise the urgent need for the improvement in school science and mathematics:

Special attention will need to be given to the compelling evidence that the country has a critical shortage of mathematics, science, and language teachers, and to the demands of the new information and communication technologies. (Excerpt from President Thabo Mbeki's parliamentary address in 1999, quoted in Department of Education, 2000).

In response to the above call, a number of interventions in mathematics, science, and technology were implemented. One of these interventions was the introduction of computers as tools in the teaching and learning of science and mathematics to assist final year secondary school learners with the external matriculation examination. This paper describes the introduction of computer-assisted learning in one rural school in the Western Cape Province of South Africa, which was part of a larger study (Hartley, 2002; Hartley & Treagust, 2003).

Objectives of the Study

The purpose of this case study was to describe the application of computers in the physical science classroom in a rural school environment in South Africa and

to examine the perceptions of Grade 12 students of computer-assisted learning, as a new innovation to their learning.

Data Collection Procedures

Classroom Observation

The computer-assisted lessons were observed through on-site visits during two cycles of two months. The first took place during April-May and the second during July-August of the same year. A total of two weeks was spent during each round with 12 lessons observed and recorded. All lessons observed took place inside the computer centre, which was used daily for physical science lessons. The medium of instruction in the classroom at this school was English even though the mother tongue of students was overwhelmingly Xhosa. A narrative report of on-site visits was used to describe the application and actual implementation of the computer centres in the daily lessons by teachers. The data collection involved observations of lessons, drawing up of field notes and videotaping the use of the computer centre in physical science lessons, and interviews. The lessons and interviews were recorded and coded for cross-reference purposes.

Student Perceptions

The perception of students of their CAL classes was established through interviews and the *Computer-Assisted Learning Environment Questionnaire (CALEQ)*. Responses provided in the questionnaire were used as a basis to guide the interviews. The development of the *CALEQ* was initiated by a search for an instrument that would adequately encompass those circumstances unique to disadvantaged schools in South Africa and focus on inviting learners' perceptions of their own learning in computer-assisted mathematics and science classes. Guidance in identifying scales (see Table 1) was obtained from existing validated and reliable classroom environment instruments (Fraser, McRobbie, & Fisher, 1996; Fraser, McRobbie, & Giddings, 1993; Fraser, 1990; Teh & Fraser, 1993; Maor & Fraser, 1993) that included both computer and non-computer settings. Two scales were developed by the researcher in order to address specific questions around students evaluating their own learning (learning assessment scale) and obtaining student perceptions of the inclusion of computers in their daily classroom activities (integration scale). The *CALEQ* was constructed in a way that would require a relatively short time to complete and hand score. The questionnaire included a small number of scales (6), each containing a relatively small number of items (8). The scale's means range from 1 to 5, with 1 for the most negative perception that represents almost never, 2 represents seldom, 3 represents sometimes, 4 represents often, and 5 for the most positive perception, which represents very often. Finally, in order to ensure that both teachers and students considered the *CALEQ*'s scales and items salient, selected teachers and learners from surrounding schools were asked to comment on the preliminary versions of the instrument for face validity, clarity of language, and suitability for issues such as culture. The Cronbach's alpha reliability test was used to determine the internal consistency of the *CALEQ*. The alpha reliability scores (see Table 2) for the scales were greater than the 0.5 threshold for small samples proposed by Nunnally (1978).

Table 1
Descriptive Information for the CALEQ Scales

Scale Name	Description	Sample item
Involvement	Extent to which students have attentive interest, participate in discussions, perform additional work, and experience the CAL classes	I am asked to explain how I solve problems (+)
Open-endedness	Extent to which an open-ended approach is adopted in the CAL classes	I must answer questions in a prescribed way (-)
Investigation	Extent to which students are encouraged to engage in the learning process	I find out answers to questions by doing investigations (+)
Material organization	Extent to which CAL classes are organized and computer hardware and software are adequate	The computer programs are hard to use (-)
Learning assessment	Extent to which the learner can assess his understanding of subject content	I have improved my ability to solve problems by using the computer (+)
Integration	Extent to which the computer is included as a tool in daily teaching of mathematics and physical science	The computer work is integrated with the regular science and mathematics class work. (+)

Note: Items designated (+) are scored 1, 2, 3, 4 and 5, respectively, for the responses Almost Never, Seldom, Sometimes, Often, Very Often. Items designated (-) are scored in the reverse manner. Omitted or invalid responses are scored 3.

Student interviews were held during the second round of on-site visits. Students' responses to the CALEQ items were used as a starting point to gather their perceptions of the inclusion of computers in their physical science classrooms. Interviews were conducted with individual students, as well as with groups of two to five students. A semi-structured interview approach was used with questions structured around a number of areas, namely, some background of the student, students' experiences about the inclusion of the computers as part of their classes, how they perceived their learning taking place, whether working on the computers improved their understandings, and how the inclusion of computers influenced their interaction with their classmates. Students also were probed for any improvements or changes to their computer-assisted classes that they would prefer. This interview framework was flexible, enabling students to discuss different issues related to their experiences.

Seven individual interviews and five group interviews were conducted. The groups ranged between two and four students and students were allowed to form their own groups, because it appeared from preliminary discussions that students who were not first language English speakers responded better in groups. The five groups consisted of one group of two students, one group of three students, and three groups of four students. A number of students were quite conversant in English, and therefore interviews with some of these students were held individually.

Details of Investigation

Context

The school is situated in one of the rural towns of the Western Cape Province of South Africa. In order to reach the school, one had to drive through the town, through an industrial area and then through a stretch of open field that looked like a no-man's land border area. The school was situated at the back of the township and was reached by driving through an informal settlement area. The school was surrounded by a high fence with an electronically operated gate guarding the entrance. The computer centre was located in a large classroom, which could be extended so that additional computers would become available. Twelve computer terminals available to students were supported by a server from which physical science software (developed by the University of the Western Cape) operated. The classroom was a prefabricated building (demountable) that had bars on the windows and a security gate in front.

Students mostly came from the informal settlement area surrounding the school; many students did not have access to electricity at their homes. There was also, in many instances, no direct water supply to homes, and they would share access to a tap with a number of households. When parents were working, very little supervision of students took place as parents would leave for work early in the morning and arrive at home late. In some cases, students needed to take care of the home and also look after their younger siblings. The ages of students in the Grade 12 class ranged from 18 to 23 years - this was not an unusual phenomenon for *black* students in South Africa. Four students indicated that they had worked as labourers before deciding to come back to school to complete the matriculation examination. Eight students had failed previous grades, three of them more than once. All the students interviewed indicated that working on the computers at the school was their first encounter in their lives with computers.

Mr. R (as we will refer to him) was responsible for the teaching of physical science to Grade 12 learners. He held a BSc degree and a teacher's diploma (HDE), and had 10 years experience in teaching physical science. There were three classes in Grade 12 with 40 physical science students. In the first two weeks of observation, Mr. R made use of the computer centre only.

Description of Lesson Implementation

The following is a description of observations of a lesson by Mr. R in teaching the principle of conservation of momentum in the physical science syllabus. The lesson description will follow the representations developed by Mills and Treagust (2002) and Hartley and Treagust (2003), namely, intended, implemented, perceived, and achieved.

[In the lessons described below, schoolwork that the teacher wrote on the black board is presented in italics.]

Intended lesson: Mr. R introduced the conservation of momentum by writing on the blackboard:

The Principle of Conservation of Linear Momentum.

Special objectives that students needed to take cognisance of were highlighted,

such as the definition of the Principle of Conservation of Momentum, calculations involving this principle, types of collision, and kinetic energy involved in collisions. The teacher pointed out that this was a double period (120 minutes), and students were expected to make use of the problems dealing with this topic on the physical science component on the computers.

Implemented lesson: Learners were reminded of previous lessons during which the concept of momentum was introduced. Exercises that were given as homework were marked during the first few minutes of the lesson. The teacher explained that momentum, like energy, remained conserved and that conservation occurs under certain conditions. He wrote the following definition on the blackboard:

The total linear momentum of an isolated system remains constant in both magnitude and direction. Alternatively, in an isolated system the total momentum before a collision equals the total momentum after the collision.

The teacher explained that two types of collision were identified as elastic and inelastic, and that momentum is conserved in any collision, but kinetic energy is conserved only in elastic collisions. He used the example of a collision of cars and used a pendulum with iron balls on his table to explain the two types of collision. He then wrote on the board:

Therefore, to determine the type of collision, the kinetic energy before and after collisions must be determined.

After this explanation, the teacher wrote the following on the board:

Momentum before collision equals momentum after collision.

$$mu_A + mu_B = mv_A + mv_B$$

Mr. R explained the conservation principle again and worked out two examples on the board, and explained the formula ($mu_A + mu_B = mv_A + mv_B$) by referring to the examples. The point of calculating total collision of all participating objects before and after collision was separately emphasised. The teacher also stressed that the students must make a note in their books that if momentum before and after is equal, then subtracting one from the other gives an answer that must equal zero. After a short explanation, students were referred to the physical science component on the computer. On the first screen, students were provided with 14 categories of which they chose "bodies in motion," which had a further eight subcategories. They were required to go to the "Conservation of Momentum" subcategory. Figure 1 is a representation of the first part of the computer lesson and one of the examples students had to work through.

A second part of the computer lesson that students worked on dealt with elastic and inelastic collisions. Figure 2 represents part of the computer lesson on this topic.

In the last part of the computer lesson, students were given a test (see Figure 3) which they worked out individually, but submitted an answer as a group after discussing the proposed answer.

Conservation of momentum:

It follows from Newton's Second and Third Laws that if no external forces act on a system of colliding bodies, then the total momentum of the bodies has the same magnitude and direction before and after the collisions.

This is called the principle of CONSERVATION OF MOMENTUM, and is useful in solving problems in dynamics.

Press F8 for more information; Press ENTER to go on, or F6 to review

~~~~~[represents next screen]~~~~~

For example, if two bodies of masses  $m_1$  and  $m_2$  having initial velocities  $u_1$  and  $u_2$  collide and then separate with velocities  $v_1$  and  $v_2$ , the equation for conservation of momentum is

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

*Animation of two balls colliding appears on the screen.*

*Press F8 to repeat the animation; Press ENTER to go on, or F6 to review*

~~~~~

Example 1. (Simple collisions):

A steel ball of mass 1kg travelling along a track at $4m.s^{-1}$ collides with another stationary steel ball of mass 2kg and then rebounds in the opposite direction with a speed of $1,33m.s^{-1}$. What is the velocity of the 2kg ball after the collision ($m.s^{-1}$)?→

Let the initial direction of travel of the 1kg ball represent positive velocity. Then we have

$$\begin{array}{ll} u_1 = 4m.s^{-1} & v_1 = -1,33m.s^{-1} \\ u_2 = 0m.s^{-1} & v_2 = ? \end{array}$$

Since momentum is conserved

$$\begin{aligned} m_1u_1 + m_2u_2 &= m_1v_1 + m_2v_2 \\ 1kg \times 4m.s^{-1} + 0 &= 1kg \times (-1,33m.s^{-1}) + 2 \text{ kg} \times v_2 \\ v_2 &= 5,33 \text{ kgm.s}^{-1} / 2kg \\ &= 2,67m.s^{-1} \end{aligned}$$

Press ENTER to go on, or F6 to review

Figure 1. Computer Lesson on Conservation of Momentum

Mr. R continued to interact with students, encouraging them to explain to each other what they were doing when they were working out problems in groups. Mr. R made a point of telling students that it was important that they learned from one another, and that this kind of interaction was beneficial to both the students who were explaining as well as to those students who were listening. Where there were disputes about a step that needed clarification, he intervened and assisted. More time was spent with some of the lower achieving students in the class who needed additional explanations. Towards the end of the second period, a worksheet with a number of exercises was handed out as part of homework for the next day.

Perceived Lesson: When the students were asked about the role that computers played in their lesson as they tried to resolve problems, the following are some answers that were provided:

I guess computers have a place, but still the teacher is more needed.

I ask my teacher, I can't ask the computer to help.

The computer is useful and my friends help because we talk about where we don't know

Elastic and inelastic collisions:

A body of mass m travelling with a velocity v has kinetic energy given by $\frac{1}{2}mv^2$. The total kinetic energy of a system of bodies involved in a collision may be calculated by adding terms of the form $\frac{1}{2}mv_i^2$. If the total kinetic energy is the same before and after the collision, then the kinetic energy is said to be conserved.

Momentum is conserved in all collisions provided no external forces act on the system. However, the total kinetic energy of the system of colliding bodies is not always conserved.

Those collisions in which kinetic energy is conserved are called ELASTIC COLLISIONS. In many collisions kinetic energy is converted to heat or is used to deform the colliding objects. These are called INELASTIC COLLISIONS.

Press ENTER to go on, or F6 to review

Example 1. (Elastic collision):

A steel ball of mass 1kg travelling along a track at $4\text{m}\cdot\text{s}^{-1}$ collides elastically with another stationary steel ball of mass 2kg.

What is the kinetic energy of the system before collision?

Kinetic energy (J) \rightarrow

$$\begin{aligned} E_k &= \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 \\ &= \frac{1}{2} \times 1 \times (4\text{m}\cdot\text{s}^{-1})^2 + 0 \\ &= 8\text{ J} \end{aligned}$$

Press ENTER to go on, or F6 to review

Figure 2. Computer Lesson on Elastic and Inelastic Collisions

answers. It must be part of our lesson because we learn more and better.

Yes, it is good to have computers as part of the lesson, our teachers become boring.

The involvement of computers is good, especially for mathematics and physics, because... it helps me go through the work and understand it. If I don't understand, I can ask my friend ...or my teacher. We must get programmes for accounting and English also.

Yes, computers used in the class are good. We, in our group, each get a turn to answer, ...and the others will help if you get stuck. Yes...we also work out on our own and compare to each other. Then we punch the answer in the computer. If we get it wrong, we are all wrong. If we get it right, we are all right. We are not scared to answer questions.

Many students expressed the central role that the teacher played in the use of the computer centre, even though one student preferred the computer sometimes in place of the teacher. The students claimed that their interaction with one another was important, and, when prompted, they accepted that they actually learned from each other during these interactions

Achieved Lesson: Students listened attentively to Mr. R and took down the notes on the Principle of Conservation of Linear Momentum, elastic and inelastic collisions, and kinetic energy, as the teacher explained. When they were allowed to go to the computers, they formed groups and followed the introductory lessons on momentum and the Principle of Conservation of Linear Momentum, provided by the physical science programme on the computers. Students used the computer to work out problems based on momentum and the related topics, as required by the

TESTING TIME!

Let's now have a short test to see if you have mastered the facts and concepts which are covered by this section.

There are 5 questions in this test
 The testing mode can be SEQUENCE/RECYCLE/DRILL

Press ENTER for the test, or F6 to change the testing mode

Two trolleys approach each other at the same speed along a track. After collision, they remain in contact at rest. Which one of the following statements is FALSE?

1. The total momentum of the trolleys remains constant
2. The total kinetic energy of the trolleys remains constant
3. Both the kinetic energy and the momentum remain constant
4. (None of the above)

Queue: □□□□□ Correct Test mode: SEQUENCE

Momentum is conserved in any collision. It is only in elastic collisions that kinetic energy is conserved as well.

Press a key 1 - 4 to alter your choice, or F9 for judging. Press ENTER to go on

Judge the sentence below according to the criteria given in the table.

"When a cannon is fired, the cannon ball leaves the barrels and the cannon recoils BECAUSE the hot gases resulting from the explosion press against the back of the barrel.

CHOICE	STATEMENT	REASON	ARGUMENT
a.	TRUE	TRUE	VALID
b.	TRUE	TRUE	INVALID
c.	TRUE	FALSE	—
d.	FALSE	TRUE	—
e.	FALSE	FALSE	—

My choice is →

Queue: □□□□□ Correct Test mode: SEQUENCE

Momentum is conserved, which means that $0 = mv$ for gases + mv for ball + mv for cannon, so v for the cannon is negative, i.e., the cannon must move backwards.

Type a letter a - e and then press ENTER (F8 for help). Press ENTER to go on

Figure 3. Computer Test on Conservation of Momentum

physical science syllabus. Each student had a pen and a notepad upon which he or she worked out answers with the aid of calculators. Because the questions required more thought than those during the first lesson, animated discussions took place amongst the students. As the problems were worked through, these were followed by additional exercises with a higher degree of difficulty. This procedure allowed only for more discussion and arguments amongst students as they thought the problems through. Students from one group were called to assist students from another group. Mr. R moved between the different groups and answered questions on how to resolve problems, and kept referring students to his own notes and encouraged them to think in terms of the principle he explained on the board.

An additional outcome of this lesson was that many students expressed the view

that computers were important and an integral part of their learning. This process kept students involved as they discussed the learning material. This situation was deemed as very favourable by teachers and the principal, considering the many distractions that students at this school faced around and outside the school.

General Observations

Teacher R taught both mathematics and physical science, and could therefore use the centre on a daily basis. The teacher used the physical science programmes as part of his teaching, and would teach a particular topic including the introductory lessons on the programmes as part of his lesson, after which students would work out problems on the computer. The teacher would also draw up his own worksheet of problems that students had to do as part of homework assignments. The programmes also provided the teacher to track the progress of students for each topic. This tracking allowed teachers to select their revision programmes in order to address problem areas. Students would come during intervals, when they had a free opportunity, and after school, to work on the computers. Additional classes were held during the vacation period; students attended these classes under the supervision of Mr. R. Students in groups were encouraged to interact with one another and that they should show one another how they went about solving problems related to the syllabus. The teacher intervened in groups, when there was no consensus about the approach to a problem or when students were not clear about how to proceed between different steps when answering a problem. The teacher also used his time to assist the lower achieving students.

Findings

In total, 40 students completed the CALEQ. A summary of the mean scores and standard deviation of each scale of the CALEQ is presented in Table 2. The mean scores of all the scales were above 3 [between sometimes (3) and often (4)] that indicated a positive perception of the computer-assisted learning environment by the students. This result supported the findings of other researchers over a number of decades (Bear, 1984; Cavin & Lagowski, 1978; Geban, Ö., Askar, P., & Özkan, I., 1992; Tao, P-K., 2004).

Table 2
Descriptive Statistics for the CALEQ (n = 40)

Scale	No. of items	Alpha Reliability	Average Item Mean	Scale Mean	Scale Std. Dev.
Involvement (IVO)	8	0.64	3.41	27.28	4.42
Open-Endedness (OE)	8	0.51	3.32	26.58	4.26
Investigation (IVE)	8	0.61	3.40	27.23	4.13
Material Organisation (MO)	8	0.64	3.49	27.90	5.19
Learning Assessment (LA)	8	0.54	3.46	27.65	5.02
Integration (ITG)	8	0.65	3.71	29.70	5.32

When comparing the mean scores of the six scales of the instrument, as indicated by Figure 1, the Integration scale had the highest item mean, which pointed to a positive integration of computer lessons within the daily teaching and learning

activities of teachers and students. This was followed by the Learning Assessment scale, which was indicative of a positive perception by students that they were able to monitor their learning through the use of the computer. The Material Organisation scale followed closely indicating a positive perception of the organisation maintained by the teacher in the computer supported classes and the adequacy of the computer programmes that were in use. The positive perception of the Involvement scale represented the extent to which students participated in the computer-assisted classes. The Investigation scale reflected a positive perception by students of the degree to which they were encouraged to engage in the learning process. The Open-Endedness scale had the lowest item mean score but which still pointed to a positive perception on the side of the students. This would be representative of the degree to which students perceived the teacher adopting an open-ended approach in the computer-assisted classes. The standard deviation scores for the six scales ranged from 4.59 to 5.83. In addition, large standard deviations scores for the Material Organisation scale in particular, and the Integration scale indicated that these two scales had a larger variation of responses compared with the other four scales.

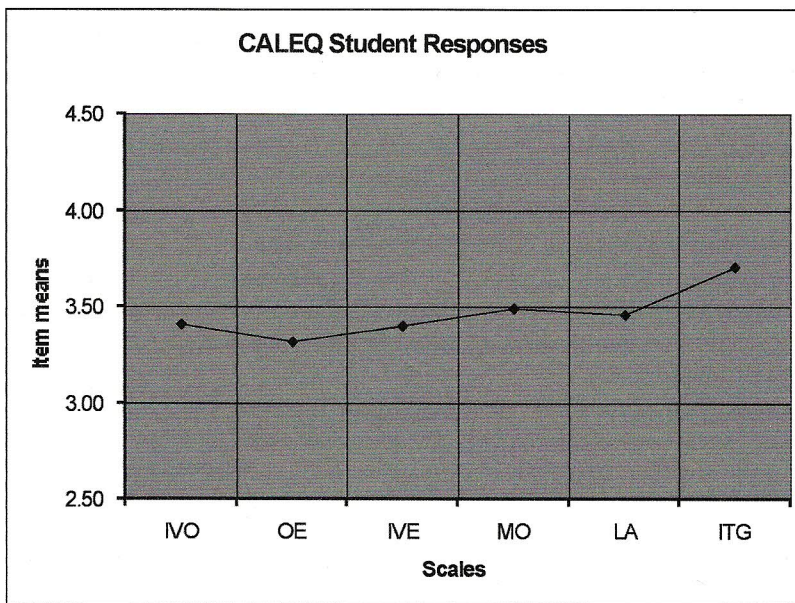


Figure 4. Graph of Student Perceptions Obtained from CALEQ ($n = 40$)

The positive feeling towards the introduction of computers in their physical science classroom represented in Figure 4 was further confirmed by the interviews conducted afterward. The majority of students (87.5 percent) indicated that they were extremely excited about the prospect of using computers for the first time, when they started at the beginning of the year. Students had participated in the initiation ceremony during the previous year when the sponsors, teachers, parents, community members, and outreach programme managers officially opened the

computer centre at the school. As one student put it:

We were excited, because we were going to be the first ones to try out computers in our area. ... everyone keeps saying computers are the future and we must learn how to use them.

Students indicated that the idea of the inclusion of computers held great promise and that they were encouraged by the principal and Mr. R to make use of the resource, which was made available exclusively for the use of Grade 12 mathematics and physical science students. Students also pointed out that they expected their achievement in physical science to increase, as typified by the following statement by one of the students:

I think by using computers that I will get very good marks in maths and physics. ... My mother said that I should try my best... and that here I had a chance to study for a good job

It appeared that students were under the impression that with the aid of computers their achievements would undergo a marked improvement, which would put them in a better position for further studies or for better employment opportunities. Further encouragement came from the parents of students, because they emphasised that the goal of the inclusion of computers was to improve the student learning in physical science and to prepare students for the future. The overall initial impressions of the interviewed students toward their computer-assisted classes could therefore be described as positive and encouraging.

The large proportion (75 %) of the students interviewed expressed the view that they were satisfied with the manner in which the computers was included as part of their daily classes in physical science (also reflected by the higher CALEQ item mean score for the integration scale) and that Mr. R's organisation of the classes contributed in general to their satisfaction. They considered their classes as consisting of two parts, a formal section and a non-formal section. The formal section was when Mr. R taught by standing in front of the blackboard, teaching and writing notes on the board. The informal section of the class was when the computers were introduced.

It's like having two classes in one. Mr. R is a good teacher and he would continue with normal classes, and sometimes we don't use the computers and he would only teach...in other classes Mr. R uses only the computers, then also he would combine both in one, especially during double periods.

The majority of students (75%) also expressed the view that they were happy with the way they were being involved in the computer-assisted classes, and that they participated readily in discussions with both the teacher and their fellow students. These students indicated that they did not feel insecure in using the computer, because of the user-friendly nature of the programmes and the fact that Mr. R was always available to assist, as supported by the following statement:

We do not have any problems with working the computer...it is fairly simple, even though it needed us getting used to at the beginning on how to punch in a square or a square root. Mr. R showed us all how to do this...everyone got a chance to do this, even after school sometimes.

In terms of open-endedness, a large number of the interviewed students indicated that they thought Mr. R allowed them sufficient freedom to explore the sections that each of them had difficulty with during other sessions, for example, when the computer room was unoccupied or after school hours. These students

were in agreement that it would be unfair to let students go to different sections in the normal classroom situation as Mr. R needed to teach and explain the sections of the work in that time, and that they also needed to complete the syllabus in these classes. The computer-assisted classes were therefore not needed to be open-ended all the time, which is reflected in the lower CALEQ item mean score on the open-endedness scale.

Students also agreed that Mr. R encouraged them continually to work out problems on their own and that they also were encouraged to assist one another where such assistance was required. According to the students, Mr. R often referred them back to the introductory lessons on the computer and also to his notes that were given to them as part of the formal teaching sections. Students, however, expressed a strong need for additional computers, so that they could work on their own.

There are not enough computers...I can do so much better, if I can have one for my own. ...but we are doing our best with what we have for now.....Mr. R knows how to use them [computers]... So, we all get some chance.

A number of students (40 %) also indicated that they appreciated the use of the computers, but that they were not sure whether the computers were helping them to do better. Students pointed out that even though they sometimes felt that the computers helped, the outcomes in the final matriculation examination was what counted and that they were more concerned with that.

Computers must help us to pass, so we can go to university or technikon. Some of us also want to work and earn a good salary. I failed the last exam and therefore I work hard on the computer.

One of the groups, consisting of three students, did not agree that using computers in the classroom assisted their learning of physical science. They viewed computers as a complete waste of time and they suggested that Mr. R should teach physical science and mathematics like they were taught in the other subjects. These three students were adamant that nothing constructive happened in their classes, when students interacted with computers and suggested that this time could be better spent by having the teacher teaching, so that they could finish the syllabus more quickly. In conversation with one student in this group during the interview, the student made the following points:

[S = Student; I = Interviewer]

S: Computers. They don't help me learning. I can work and get money without computers.

I: Why do you say that?

S: Well, we are here to get matric and computers don't get you matric.

I: And what kind of work do you have in mind?

S: I can work at the taxi rank. I work there and get money.

I: Okay, why do you need matric then?

S: I just need the paper to show I have been here (school). I did not waste my time.

The other two students agreed with the above sentiments, and it was evident that they had discussed their opinion before being interviewed. When the opinion of the particular students was discussed with the teacher afterward, he pointed out that one of the students actually worked at the taxi rank, and that his attendance at school was not consistent. The same student could be found early in the morning before school at the taxi rank as well as in the evenings. The other two students, who were related to each other, joined the school late in the year and were strug-

gling to learn all the work they had to catch up on. The two students came from a school in another region, and Mr. R suspected that they had not attended school regularly, hence their insistence for the traditional teaching method.

All seven individual students interviewed and the majority of students in the groups agreed that they perceived their learning in physical science to have improved, because they managed to answer the questions on the computers after the lessons. Students suggested they would be able to fare better in the examinations, because they understood the work much better. They considered that learning with computers was much better than their experiences in the previous year (Grade 11). Students also expressed satisfaction with the integration of the work they get in physical science lessons and the contents of the programmes on the computers. One of the students did raise an important concern that although they learned better with computers, she still felt that "answering on computer and answering in the exam, these things are different." This student did not want to expand upon the point when probed as to why she made this statement. Three students in one group indicated that they believed no learning took place by sitting in front of a computer. The premise of their argument was that they wanted to be taught by Mr. R in the traditional sense of talk-and-chalk. When probed they stated that they believed that "computers should not replace humans", as their reason for their negativity to CAL.

Students indicated that Mr. R encouraged them to form their own groups, so that they could therefore better relate to students within their group. Interactions took place between students and the computer, students and students, as well as between students and the teacher. Students also pointed out that when working on a problem, Mr. R wanted each one to try it on his/her own, and then compare answers and calculations with one another. Students could then discuss how they proceeded to get to the answers with those who are struggling. In this way, students learned from one another. Where students still had problems, Mr. R was called to clarify problem areas. Students pointed out that in many instances, students would get one person to work out the problem, and then punch the answer in to the computer. If the answer was correct, everyone would write down the entire sum. They also pointed out that there was often not enough time for Mr. R's expected procedure, so students used their own means of getting answers to problems by, for instance, making sure that a group contains someone whom they thought would be able to assist in getting the right answers.

Many students (60%) agreed that through discussion with one another, they gained a better understanding of how to tackle problems in physical science. The students agreed that they could possibly learn from one another, but they would want the teacher to play the central role in their final year of secondary schooling.

When asked about suggested changes to their CAL classes, almost all of the interviewed students were in agreement that they needed additional computers. They suggested that for greater individual involvement, it was important that students were provided with the opportunity to work on the computers on their own. Students pointed out that even though the interactions with fellow students supported their own learning, they also needed an opportunity to investigate their own abilities to complete tasks separately from other students. They also linked their improvement in learning with the availability of additional computers, sug-

gesting that they could better follow whether they understood a problem by working on it on their own (reflected by the learning assessment scale). The teacher could therefore respond to an individual need instead of a group need, as suggested by one student:

If I had a computer for myself, I would work out problems myself in the class. Mr. R can help me with what I don't know. Now he has to listen to everyone talking.

A second recommendation was that the programmes that they were using needed to be upgraded or added to. Students suggested that programmes testing more than just mathematics and physical science content should be included, and also programmes that would add to their computer literacy, as indicated by the following comment:

...Can't we get programmes that help us know how to use the computer? We want to type our tasks on the computer... We also want to use computers for internet.....

Students also suggested that programmes for other subjects, which they had difficulty with, like accounting and English, should be included on the computer. A large number (87.5 %) of students recommended that the incorporation of the computers into the classroom take place during earlier grades, so that students are exposed to this method of teaching before reaching Grade 12. One group suggested that:

These computers should have been started with Grade 10 or 8 then we would know what to do. Starting in Grade 12 with computers is difficult. We are writing final exams so we need our teacher more now

Conclusion

This study is a response to President Mbeki's plea (Department of Education, 2000) to meet the challenges and demands of the new information and communication technologies, and to provide support to learners and teachers in mathematics, science and languages. This paper presented one case study of a rural school which formed part of a wider study into computer-assisted learning at schools in the Western Cape Province of South Africa.

Students, in general, exhibited a positive attitude toward the inclusion of computers in their classroom, but some of the responses would suggest that during their final year at secondary school, a balance needs to be struck between the usefulness of computers as teaching and learning tools, and the perceived needs of learners to work directly with their teacher be prepared for matriculation examinations. As suggested by a relatively large number of students (87.5 %) during their interviews, computers should be included during earlier grades and that more computer terminals are made available to serve their individual needs, as opposed to group activities in front of one terminal. It would be important in the future to determine what effect the inclusion of computer-assisted classes in the lower grades would have on student perceptions, when they reach the upper grades.

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