Toward ICT Integration in the Science Classroom: A Comparative Study of Cases in Lesotho and South Africa

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Abstract: This comparative study into the integration of technology into teaching and learning, examines cases of computer use and e-learning in Science classrooms in two Southern African states, namely, South Africa (SA) and the Kingdom of Lesotho. Twenty one teachers from four high schools, two in each country, participated in data collection involving observation sessions, questionnaires and interviews. E-learning in SA schools with established e-learning programmes was compared with the Lesotho situation to establish precedents. Furthermore, obstacles were identified that impede ICT integration in Lesotho. The Lesotho teachers are enthusiastic and keen to persevere, but consistent integration of technology as a teaching and learning tool has yet to emerge. The study identified the following main issues that hinder ICT integration: Teachers require appropriate training and workshops; more time should be set aside for technological orientation, lesson planning, and for students to use computers; hardware and software infrastructures require systematic maintenance and upgrades.

Introduction

Information and communication technology (ICT) relates to the set of activities that facilitate – by electronic means – the processing, transmission, and display of information. ICT has systematically and pervasively infiltrated most aspects of life, including teaching and learning (Capobianco & Lehman 2006; Birch & Sankey 2008). For the past ten years, there have been discussions in numerous forums, e.g. Government of Lesotho Vision-2020 (2001), on ICT within education in the Kingdom of Lesotho. The question arises: If ICT has such potential for education (Lin et al, 2004; Hwang & Wang 2004; Brown & Warschauer, 2006), why have certain schools been reluctant to apply it in teaching and learning? Furthermore, what are the particular obstacles to e-learning and the integration of ICT in Lesotho schools?

Despite the resources invested in computer hardware and software (Government of Lesotho ICT Policy, 2005), there has been less success identifying how computers can most effectively be used for teaching and learning (Dooling, 2000; Cuban, 2001). Teachers in Lesotho are generally under-prepared to integrate technology into instruction in meaningful ways. Teachers in South Africa, by contrast, have come to appreciate its potential in enhancing education. In Lesotho, as well as other countries around the world, there are indications that schools and teacher-education programmes are addressing these issue of computer technology in classroom situations (Karchmer, 2001; Roblyer, 2003; NEPAD Action plan, 2006) by paying particular attention to what is actually happening in the classroom, yet the question remains: Why has the integration been so much slower than the acquisition of hardware and software? Some researchers suggest that early efforts to integrate ICT into the classroom failed because of poor planning (Bauer & Kenton, 2005) and this appears to be the case in Lesotho. It is also argued that teachers were inadequately prepared (Cuban, 2001) and lack the belief that ICT can enhance the learning process (Lim & Khine, 2006; Fuller, 2000). Educational computing holds the potential to be a change agent, but it is under-utilised, which is a serious problem (Stols, 2008). Computers frequently reside in laboratories, removed from the classrooms, and are therefore not an integral part of instruction. This is the case in Lesotho. Furthermore, Fuller (2000) emphasizes the role of the educator, suggesting that students benefit more from technology investments when the instructional technology incorporates explicit means of supporting teachers in understanding of how best they should use ICT for teaching.

Broad Context and Research Questions

The purpose of this comparative study is to examine a sample of four cases of computer use and e-learning ─ two each in neighbouring Southern African states, namely the Republic of South Africa (SA) and the Kingdom of Lesotho. Educational computing has been established for some time – up to 25 years – in South African schools. At one end of the spectrum, some SA schools have highly sophisticated facilities, while others, particularly in rural areas, have no computing facilities at all and may not even have electricity. Computer laboratories are well established in most urban and suburban schools and also in many township schools ('townships' being the urban areas mainly occupied by historically-disadvantaged black communities).

Lesotho is a small, land-locked state, called the 'Mountain Kingdom'. Educational computing commenced in the early 1990s, when private initiatives donated computers on an *ad hoc* basis, with no involvement by the Lesotho Ministry of Education. They were mainly used in teaching basic computer literacy and there was no formal subject-based e-learning. In the rural areas, there were no facilities whatever. However, more structured ventures have occurred since 1999, when *SchoolNet*, a registered NGO (non-government organisation), began to build laboratories and provided computers, software and intranet connectivity to address the issues and challenges. The ultimate aim was to use computers to facilitate actual teaching and learning, over and above computer literacy. This initiative was supported in principle by the Ministry of Education but, at that stage, the new technology was not incorporated into curricula. Efforts are currently being made to do so (Government of Lesotho ICT Policy, 2005; Nepad Action plan, 2006), which has given rise to the present study, of which the long-term goal is to support and enhance the integration of e-learning in Lesotho schools.

To support this long-term aim, and despite the broad gap between the extent and standard of e-learning and use of technology in the two states, it was decided to investigate educational computing and e-learning in certain South African (SA) schools and compare it with the current Lesotho situation. We recorded how SA teachers and students are using ICT in teaching and learning and similarly investigated the pioneering situations in certain Lesotho schools. Where appropriate, the SA situation can be applied to Lesotho as a precedent study. In each country the study targeted two schools from the upper end of its respective spectrum, by selecting two SA schools where ICT is well established and integrated into the curriculum and, from Lesotho, selecting some of the more innovative schools in the *SchoolNet* project. Thus, although the study compares two very different situations, in each case it examines respective best-practices. To delimit the scope, the study was restricted to the teaching and learning of Science in high schools. 'Science' encompasses Chemistry, Physics and Biology.

The research questions are:

- What is meant by 'the integration of computers into teaching and learning' in schools with established e-learning programmes?
- What are the obstacles to be overcome to find an appropriate model of ICT integration in Lesotho?

Immediate Context of Study

At the beginning of 2000, the government of Lesotho launched compulsory and free education for children between the ages of 6 and 13, starting from Standard One (Grade 3). This created a ripple effect as the number of pupils completing primary school and proceeding to high school increased greatly from 2006, while the number of teachers remained constant, as did teacher training and infrastructural support. The *SchoolNet* project was launched within the same period and is currently piloted in six high schools around the country. Each school is provided with ten computers, network cabling, CD-based interactive subject-based software and, in some cases, an Internet connection.

This comparative study examines four cases as a sample of computer use and e-learning. In Lesotho, two *SchoolNet* schools, School A and School B, were selected, along with two state schools, School C and School D, in South Africa. Tables 1 and 2 depict the profiles of the four schools and background information about the teachers, respectively. The codes assigned to the teachers in Table 2 indicate, for example, that LA5 is Teacher 5 in School A in Lesotho and SD1 is Teacher 1 in School D in South Africa.

School	A	B	C	D
Country	Lesotho	Lesotho	RSA	RSA
Region	Semi-urban	Semi-urban	City	City
Status	State	State	State	State
No of Students	735	469	1200	430
No of Participant Teachers	8	6	3	4
Computers	45	25	180	25
Note	All teachers in School C in SA are required to study and write the International Computer Driving License (ICDL) examination, and the school has introduced the use of interactive white boards in all science classrooms.			

Table 1: Profile of the schools

No.	Teacher	School	Subject	Years of Experience	Educ. Level	Workshop Attended	Computer Course
1	LA1	A	Physics	2	Diploma	0	1
2	LA2	A	Physics	5	Degree	1	1
3	LA3	A	Physics	4	Degree	0	1
4	LA4	A	Chemistry	2	Degree	0	1
5	LA5	A	Chemistry	4	Diploma	2	1
6	LA6	A	Biology	1	Degree	0	1
7	LA7	A	Biology	5	Certificate	2	1
8	LA8	A	Biology	1	Degree	0	1
9	LB1	B	Physics	7	Diploma	1	1
10	LB2	B	Physics	2	Degree	0	1
11	LB3	B	Chemistry	5	Certificate	2	1
12	LB4	B	Biology	8	Diploma	2	2
13	LB5	B	Biology	1	Diploma	0	1
14	LB6	B	Biology	4	Degree	0	1
15	SC1	C	Chem/Physics	9	Degree	9	6
16	SC2	C	Biology	5	Degree	6	4
17	SC3	C	Biology	2	Degree	4	4
18	SD1	D	Chemistry	6	Diploma	4	3
19	SD2	D	Chemistry	5	Degree	8	3
20	SD3	D	Biology	3	Degree	2	1
21	SD4	D	Physics	5	Diploma	4	2

Table 2: Teachers' Background Information

Research Methodology

Participants

As stated, the participating schools, two in Lesotho and two in SA, were selected as examples of good practice in each of the countries relative to its spectrum of e-learning application. In total, twenty one science teachers from the four high schools participated, fourteen from Lesotho and seven from SA, as shown in Table 2.

Data Collection

The methods of data collection are given below. To simplify presentation, they are in a list format:

a. Field notes taken by the researcher during observation of classes,
b. A questionnaire survey to gather information on teachers' background information, their ICT experience and perceptions of ICT use,
c. semi-structured interviews conducted with teachers and students,
d. Focus-group interviews with teachers,
e. Document reviews of existing records and other documentation not developed specifically for this evaluation.

Participant teachers in all schools completed a **survey questionnaire**, with the following sections:

1. Background information: data regarding their previous exposure to ICT within teaching,
2. ICT experience: to explore their practical ICT experience and expertise,
3. Perceptions of ICT use: data on how they view their own skill and confidence levels with computers, as well as those of their students.

In the **interviews** four issues, which are an adaptation from Bauer & Kenton (2005), were discussed with the teachers to explain various actions and to determine the nature of difficulties experienced during Science lessons:

1. What were some of the things you were trying to accomplish in today's lesson?
2. What is your assessment on how things went?
3. What are some of the issues and concerns you dealt with today, that have been fairly common for you in technology-based lessons?
4. What other difficulties have you encountered as you have seek to use computers in class?

Results

Table 3 is a comparative picture of the forms of e-learning used in the four participating schools. Schools A and B in Lesotho use a combination of CD-ROM-based courses and electronic encyclopaedia-based research to teach Chemistry, Biology and Physics. Teacher LA3 initially orientates students in a classroom setting and then requires them to use the *Cyber School Technology* simulation software installed in the lab to prepare their presentations the following week. Students also have access to other pre-installed electronic encyclopaedias for these assignments. The teaching of topics such as the combustion of fuel, exothermic reactions and Faraday's second law of electrolysis in Chemistry; velocity and sound, electromagnetism and fusion in Physics; and unicellular organisms, the human circulatory system and the respiratory system in Biology are supplemented with electronic resources.

In SA, Science teachers in School C use simulated experiments from *Crocodile Clips* with its *Absorb* courseware that combines "Crocodile" simulations with a spoken narrative, interactive animations and targeted exercises to teach chemistry. The school also has a web-based encyclopedia, and science teachers refer student to it in preparation for their projects. An important form of e-learning in Schools C and D is the interactive electronic Forum. This entails asynchronous communication, whereby a science teacher posts a topic or issue for discussion over a specified period of time. All students taking the course are expected to participate in the discussion at least twice in a two-week period. Their views are ranked by the teacher and they receive grades for their participation in this constructive collaborative development of themes. Such forums are organised twice or three times per semester. Teacher SC3 supports his Biology Students by providing them with access to a virtual library. Apart from these electronic materials that they can access from anywhere at any time, the teacher has an additional system whereby

he sources additional relevant reference materials in the form of notes or articles and posts them in a special section of the virtual library. Unlike the situation in conventional libraries, students can access these materials via the Web at home, at school or elsewhere and at any time of the day or night.

Forms of e-learning	**Lesotho**		**South Africa**	
	School A	**School B**	**School C**	**School D**
CAI Tutorials	X	X	X	X
Multi-media Production	X	-	X	X
Simulations	X	-	X	X
Educational Games	-	-	X	X
Interactive Learning/Practice	-	-	X	X
CD ROM-Based Courses	X	X	X	X
Web-based Courses	-	-	X	X
Drill and practice	X	X	X	X
Video Conferencing	-	-	-	-
Internet-Based Research	-	-	X	X
Electronic encyclopaedia-based research	X	X	X	X

Table 3 Forms of e-learning used in the participating schools

Key Findings

Teacher Perceptions of ICT

Teachers were asked to rate their personal confidence using ICT and their perceived ICT skill level, using a Likert scale (1=low, 5=high). They were also required to rate the confidence and skill levels of their students. Figure 1 shows these perceived confidence and skill levels of the teachers and their students in Lesotho and South Africa.

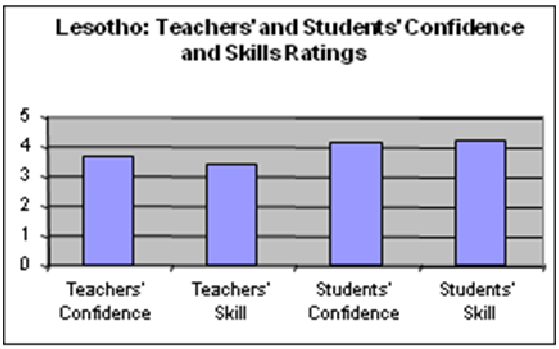

Figure 1 Teachers' and Students' Confidence and Skills in Lesotho

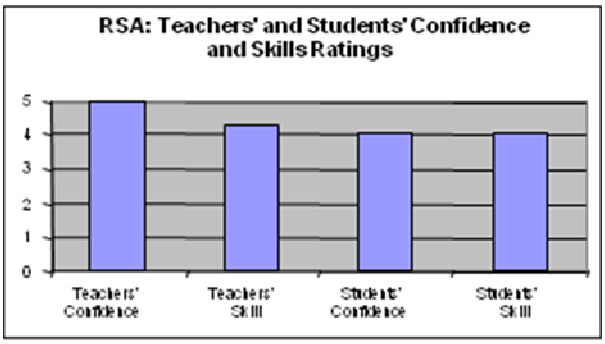

Figure 2 Teachers' and Students' Confidence and Skills in RSA

A confidence level mean of 3.7 and a skill level of 3.4 for teachers, and a confidence mean of 4.1 and skill mean of 4.2 for students – on a scale where 5 is highest – are statistically strong levels of confidence and skill among the teachers and students in Lesotho. Two teachers (14%) for schools A and B rate themselves as low in confidence and skill, confirming that confidence and skill are linked. However, the two expressed their strong aspiration to develop and improve their ICT knowledge. One expressed it this way: "I would like to know more and use ICT in my daily teaching and even in my preparation." Nine (64%) confidence levels and eleven (78%) skill levels among teachers were at the middle of the scale (3). The standard deviations of 0.9 for confidence levels and 0.6 for skills, show how close teachers were in their responses. Fairly high levels of confidence and skill were indicated at both schools, with fourteen teachers (100%) rating themselves as 'above average'. Of these, four teachers (30%) rated their students' confidence level at 5 on the Likert scale and five of them (35%) rated the skill level at 5.

In South Africa, the confidence and skill levels of teachers are higher than those of Lesotho. Teachers scored higher levels when compared to students. A confidence mean of 5 and a skill mean of 4.3 for teachers, and a confidence

mean of 4.0 and skill mean of 4.0 for students are also statistically higher. Teachers rate their students' confidence and skills lower than themselves, unlike the case in Lesotho. Teachers pointed out a dichotomy, in that they are dealing with students who have different inherent levels of expertise – some have had extensive prior exposure to computing at home, and others not at all.

Most of the points raised in this section arise from questionnaire responses, although some issues came from the interviews. Most of the information identified in interviews is presented in the next section on obstacles to effective implementation of ICT and e-learning.

Overcoming the obstacles identified

Professional Development

The Lesotho teachers felt strongly that their personal lack of expertise is an impediment to teaching with technology; they believe that if they were more exposed to various ICT training sessions, programmes or workshops they could cope better with integrating e-learning components into the Science classroom. Four of the teachers had similar comments in this regard. Teacher LB2 phrased it: "There are many things that I have learned during the orientation sessions that make me believe that, with more personal exposure to ICT, I should be able to integrate it fully in my teaching". Teacher LB5 said: "I have been fearful of using computers all my life. Now I am more confident and relaxed and I am sure that if given the opportunity to attend some informative computer training workshops, I will perform even better".

In contrast, teachers in SA felt that they were successfully integrating ICT in class; to a large extent, this was because of the training that had been organised by their schools. In School C, attainment of the ICDL qualification is a requirement for all Science teachers. They also had opportunities to attend workshops and are exposed to state-of-art courseware. One of them, SC3, explained that after attending a workshop in London and visiting schools where ICT was well implemented, he felt confident to start using it in his own classes. Teacher SC2 also expressed the same sentiment, but indicated: "… every year we attend a computer faire and discover new software; we are encouraged to want to use ICT even more". Teacher SC1, who shared the same opinion, put it this way when referring to a Physics lesson on the laws of motion: "I am longing to see the day that I will use 3D software to demonstrate during my physics class". The same teacher explained that the transition from traditional teaching to a blended approach – combining class-based teaching with e-learning – had gone smoothly due to exposure to workshops, the ICDL course and other training.

Time with Computers

Lesotho teachers cited lack of dedicated time as one of the major factors preventing both their own and their students' integration of technology in the classroom. With regard to teachers, they suggested that periods should be set aside for further professional development. With relation to pupils they found, as did their counterparts in SA, that discrepancies occur. Certain students need block time for basic orientation before across-the-board e-learning can be implemented. Teacher LB5 said: "Since some students have computers at home and spend more time using them, and others not, it creates an imbalance between them so much that our effort to improve all students' outcomes might be futile". Teacher LA4 suggested a well-structured time-table for computer laboratories that incorporated extra time for students who do not have computers at home. A further point was that in certain sites – due to over-zealous concern for security – the software was held in safe keeping and not available for general use.

Although time was not mentioned by School C teachers as an obstacle to effective integration of technology into the classroom, they indicated that, particularly in the early stages of integration and implementation, they needed more time to become personally familiar with the systems and time to visit other schools where ICT was satisfactorily implemented. School D also indicated that both teachers and students require time, either at school or at home, to adjust to the new approaches to lessons and assignments. They believe that if additional time is allocated to them and to their students, this could improve teaching and learning with the new hardware and software.

Infrastructural Support and Learning Environment

Participants in Lesotho reported various hardware and software problems. Teachers described failures in operating programs, while others had encountered hardware difficulties and technological breakdowns. Teacher LB2 had solved this by working closely with the computer lab technician when preparing her presentation. She put it this

way: "Following the orientation sessions, I started working closely with the technician and some times preparing PowerPoint slides with him until I became more confident to do it myself". The Internet was another issue. The *SchoolNet* schools had been promised connectivity, but had not yet received it. Teacher LA8 said that "The internet has got so many things that we could include in our presentation during classes. Getting connected will improve our performance and that of our students". During the observation sessions, the researcher noticed that students with general skills in ICT were able to respond rapidly and were motivated to participate fully. In contrast, those without such skills were daunted. They became frustrated when required to do activities on a computer, even simple tasks; one of them asked the teacher if he could rather do it manually.

Schools in RSA had acceptable infrastructures, both hardware and software. Table 3 indicates the variety of applications and software tools being used. Teachers were able to use these both in classrooms and in laboratory environments; students were given group assignments in which they worked collaboratively, optimising on their various skills. These could be done either at school or at home and were presented to the class in peer-teaching sessions. Participants reported relatively few occurrences of hardware and software problems. Teacher SC3 stated that he very occasionally gets calls from colleagues in his own school requiring help; perhaps once in two weeks. Since 2004, School C has had a policy of acquiring new computers for the lab each year and moving 20 from the lab to classrooms or the library – or developing completely new laboratories together. From 2003 there has been a move towards installing interactive white boards in every classroom. Although many teachers were initially unenthusiastic, they are now motivated and 75% of the overall teaching staff are using them. During the observation sessions, the researcher noted that students were actively engrossed during collaborative group presentations by their peers, as well being highly engaged during technology-assisted lessons.

School D in SA has an ongoing maintenance program for hardware and software, managed by an external service provider from a local company, rather than by a full-time computer technician on the school staff. Regular upgrades are done in the laboratory, the classroom, and in the school's administrative offices. As in School C, teachers in School D attend workshops and computer fairs.

Discussion and Conclusion

The first research question investigated was: *What is meant by 'the integration of computers into teaching and learning' in schools with established e-learning programmes?* An answer to this can be obtained from the content, context and infrastructure of e-learning described in the previous section, with regard to the South African schools, C and D.

The second question, namely, *What are the obstacles to be overcome to find an appropriate model of ICT integration in Lesotho*? is key to the long-term goal of this study, namely, to support and enhance the integration of e-learning in Lesotho. According to the participating Lesotho teachers, their major problems with regard to ICT integration in the teaching and learning of the Science curricula, relate to:

- professional development of teachers in the context of educational technology,
- time allocation for initial orientation, training, and practice of the new skills, and
- issues of infrastructural support and learning environments.

Given their situations, as attested to by their responses in individual- and focus-group interviews, and confirmed by the researcher's observation, these are just concerns that impact on the teachers' ability to succeed in the integration of e-learning. If this argument is accepted, then it is important to start addressing these issues progressively.

This research indicates that true integration of e-learning has not yet occurred in Lesotho, despite the acquisition of hardware and software and the teachers' enthusiastic attitude and willingness to start integrating it into their curricula. Much can be learned from the situation of their SA counterparts, who were exposed to technology long before using it in class situations. Moreover, their ICT training and workshop attendance has given them confidence, as demonstrated in Table 2. Before implementation of ICT in their own schools, teachers in SA went on site visits to precedent schools where ICT was well established. In considering the Lesotho situation, some SA teachers suggested that, as had been their situation some years previously, schools commencing ICT ventures should initially consider using simple and less expensive solutions such as CD-based courseware and projectors connected to laptop computers for presentations. As both teachers and students gain confidence in these basic e-learning tools,

they could progress gradually to the more expensive and high-technology applications. Providers of ICT solutions should discerningly investigate the type of software that would be appropriate and relevant for each particular context or environment.

The results of this study support Dooling's (2000) observation that students appreciate real and relevant learning experiences. The study included observation of students undertaking e-learning experiences. They were also involved in the research and data collection, in that certain students were interview respondents and several were observed as they used technology to conduct independent research and to present findings during class-lessons and in laboratory sessions. The responsiveness of students contributed to the confidence of teachers and their continued willingness to use e-learning applications and to integrate ICT into their teaching of Science.

Recommendations for Future Study

Future studies should be based on input from a greater variety of teachers – teachers in other fields, as well as Science teachers. Furthermore, parents could be surveyed on their children's' ICT usage at home; this would provide perspective on the relationship of home usage and overall performance in the classroom. Finally, and most important, there is a need for research into the creation of optimal learning environments in Lesotho to support the acquisition of general technology expertise, as well as the determination of conditions that support the integration of ICT into subject teaching and learning.

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