HAR07639

Examining learner perceptions of the introduction of computer-assisted learning in mathematics at a peri-urban school in South Africa

M.S. Hartley[1] and D.F. Treagust[2]

[1]Contract Research Department, Cape Peninsula University of Technology, South Africa

[2]Science and Mathematics Education Centre, Curtin University of Technology, Australia

M.S. Hartley
Cape Peninsula University of Technology, South Africa
Contract Research Department
PO Box 1906, Bellville, 7535, South Africa
Telephone +27 21 959 6431
Fax +27 21 959 6896
hartleys@cput.ac.za

D.F. Treagust
Science and Mathematics Education Centre
Curtin University of Technology, Australia
GPO Box U1987, Perth, Western Australia, 6845
Telephone +61 8 9266 7924
Fax +61 8 9266 2503
D.F.Treagust@curtin.edu.au

Examining learner perceptions of the introduction of computer-assisted learning in mathematics at a peri-urban school in South Africa

Abstract

This study responds to a national call to improve the outcomes in mathematics in the Grade 12 matriculation examination by reporting on the perceptions of learners on the introduction of computer-assisted learning in their mathematics classroom. Three Grade 12 mathematics classes in a peri-urban school in South Africa were visited over a period of four months to observe the inclusion of a computer centre as part of the teaching of mathematics. Learner perceptions were obtained from (1) individual and group interviews and (2) an actual and preferred version of a learning environment instrument called the *Computer-Assisted Learning Environment Questionnaire (CALEQ)*, which was developed for the South African context. The learners' indicated that they considered application of computers as a positive step as it (1) increased their involvement in the mathematics classroom, (2) gave them more exercise in problem solving in mathematics, and (3) provided them the opportunity to assess their own learning. However, a strong recommendation from this response is for more computers to be made available that would allow students to work individually thereby being able to spend more time on the computer.

Key words: Computer, Constructivist, Secondary, Case Study, IT-use, Learner Perceptions

Examining learner perceptions of the introduction of computer-assisted learning in mathematics at a peri-urban school in South Africa

Introduction

The change to a democratic dispensation in South Africa in 1994 brought to the fore the stark reality of the former policies of exclusion along racial lines. The new national education authority was faced with the challenge of bringing the education system in line with principles of democracy, equality and justice. The new government recognised the importance and the critical role of education in developing the country's human resource capacity in science, engineering and technology (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. To this end the White Paper on Science and Technology (Department of Arts, Culture, Science and Technology, 1996) stated that the 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)

The Department of Education and the Department of Arts, Culture, Science and Technology commissioned a report about the status of mathematics and science teachers in South Africa (Arnott, Kubeka, Rice and Hall, 1997). The report examined 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. This report provided a startling overview of the difficulty the Department of Education was facing in mathematics and physical science being able to provide adequate numbers of teachers. Added to this difficulty was the dismal performance of South African learners in the 1995 and 1999 TIMMS tests (Howie, 1997, 2001). Furthermore, a decline in the number of those achieving matriculation exemption in the Senior Certificate Examination was of concern. Independent confirmation of the serious shortcomings in science and mathematics education presented in the Presidential Education Initiative Research Report (Department of Education, 1999) 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.

Objectives of the study

This paper describes the introduction of computer-assisted learning in one peri-urban school (on the outskirts of the city) in the Western Cape Province of South Africa and forms a subset of a larger study (Hartley, 2002; Hartley & Treagust, 2006). Of specific interest was the application of computers in the mathematics classroom and the perceptions of Grade 12 students of computer-assisted learning as a new addition to their learning.

Data collection procedures

Classroom observations

The computer-assisted lessons taught by two teachers were observed through on-site visits during two cycles of two months; the first cycle took place during April-May and the second cycle during July-August of the same year. A total of two weeks was spent during each cycle with 12 lessons observed and recorded, six for each Grade 12 mathematics teacher. The lessons took place both in the normal classroom and in the computer centre depending on the availability of the centre. 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 mathematics 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, firstly, adequately encompass those circumstances unique to disadvantaged schools in South Africa and, secondly, 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 and Fisher, 1996, Fraser, McRobbie and Giddings, 1993, Fraser, 1990, Teh & Fraser, 1993, Maor & Fraser, 1993) which included both computer and non-computer settings.

Two additional scales were developed by the researchers given the context of the school. The instrument was constructed in a way that would require a relatively short time to complete and hand score, by including a small number of scales (6), each containing a relatively small number of items (8). Each scale's mean ranged 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. Two versions of the CALEQ were developed, namely the actual and preferred formats. The actual format referred to how students actually perceived their CAL classes whilst the preferred referred to how students would want (preferred) these classes to be. The Cronbach alpha reliability values used to determine the internal consistency of the CALEQ (see Table 2) for each scale were greater than the 0.5 threshold for small samples proposed by Nunnally (1978) and therefore the instrument was considered acceptable for research purposes.

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 student is 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. The same scoring procedures apply to both actual and preferred formats of the CALEQ.

Learner interviews were held during the second round of on-site visits. Learners' responses on the CALEQ were used as a starting point to gather their perceptions of the inclusion of computers as part of their mathematics lessons. 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 understanding of the work, and how the inclusion of computers influenced interactions with their classmates. Students also were probed about any preferred improvements or changes to their computer-assisted classes. This interview framework was flexible, enabling students to discuss different issues related to their experiences. Nine individual interviews and five group interviews were conducted with between two and five students. Students were allowed to form their own groups because it appeared from preliminary discussions that students who were not proficient English speakers responded better in groups.

The five groups consisted of one group of two students, three groups of four students, and one group of five students.

Details of the investigation

Context

The school was situated in a peri-urban area on the outskirts of Cape Town that was developed by the apartheid government for people of African (*black*) origin. Very few resources (in terms of libraries, sport, entertainment) and infra-structure (electricity, water, roads) were available to students in this area because the area consists mainly of informal housing - a so-called squatter area. The school stood out amongst its surroundings as it had the structure of a modern school. Bus and taxis from the surrounding informal settlement areas transported a large number of the students to and from this school.

On the way to the school, one drove through a number of informal settlements in between which the school was located. The school was surrounded by a high fence with an electronically operated gate guarding the entrance. The entire school was an enclosed structure with all classrooms opening toward the inside of the school and was under one roof. A courtyard (also under the roof) was situated in the middle of the school with the computer centre next to it. This courtyard appeared like a market during lunch-breaks as members of the community sold their food and beverages here. The computer centre, located in a large room almost like a hall, contained 15 computer terminals spaced along three walls available for students which were supported by a server from which the Computer Aided Mathematics Instruction (CAMI) programme operated. There was more than enough space in this centre to add an additional 30 computer terminals. The school had 1329 students with 37 teachers. There were three classes in Grade 12 and all three classes had learners that followed mathematics. In total there were 80 mathematics learners. Two teachers were responsible for the teaching of mathematics at Grade 12 level. The one mathematics teacher (Mr. U), who was the head of the mathematics and physical science department, held a BSc degree and a teacher’s diploma (HDE). The other mathematics teacher held a BA degree and a diploma for Adult Basic Education and Training (ABET). Both teachers had between 10 and 15 years experience in teaching.

A large number of students came from different areas outside the immediate informal settlement and were transported by taxis to the school. The ages of the students interviewed ranged from 18 to 22 years. Nine of the students interviewed failed at least once in a previous grade and three students came back to school after working. The informal settlements where students lived had no access to electricity or direct supply of water and unemployment levels were high. Many students indicated that they were not living with their parents, but with one of their family members. In many instances parents were living in another province or in rural areas and sent their children to learn in the city resulting in the expansion of peri-urban informal settlements. All the students interviewed, except for one, indicated that working on the computers at the school was their first encounter with computers in their lives. The one student indicated that he had played games on a computer of a friend whom he had visited in the city.

Findings of one early lesson

Description of lesson

The following is a description of observation of a lesson that Mr. U used to prepare students for the mathematics examination. The lesson description follows the representations developed by Mills and Treagust (2003) and Hartley and Treagust (2006), namely, intended, implemented, perceived and achieved lesson.

Mr. U's lessons took place in the computer centre. He was in the centre before the class started so that he could prime the computer terminals — the server needed to be switched on — followed by the individual terminals. Mr. U described this process as time-consuming because there was little time available between lessons because the computer centre was shared between the mathematics and physical science teachers. Only ten of the 15 terminals could be used for mathematics as the centre only had one licence for the CAMI programme. Each licence allowed a maximum of ten computers to be linked to the server.

<u>Intended lesson</u>

Mr. U had a double period session with one of his Grade 12 mathematics classes. He indicated that they used the computer centre to test learners about work completed in the normal classroom. He could only manage to use the centre once or twice a week for each of his classes as allowed on his time-table. This particular session started out with simple factorisation leading to the use of the quadratic formula. The mark that students obtained counted towards their year mark. Mr. U was able to monitor each student's progress on the CAMI programme as each student logged in under his or her own name. The computer flashed after a few minutes if students took too long to answer a particular item (question). Each student was given a maximum of five items to complete.

<u>Implemented lesson</u>

As students came into the centre, they were allowed to sit at the entrance. Mr. U reminded the students of the process that they normally followed. The first ten students were then each seated at a terminal and were told to log in. They were directed to the relevant section and were told to start. Appendix 1 is a representation of the computer lesson on factorisation and shows examples that learners had to work through. Each student carried with them a pen and paper and started by reading the problem on the computer and answering the items, for example one item under the factorisation test (at the first difficulty level) required students to factorise the following quadratic equation: $x^2 + 5x + 6 = 0$. The computer provided two sets of brackets and students had to complete the contents, in this items the correct solution was $(x + 6)(x – 1)$. Students were then required to give the values for x, which for this item were $x = -6$ or $x = 1$. In the next item, the difficulty level was increased with, for example, the addition of a coefficient to the first term of the equation. The students were allowed a certain amount of time at a terminal to complete an item before the computer flashed they were told to continue to the next item. When students completed answering an item, they automatically moved on to the next one. Students who completed their five items were replaced by the students waiting who were frantically going through their notes.

When the test session ended, students were allowed to work on the computers in groups and discussion ensued on the sections dealing with factorisation and using formulae and the missed chances for successful solutions. The group sessions had a number of learners around each of the 10 available computers. They were directed to the computer to start answering the section on factorisation followed by exponential and quadratic equations. Both teachers encouraged students in groups to interact with one another and that they should show one another how they went about solving problems related to the syllabus. Teachers 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. Teachers also used their time to assist the academically weaker students.

Perceived lesson

Students indicated that they enjoyed the sessions when they got to use the computers to see if they understood what was taught in class. The following were some feedback obtained from students who were interviewed after the lesson:

> Using the computer is important to test how quickly you can answer. It is almost like an examination when you are under pressure. *Student 1*
>
> The testing with computer is not so nice. [But] I like using the computer to work on my own and at my own time. *Student 2*
>
> I cannot think so fast, especially when Mr. U is looking over my shoulder. *Student 3*
>
> I have no problem with using the computer, even in a test. We will have to learn to use the computer anyway, so now is a good time. *Student 4*
>
> The computer is just used to test if we know our work. Mr. U explains the work well, and we can always ask him. He is always in the computer centre during intervals. *Student 5*
>
> Testing with the computer helps us know where we don't understand. For if I struggle, I will try and try until I get it right. Then I know it and can answer it again. This is how computer is a help. *Student 6*

On the whole, students expressed their satisfaction with using the computer. They saw the computer as integral to their learning as pointed out by students 4 and 6 above. Some students considered the pressure that they are put under as good (Student 1) because this represented the pressure that they would experience under examination conditions; other students saw the combined pressure of working on the computer and the teacher monitoring their progress as limiting or inhibiting (Student 3). The role that teachers played still remained central to the classroom environment as expressed by Student 5, who regarded the teacher as the interactive resource that could be approached should they require additional assistance. Student 2 expressed the view that working on the computer individually still suited some students.

Achieved lesson

The key outcome of this lesson was that students were tested for their understanding of factorisation and using the quadratic formula by completing a test on the computer. Students showed a great willingness and acceptance for a test of this nature. Because it was a test, no interaction took place between students but they generally agreed to the test being a measure of their ability in factorisation. The lesson also led to some students examining their own abilities in the two selected topics which resulted in many of them going back to these sections on the computer. The test also placed both teachers in the position of determining which students still had problems with the tested areas, and the kind of remedial work or revision programme that needed to be structured. The outcomes of the test contributed towards the year mark of students which eventually determined their achievement in the final examination.

General comments on the implementation, perception and achievement of lessons

There were a number of teachers utilising the centre for Grade 12 mathematics and physical science, which potentially caused a clash of time-tables should all of them decide to use the computer centre for all of their lessons. To solve this problem the teachers planned their annual timetable to allow for double periods during which time the centre could be used and so they took turns to use the computer centre. The computer programmes were mostly used for reinforcement for what was already taught in the class. These sessions would also be planned around a particular topic that would provide students with the opportunity to hone their ability to work quickly and accurately. The centre was therefore not used as a classroom in the strict sense of the word, but as an additional resource centre. The mathematics programme also was used to track the progress of students for each topic. This tracking, teachers claimed, allowed them to select their revision programmes in order to address problem areas. Learners would come during intervals, when they had a free opportunity and after school, to work on the computers. Unfortunately, during vacation periods computers have to be removed from the centre and locked because the computers to be in the computer centre were vulnerable to theft.

Findings after one year of CAL use

In total, 49 students completed the CALEQ. Table 2 represents a summary of the standard deviation and mean item scores of each scale of the CALEQ.

Table 2

Scale means and standard deviations for the actual and preferred versions of the CALEQ (n = 49)

Scale	No. of items	Form	Alpha reliability	Average Item Mean	Scale Std. Dev.	t-value
Involvement (IVO)	8	Actual Preferred	.64 .79	3.37 3.59	4.95 6.53	-1.56
Open-Endedness (OE)	8	Actual Preferred	.51 .59	3.15 3.27	4.79 5.13	-0.92
Investigation (IVE)	8	Actual Preferred	.61 .53	3.33 3.20	5.01 4.49	1.07
Material Organisation (MO)	8	Actual Preferred	.64 .64	3.32 3.24	6.30 5.79	0.47
Learning Assessment (LA)	8	Actual Preferred	.54 .63	3.43 3.87	4.66 4.73	-4.03*
Integration (ITG)	8	Actual Preferred	.65 .70	3.51 3.59	5.25 5.67	-0.6

*$p < 0.01$

The Material Organisation scale had the highest standard deviation for the actual version of the CALEQ and the Involvement scale had the highest for the preferred version which reflected the largest variation of responses to the two versions of the instrument. The Learning Assessment scale and the Investigation scale had the lowest range of responses for both the actual and preferred formats of the instrument respectively. However, two-tailed t-tests to determine the statistical significance between the actual and preferred versions of the CALEQ indicated that only the Learning Assessment scale ($p<0.01$) was statistically significant. The mean scores of all the scales were above 3 [between sometimes (3) and often (4)] which indicated a positive perception of the computer-assisted learning environment by the students. These findings were also reported by other researchers over the past few decades (Bear, 1984; Cavin & Lagowski, 1978; Geban, Ö., Askar, P., & Özkan, I., 1992, Tao, P-K., 2004).

When comparing the item mean scores of the six scales for the actual and preferred formats of the instrument, as indicated by Figure 1, all six scales of the actual version were found to have relatively similar item means. The Integration scale had the highest item mean which reflected that learners perceived the integration of computer lessons within the daily teaching and learning activities of teachers and learners as positive. The Open-Endedness scale had the lowest item mean indicating that learners perceived less open-endedness in their computer-assisted classes than the other dimensions.

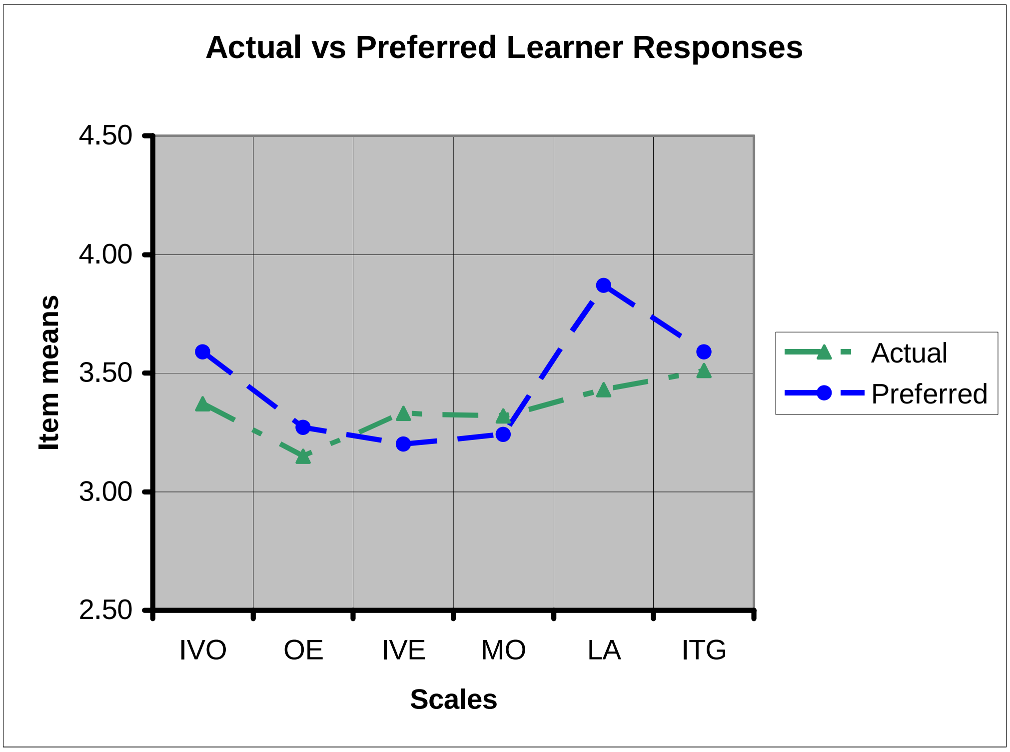

Figure 1
A comparison of the item means obtained from the actual and preferred forms of CALEQ of students (n = 49)

The preferred version that represented perceptions of students of how they would prefer the computer-assisted learning environment pointed towards a more positive preferred learning environment. The findings indicated that the students' mean item scores were higher than the actual means on four scales — Involvement, Open-Endedness, Learning Assessment and Integration. These results indicate that students would prefer to be more involved, to have more open-endedness in their classes, to increase the learning assessment opportunities and to have a greater level of integration of computers in their mathematics classes.

The preferred scores for the Learning Assessment scales were the highest indicating a greater preference for monitoring their own learning. This result is consistent with what was reported in the qualitative data. Students wanted more computers at their centres and also emphasised their individual needs to have a computer of their own in order to assess their own learning. The higher scores for this scale on the preferred level could possibly be attributed to the fact that students, in most instances, only worked on computers about once a week and expressed a desire to have enough computers to work on their own. A number of students linked the monitoring of their learning to learning on their own pointing out that the additional exercise they gained from working on the computers improved their problem-solving skills and the speed and accuracy with which they worked. This improvement in problem-solving supports the research findings of Yalcinalp, Geban & Ozkan, (1995).

The learners also preferred to have a greater integration of computers in their daily classes. These preferences also could be linked to the implementation strategy at this school because learners, who used the computers on average once a week, would prefer greater integration of computers in their lessons. The increase in the scores of the open-endedness scale from actual to preferred format was supported by indications by learners that they wanted greater control over the sections that they could explore on the computer. The current strategy allows them to only work those areas of mathematics curriculum determined by the teacher.

For the Involvement scale, the preferred mean item scores were higher than the actual version. Most students were satisfied with the way that they were involved in computer-assisted classes and indicated that they readily participated in discussions with fellow students and with the teacher about the work on the computer. From reports of the interviewed teachers, more students were willing to share their ideas and thoughts on topics that were based on the work from the computer but were reluctant to participate in the formal class. Students were encouraged by their teachers to interact with each other while answering questions on the computer. This interaction allowed greater involvement in the classroom tasks because students had to work in groups around the limited number of computers. Some students reported co-operative relationships with their peers, which were also encouraged by a number of researchers (Bennett, 1992; Oshima, Murayama,& Tenaka, 2004; Tao, 2004; Yalcinalp et al., 1995).

The scores for the Investigation and Material Organisation scales indicated lower levels of these two scales for the actual version of the CALEQ and then even lower scores for the preferred version though these were not statistically significant. However, the trend of these results indicated that students preferred less investigative activities and less organisation in the computer centre. Indeed, many students indicated that they did not like to work out problems with the teacher standing behind their backs looking over their shoulder. Some students considered it as distracting "I cannot think so fast when Mr. U is looking over my shoulder”, and suggested that they preferred to call the teacher when he was needed. Also, students indicated that they preferred the situation where the teacher worked out the problems on the board and then they could just follow what the teacher was doing, instead of struggling with problems on their own. These situations possibly could be attributed to the lower investigation preference by students. The lower mean item scores for Material Organisation also could possibly be attributed to the fact that the computer centre was used only for additional exercises and reinforcement of work already taught in class. During the interviews, students indicated that they wanted to work on the computers as individuals which could imply that they preferred a less structured approach in the computer centre.

Most learners that were interviewed related that the inclusion of the computer centre as part of mathematics periods took place mostly once and sometimes twice a week. The computer centre was used as a resource centre where additional reinforcement of the work taught in the classroom took place. The everyday teaching of mathematics and physical science would thus take place in the classroom without the inclusion of the programmes on the computers. Consequently, the computer-assisted classes were separate from the lessons that dealt with a particular topic; when students attended the computer centre during a double period, they would be referred to the topic covered in the classroom.

Students indicated that they were satisfied with the way that their classes on the computers were conducted and acknowledged that their level of involvement in the discussions that emanated from their interactions with the computers and fellow students, were adequate. They participated readily in discussions with both the teacher and their fellow students; teachers allowed students the freedom to interact with one another about problems on the computer. These students also indicated the programmes were reasonably user-friendly and allowed easy access to the different parts of both subjects.

> …in mathematics we can jump to problems of different difficulties...we did struggle initially with using some of the keys, but we got used to them very quickly…working with these computers are no big deal.

Many of these students indicated that they made use of the computers during intervals or when they had a free session, for example, when a teacher was absent. Students also pointed out that Mr. U was in the computer centre during lunch intervals and that he allowed them during this time the freedom to explore the sections with which each individual had difficulty.

Students also pointed out that the teachers encouraged them to work out problems on their own but also encouraged them to share their way of working out problems with fellow students who were struggling. Students emphasised that they were notified at the beginning of the year to bring their notebooks to the computer centre because they were not allowed to sit at a terminal without having an additional resource to refer to. They also were required to write down problems that were presented on the computer and calculate the answers separately before going back to the computer. As pointed out by one student:

> I always have scrap paper to work out. When I get the answer we will then put it in the computer. If the answer is right, … I mean the computer says ‘okay’, then I can write it in my notebook. I don’t have a textbook you see.. so now I make lots of sums [problems] in my notebook.

Some of the students interviewed also indicated that they were not always sure whether the exercise that they got on the computer would lead to them faring better in the matriculation examination. Some felt that it made no difference if they worked on the computer or were just taught in the classroom.

> We get our classes, then we have to also go once a week to work on computers. ...the work on the computers are the same as what we get in the class. Anyway, there’s not enough computers so we sit and talk and work out problems. We can do the same in the class.

A few students also had negative feelings about the computers because in their opinion it took too long for there were not sufficient computer terminals to have one for each student.

Most of the interviewed students indicated that they considered the extra exercise from answering questions on the computer to be helpful to their learning. They also pointed out that when they assisted one another in working out problems they were improving their own problem-solving skills. One student related that:

> We are also helping one another, and by helping one another we are also learning at the same time. I can think with one problem in Algebra, I gave an answer which the computer accepted. When ...(friend)... asked me how to work it out, I showed him in my book. It helped me to work out the next question on the computer, and I remembered it in a test we wrote. So it helps to help each other.

Other students indicated that the regular exercise they got on the computer helped them with working out problems more quickly and more accurately. Again a few students pointed out that if there were more computers, their learning would improve because they would be working on problems on their own and learning in their own way. They considered working on their own as important because:

> I write the exam on my own and would like to work on my own… My marks in Maths did increase but I still need to work harder in the Physics.

In a response to a question by the author to all interviewees, students all agreed that learning of the two subjects was much better than in their previous grades and that the improved learning was at least in part due to their interactions with computers.

As pointed out above, most students interviewed linked their interactions in the computer centre with an improvement in learning. These interactions occurred between students, students and the computer and students and their respective teachers. They found these interactions useful because it gave them a chance to discuss the problems in groups where they did not feel threatened by the presence of a person representing authority. The teacher became involved when he was called upon to provide assistance where consensus could not be reached. Students stressed that because they were only allowed to work on the computer once a week during school hours, they considered the time spent on the computer as essential to sharpen some of their skills in answering problems. In one of the groups, a student stated that:

> Sometimes we challenge each other to work out problems on our own and to punch in the answer in the computer. …We keep our calculations covered like and also wait until one person gets the right answer. We then compare with everyone in the group to see who also get it right. We see who gets the most right answers.

However, some students did argue for a reduction in interactions between students and that they should be allowed to work on the computers as individuals to cater for their individual needs. Interviewed students on the whole wanted more computers. They claimed that the computer centre could hold more than 40 computers and that this would go far to assist them in the two subjects. It would also help those who wanted to work more as individuals while a group of students could still work jointly on one computer. Students also wanted more and different programmes to be included on the computer. They stressed that the programmes were too curriculum-related and that more interactive programmes should be made available. Other subjects such as geography, accounting and English also should be included on the computers. Students also mentioned that they could only use ten of the 15 available computer terminals for mathematics due to the licence agreement with the CAMI mathematics programme and that they wanted this licence to be extended so that all computer terminals were available to use in their mathematics lessons.

Conclusion

This paper presented one case study of a peri-urban school which formed part of a wider study into computer-assisted learning at disadvantaged schools in the Western Cape Province of South Africa. This study responded to a national plea to provide support to learners and teachers in mathematics, science and languages in order to meet the challenges and demands of the new information and communication technologies. The computer-assisted learning strategy described in this study was geared at providing learners access to computers as an add-on to their daily lessons which occurred in the normal classroom. It provides an opportunity for future CAL practitioners on learner perceptions of how this strategy impacts on their preparation for the external matriculation examination.

A number of key recommendations to mathematics practitioners in disadvantaged schools have emerged from this study for implementation of an effective CAL strategy. The learners’ indicated that they considered application of computers as a positive step as it increased their involvement in the mathematics classroom, gave them more exercise in problem solving in mathematics, and provided them the opportunity to assess their own learning and understanding of the different aspect in the mathematics curriculum. Given the demand for the limited resource, learners articulated a strong recommendation for more computers to be made available that would allow them to also work individually and to spend more time on the computer.

The study also provides baseline data for future research in computer-assisted learning at disadvantaged schools and the role computers could play in supporting teachers and learners in a key subject like mathematics.

References

Arnott, A., Kubeka, Z., Rice, M., & Hall, G. (1997) *Mathematics and science teachers: Demand, utilisation, supply and training in South Africa*. Craighall, SA: EduSource.

Bear, G. G. (1984) Microcomputers and school effectiveness. *Educational Technology, 24*, 11-15.

Bennett, J. P. (1992) Computers in mathematics education: A 'not really for the researcher' review of recent unique findings. *School Science and Mathematics, 92*(1), 38-39.

Cavin, C. S., & Lagowski, J. J. (1978) Effects of computer simulated or laboratory experiments and student aptitude on achievement and time in a college general chemistry laboratory course. *Journal of Research in Science Teaching, 15,* 455-463.

Department of Arts Culture Science and Technology. (1996) *White paper on science and technology: Preparing for the 21st Century*. Pretoria: CTP Book Printers.

Department of Education. (2001) *Education in South Africa: Achievements since 1994*. Pretoria.

Department of Education. (1999) *The presidential education initiative research report*. Pretoria: Department of Education.

Fraser, B. J. (1990) *Individualised classroom environment questionnaire.* Melbourne, Victoria: Australian Council for Educational Research.

Fraser, B. J., McRobbie, C.J. & Fisher, D.L. (1996) *Development, validation and use of personal and class forms of a new classroom environment instrument.* Paper presented at the Annual meeting of the American Educational Research Association, New York.

Fraser, B. J., McRobbie, C.J. & Giddings, G.J. (1993) Development and cross-national validation of a laboratory classroom environment instrument for senior high school science. *Science Education, 77*(1), 1-24.

Geban, Ö., Askar, P., & Özkan, I. (1992) Effects of computer simulations and problem solving approaches on high school students. *Journal of Educational Research, 86*, 5-10.

Hartley, M.S. (2002) *The effectiveness of an outreach programme in science and mathematics for disadvantaged Grade 12 students in South Africa*. Curtin University of Technology, Perth, Australia.

Hartley, M.S & Teagust, D.F. (2003) *Investigating the effectiveness of an outreach programe in science and mathematics for disadvantaged Grade 12 students in South Africa.* Paper presented at the 3rd International Conference on Science, Mathematics and Technology Education, January 2003, East London.

Hartley, M.S., & Treagust, D.F. (2006) Learning physical science in a rural South African school: A case study of student perceptions of the value of computer-assisted learning. *Science Education International, 17,* (1), 13-29.

Howie, S. J. (1997) *Mathematics and science performance in the middle school years in South Africa: A summary report on the performance of the South African pupils in the third international mathematics and science study*. Pretoria: HSRC.

Howie, S. J. (2001) *Third international mathematics and science study repeat (TIMMS-R)*. Pretoria: HSRC.

Maor, D., & Fraser, B. J. (1993) Use of classroom environment perceptions in evaluating inquiry-based computer learning. *The Study of Learning Environments, 7*, 57-71.

Mills, J., & Treagust, D. F. (2003) Using projects to teach structural engineering. *Australian Journal of Structural Engineering, 4* (3) 211- 220.

Nunnally, J. (1978) *Psychometric theory.* New York: McGraw-Hill.

Oshima, J., Oshima, R., Murayama, I., Inagaki, S., Takenaka, M., Nakayama, H., & Yamaguchi, E. (2004) Design experiments in Japanese elementary science education with computer support for collaborative learning: hypothesis testing and collaborative construction. *International Journal of Science Education, 26*(10), 1199-1221.

Tao, P-K. (2004) Developing understanding of image formation by lenses through collaborative learning mediated by multimedia computer-assisted learning programs. *International Journal of Science Education*, *26* (10), 1171-1197.

Teh, G. P., & Fraser, B. J. (1993) A study of computer-assisted learning environments in Singapore. *The Study of Learning Environments*, *7*, 42-56.

Yalcinalp, S., Geban, Ö., & Özkan, I. (1995) Effectiveness of using computer-assisted supplementary instruction for teaching the mole concept. *Journal of Research in Science Teaching, 32*(10), 1083-1095.

Appendix 1. Representation of the computer lesson on factorisation

FACTORISATION

0	Quit	
1	Common factors	SEC - 2 - 4 - 1
2	Factorisation by grouping	SEC - 2 - 4 - 2
3	Differences of two squares	SEC - 2 - 4 - 3
4	Trinomials	SEC - 2 - 4 - 4
5	Common factor in trinomials	SEC - 2 - 4 - 5
6	Division through factorisation	SEC - 2 - 4 - 6
7	Sum and differences of cubes	SEC - 2 - 4 - 7
	Choose (0 to 7)	

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~*[next screen]*~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Common factors

Factorise the following expressions:

Level A

$2p^2 - 5pr$
= ____ (   )

Level B

$7q^4 - 3q^3$
= ____ (   )

Level C

$12f^4 - 42f^3p^3$
= ____ (   )

Level D

$30k^4y^3 - 24ky^5$
= ____ (   )

Level E

$56g^4r^3y^3 - 16g^3r^7y^7$
= ____ (   )

Hint: Remove the common factor.
Press Enter to mark, A - E for level, H for Help, ← to erase.

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~*[next screen]*~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Factorisation by grouping

Factorise the following expressions:

Level A

fr + nr + fx + nx
=____ (   ) + ____(   )
= (   ) (   )

Level B

$k^2 - k(8 + r) + 8r$
(   )(   )

Level C

Factorise the following expression:

$10n^5 – 12n^4z + 15nz^4 – 18z^5$
=____ (   ) + ____(   )
= (   ) (   )

1st Hint: Take out the common factor from the first two terms
2nd Hint: Take out the common factor from the last two terms
3rd Hint: Take out the common factor in the brackets.

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~*[next screen]*~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Difference of two squares

Factorise the following expressions:

Level A

$49 – t^2$
= (   ) (   )

Level B

$25p^2 – q^2$
= (   ) (   )

Level C

$36m^2 – q^4$
= (   ) (   )

Level D

$9n^{12} – 36y^4$
= (   ) (   )

Level E

$16k^{16}q^{12} – 36x^{16}$
= (   ) (   )

Complete the first bracket.
Complete the second bracket

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~*[next screen]*~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Trinomials

Factorise the following expressions:

Level A

$g^2 + 9g + 18$
$= (\quad)(\quad)$

Level B

$q^2 – 4q + 4$
$= (\quad)(\quad)$

Level C

$20f^2 – 39f + 18$
$= (\quad)(\quad)$

Complete the first bracket
Complete the second bracket

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~***[next screen]***~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Common factor in trinomials:

Factorise the following expressions:

Level A

$4g^2 – 4g - 8$
$= \_\_\_\_\_ (\quad)$
$= \_\_\_\_\_ (\quad)(\quad)$

Level B

$14g – 6g^2 – 8$
$= \_\_\_\_\_ (\quad)$
$= \_\_\_\_\_ (\quad)(\quad)$

Level C

$2n^5y^5 + ny^5 – 3y^5$
$= \_\_\_\_\_ (\quad)$
$= \_\_\_\_\_ (\quad)(\quad)$

Level D

$–6g^2t^3 – 9gt^3 + 6t^3$
$= \_\_\_\_\_ (\quad)$
$= \_\_\_\_\_ (\quad)(\quad)$

Level E

$6g^6x^4 + 14g^5x^4 + 8g^4x^4$
$= \_\_\_\_\_ (\quad)$
$= \_\_\_\_\_ (\quad)(\quad)$

Hints: Take out the common factor.
Write the remainder in descending order
Complete the first bracket
Complete the second bracket

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~***[next screen]***~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Division through factorisation

$$\frac{25y^2 – 9}{15y^2 + y – 6} = \frac{(\quad)(\quad)}{(\quad)(\quad)} = \frac{\quad}{\quad}$$

Hints: Factorise the numerator. Complete the first bracket.
Factorise the numerator. Complete the second bracket.
Factorise the denominator. Complete the first bracket.
Factorise the denominator. Complete the second bracket
Cancel the common factor. Give the numerator.
Give the remaining denominator.

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~***[next screen]***~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Sum and difference of cubes

Factorise the following expression:

$n^{12} + 8y^{12}$
$= (\quad)(\quad)$

$27g^6 + 64q^{12}$
$= (\quad)(\quad)$

Hints: Complete the first bracket.
Complete the second bracket.
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~