E-LEARNING IN THE SCIENCE CURRICULUM: A STUDY IN SELECTED HIGH SCHOOLS IN LESOTHO

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Abstract: This research investigates progress in the integration of information and communication technology (ICT) into curriculum-based teaching and learning in the Lesotho high school science classroom, with the aim of establishing how effective e-learning can be supported to enhance teaching and learning. Using a variant of action research, this study investigated the extent of computing infrastructure in schools and ways in which ICT tools were used in subject-based teaching. Barriers to ICT implementation and the perceptions, aptitude and skills of Lesotho science teachers and students were investigated. Literature studies were conducted and pertinent concepts were used to generate a framework of evaluation categories and criteria for addressing the research questions. The criteria were translated into questions and evaluation statements for collecting data. The study identified notable progress, but determined that more needs to be done to support e-learning in Lesotho.

INTRODUCTION

In the information technology revolution, ICT and e-learning have the potential to support classroom practice and to enhance teaching and learning, making it more interesting and stimulating for teachers and students (Government of Lesotho, Vision 2020, 2001; Government of Lesotho, ICT Policy, 2005). In 2000 the Lesotho government made education compulsory and free for children between the ages of six and thirteen, starting at Grade 1. This created a ripple-effect as the number of students proceeding to high school increased, while the complement of teachers remained constant. Furthermore, teacher training and infrastructural support were unchanged in many Lesotho schools. Capacity became an issue both in terms of professionally trained staff and infrastructural facilities. The need for supplementary ICT-based teaching and learning became evident. In this context, three non-governmental organisations (NGO's), namely SchoolNet, NEPAD e-School and Microsoft School Technology Innovation Centre (STIC) partnered initiatives with Lesotho educational authorities, particularly promoting and providing the use of educational technology in certain school. Due to economic, contextual and educational factors, the integration has been complex. This study relates to e-learning in science education following these initiatives, concentrating on interactive curriculum-based activities. To understand the complexities, it is important to investigate the professional development of teachers in preparation for using ICT in schools; the use of e-learning in subject teaching; time allocated to using ICT resources; and to conduct systematic research into technological learning environments within schools. As a theoretical basis, a list of criteria has been developed from the literature and applied to build the research instruments used in these studies.

Contextual and localised research is needed on e-learning, particularly on the progress of ICT integration in the science classrooms, since science teachers were among the early adopters of the new technologies. Findings should be used towards the creation of appropriate learning environments, and the provision of support before, during and after integration – the lack of which contributed to the failure of ICT integration in Lesotho's education system during the period before 2007.

RESEARCH OBJECTIVES AND QUESTIONS

One of the objectives of this study is to identify barriers to ICT integration, along with associated solutions that contribute to a conducive learning environment. Some of the research questions addressed in the study are listed in Table 1, while others are omitted from the present paper.

Table 1: Research Questions

Main Research Question
How can effective e-Learning and integration of ICT be supported in the science classroom in Lesotho high schools?
Supporting Research Questions
What are the perceptions of Lesotho high school science teachers regarding the use of ICT and e-learning in the classroom?
What barriers/obstacles exist to the integration of ICT in Lesotho high schools?
Are ICT professional development programmes presented to teachers?
What hardware and software is supplied to schools and to what extent is it used by teachers and students?

LITERATURE REVIEW

In keeping with the action research approach, a literature review was undertaken to investigate related literature on the objects of interest and to develop initial concepts. This review touches briefly on only a few sources from the abundance of literature on these issues. Concepts identified from the literature, contributed to the synthesis of evaluation frameworks for data collection in the empirical studies.

ICT in education

The integration of technology into teaching and learning dates back to the use of radio, photography, audio tapes and television. Nevertheless, with the rapid development of emerging technologies, such as Internet and Web, ICT integration has increasingly attracted the attention of educators and created new challenges to teaching and learning (Bingimlas, 2009; Erixon, 2010). Technology-based learning, however, was a new concept to many educators and educational managers. Lesotho is a small African country, where – as was initially the case internationally – institutions and their NGO partners focused on acquiring computers and related equipment for schools (Zemsky and Massy, 2004; Laurillard, 2006), while paying insufficient attention to practical implementation issues and potential obstacles to integration (Kalanda and de Villiers, 2008).

With regard to the use of ICT in teaching science, this is a subject of much discussion. Some studies (Culp, Honey and Mandinach, 2005; Zhou, Brouwer, Nocente and Martin, 2005) have shown that ICT can enhance teaching and support students in achieving learning outcomes. A misconception regarding the learning of science, promotes the belief that relatively few individuals can be proficient in science (Hapkiewicz, 1999). A further fallacy is that only males have the ability to become scientists, yet students, regardless of gender, may be daunted by the challenge of abstract thinking (Kalanda and Oliphant, 2009). Proficiency in science is highly desirable for all learners.

Although many studies indicate that educational technology has a positive impact on teaching and learning, other results hold reservations regarding pedagogically complex uses of e-learning and concern as to whether ICT can foster higher-order thinking skills in learners. Bloom's model of s educational objectives, *'Bloom's Taxonomy'* (Alford, Herbert, and Frangeheim, 2006) categorises different levels of learning: knowledge, comprehension, application, analysis, synthesis, and evaluation. Knowledge is considered the lowest level of learning and evaluation the highest.

Literature also suggests that the educational sector has not yet achieved a level of maturity with regard to e-learning practice, particularly in third world situations (Garrison and Anderson, 2003; Zemsky and Massy, 2004; Laurillard, 2006; Howie and Blignaut, 2009). The rapid introduction of new technology, in education without adequate preparation of teachers and students for the changed environment, has hampered the implementation of e-learning (Kalinga et al. 2007; Tondeur, van Keer, Van Braak and Valcke, 2008; Erixon, 2010). The study by Kalinga et al. is an African study on the use

of an e-Learning Management System (e-LMS) within urban and rural secondary schools in Tanzanian. Howie and Blignaut, who investigated South Africa's readiness to integrate ICT into mathematics and science education in secondary schools, recommend that schools should embrace ICT as a general component of teaching practice. However, various studies, both international and local, suggest that the introduction of ICT has not been managed in a way that can transform learning and teaching.

Challenges

While technology in education may create opportunities for innovation (Lateh and Muniandy, 2010), it also presents challenges and requires changes to existing processes in the form of shifts in educators' pedagogy and practice (Laurillard, 2006). Contextualized African research, such as this study, is required to contribute to teaching and learning practices that conform to appropriate theoretical foundations. Schoepp (2005) refers to the challenges and difficulties as 'barriers' to successful engagement in ICT practices. Pelgrum (2001) classifies the obstacles as 'material', namely, lack of hardware and software, and 'non-material', including inadequate ICT knowledge and skills on the part of teachers and insufficient time to meet the additional demands of the new approaches.

RESEARCH DESIGN, RESEARCH METHODS, AND EVALUATION PROCESS

Action research (AR) is extensively used in social science disciplines, including education, as an approach that includes both qualitative and quantitative research (Baskerville, 1999; Cohen, Manion and Morrison, 2005). As a longitudinal approach, it is suitable for studying an emerging field over a period of time, such as educational technology where information is required to explain phenomena and used in responsive actions to improve implementation (Charmaz, 2002; de Villiers, 2005). AR is also characterised by a participative ethos, where the researcher plays a key role.

In the present work, the underlying research design is a variant of action research (VoAR). In the six sequential studies portrayed in Figure 1, data was collected from a variety of sources.

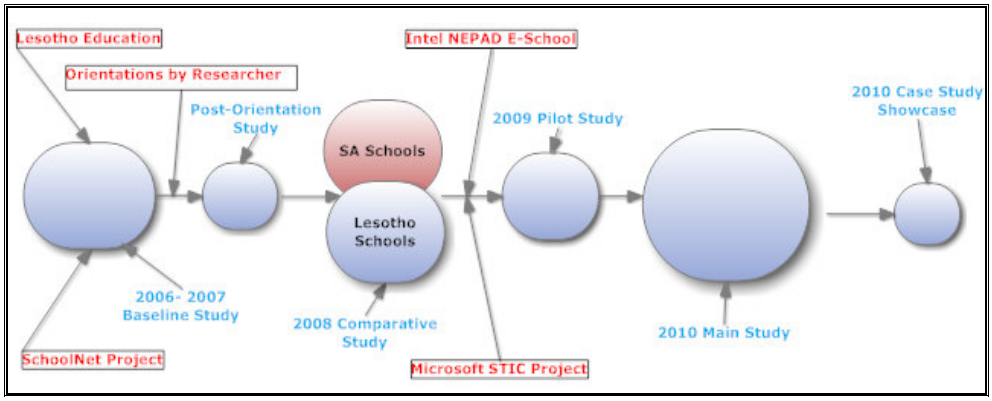

Figure 1: Research Design – a Variant of Action Research

The diagram shows the studies and the interventions in a process which differs from standard AR. In classic AR the findings of each study lead to reflection and inform changes to the interventions, i.e. interventions result directly from findings of a previous study. In the present research, however, most of the interventions are external and would have occurred regardless of the findings of the researcher.

The circles on the horizontal axis of Figure 1 show the six studies, respectively, while the blocks linked in with arrows indicate five interventions, comprising actions of Lesotho educational authorities, the three partnership projects, and a training orientation by the primary researcher.

This paper reports only on the Main Study, prior to which a Pilot Study was conducted to try out the research methods and evaluation criteria, and refine them for the Main Study. Qualitative data collection involved field notes during observation of ICT-based lessons; open-ended questions in questionnaires; and face-to-face interviews with principals, teachers and students on ICT integration in

science and whether e-learning supports learning. This qualitative data was analysed using thematic analysis and a simplified grounded theory approach (Cockton, 2004; de Villiers, 2005) Quantitative Likert-scale data came from questionnaire surveys among teachers and students. The data was analysed by frequency counts and descriptive statistical analysis. This combination of multiple sources of data and different research methods triangulated the research.

The Main Study involved nine schools (three from each of the Projects: SchoolNet, NEPAD E-Schools and STIC) and 40 participants (2 principals, 21 science teachers and 17 students). Table 2 details the participants and the data collection methods used to identify barriers, support needed, and desirable characteristics of environments for facilitating ICT integration. Questions were also asked on the status of e-learning in the science curriculum and the various technologies being used.

Table 2: Human Participants (Main Study)

2010		Selection	Comments
Participants (n = 40)	9 Schools	Schools from the three projects.	Three schools from each of the three projects: SchoolNet, NEPAD e-School, and Microsoft STIC, respectively
	Two principals 21 teachers 17 students	• Teachers who had undertaken significant ICT professional development training programmes from the three projects • Teachers using ICT in classroom teaching. • Science teachers who volunteered to participate.	
Data Collection Method	Questionnaires, Observations and Interviews	A total of 14 observations, with one or two per school. 17 students and 2 principals interviewed - two or three per school. 21 teachers answered the survey questions. Two teachers per school were interviewed. A total of 18 teachers interviewed.	

Table 3 lists the nature and distribution of the nine schools. The 17 (10 +7) teachers in Schools 4 to 9 had been trained in concepts of ICT and e-learning at workshops held by the STIC and E-School Projects, respectively.

Table 3: Participating Schools (Main Study)

Project		District	Location	Numbers					
				Schools	Teachers		Students	Computers used by teachers	Internet Yes / No
1	SchoolNet	HL	R	1	1		2	2	No
2	SchoolNet	ML	R	1	1		1	1	No
3	SchoolNet	LL	U	1	2	**4**	2	2	Yes
4	STIC	LL	U	1	4		3	45	Yes
5	STIC	LL	U	1	3	**10**	2	26	No
6	STIC	LL	U	1	3		3	49	Yes
7	E-School	ML	R	1	2		1	15	No
8	E-School	HL	R	1	3	**7**	1	21	No
9	E-School	LL	U	1	2		2	43	Yes
Total				9	21		17	204	

Key: HL - Highland; ML - Midland; LL – Lowland; U - Urban; R – Rural

Based on concepts derived from extensive literature studies, the researchers synthesized a theoretical evaluation framework to investigate the concepts associated with the research questions. The framework is comprehensive, comprising various categories populated with sets of criteria and subcriteria. To justify and validate the synthesis, the tabulated framework includes a column citing the publications from which the criteria originated. Hence, the table occupies considerable space – both in the text and in the List of References, and is beyond the capacity of this paper. However, it is partially incorporated in the paper, since the questions in the questionnaire (see next section) are based on criteria in the framework, but in more concise terms. Questionnaires were administered to the 21

science teachers. Some responses were options on a 5-point Likert scale; others were True/False; while yet others were open-ended to obtain qualitative data. Participants were also asked about their ICT professional development programmes and the hardware and software supplied to their schools.

FINDINGS OF THE MAIN STUDY AND DISCUSSION

Table 4 lists some of the questions in the questionnaire, along with tallies of the teachers' responses. As explained, the questions are based on criteria from the evaluation framework. Selected responses are discussed after the table, along with mention of a few associated qualitative findings.

Table 4: Findings of the Empirical Study

Criterion A ~ Perceived Technology Importance in Education					
Criterion A1: Human and Social Rational		**Yes/ True**	**Not Sure**	**No/ False**	
A.I.1.1	*ICT enhances students' performance and progress*	19	1	1	
A.I.1.2	*Improvement in students' attitude when technology is used, as an indication of positive change*	15	4	2	
A.I.2.1	*I enjoy using technology to help students have an authentic view of real-world phenomena*	15	3	3	
A.I.2.2	*I believe e-learning can help me to become more innovative in class*	14	4	3	
A.I.3.1	*I believe e-learning can support the instructional process*	16	4	1	
Criterion A2: Pedagogic Rationale					
	Students enjoy learning activities that take place in computer labs	7	1	13	
A.II.2.1	*My students are more motivated and engaged in a subject when feedback is provided immediately via technology*	21	0	0	
A.II.2.2	*Technology is just a tool to help students do things and cannot help them develop higher-order thinking skills*	2	0	19	
Criterion B ~ Barriers to ICT Integration					
Criterion B1: Lack of, or limited, professional development					
B.1.1	*Do you see your role today as being a mentor and facilitator of learning, rather than just being an instructor?*	12	7	2	
		Internal	**Outside**	**Never**	
B12	*What type of ICT professional development programmes have been offered to teachers in your school?*	3	11	5	
Criterion A ~ Perceived Technology Importance in Education					
Criterion A1: Human and Social Rational		**Strongly Agree**	**Agree**	**Not Sure**	**Dis-agree**	**Strongly Disagree**
A.I.1.2	*I am content with a traditional way of teaching*	1	2	0	13	5
A.I.3.1	*The way I personally view and use technology has an effect on the students' attitude to ICT integration in my teaching and their learning*	12	5	4	0	0
Criterion B ~ Barriers to ICT Integration						
Criterion B2: Time Allocation for Teachers' Use of ICT Resources						
B.2.1	*The school periods in which computers are used are long enough to complete all the tasks*	0	0	0	17	4
Criterion B3: Infrastructural Support and Technological Issues						
B.3.2	*It is essential for teachers to have basic computer skills before using technology for subject-related activities*	17	4	0	0	0
B.4.2	*My students need basic computer literacy skills before integration of ICT into the science classroom*	19	2	0	0	0
Criterion B4: Impacts of Motivation and Occurrence of Distraction						
B.4.3	*In my class, students like to discover new things by themselves when they are motivated*	11	4	5	1	0
B.4.4	*Technology can distract students from the learning content.*	0	3	2	2	13
B.4.5	*Students also use the technologies for activities not related to subject matter.*	6	8	1	4	2
Criterion C ~ ICT in Science Classrooms						
C.3	*By using e-learning software, I am able to demonstrate various scientific phenomena*	5	14	2	0	0

C.1	*It is essential to use animation and simulation software in teaching Science, since it facilitates students' acquisition of scientific processing skills*	7	13	1	0	0

The findings presented in Table 4 are now discussed.

Criterion A ~ Perceived Technology Importance in Education

Criterion A1: Human and Social Rationale

Ten questions in the questionnaire address teachers' perceptions on the social and subjective aspects of technology use in schools by both teachers and students.

The findings from this criterion indicate that teachers from all three projects perceive the value of technology for themselves and their students. The human and social reasons for ICT integration in schools are in agreement with findings from other research, both in the region (Howie and Blignaut, 2009) and elsewhere (Kozma, 2005; Yücel et al. 2010). As also indicated in the literature, students collaborated better with each other in the context of ICT-based lessons.

For example, in answering the question for **Criterion A.I.1.1,** most teachers (19 out of 21, 90%) from the participating schools believed that ICT enhances students' performance and progress. This is shown in Table 5. This result largely corresponds with the response to **Criterion A.I.1.2,** where only three teachers (14%) preferred to continue with traditional teaching. By implication the other eighteen teachers, 86%, considered that teaching supplemented with the use of technology is better than traditional teaching. With regard to e-learning (**Criterion A.I.2.2** and **Criterion A.I.3.1**), 67% and 76, respectively felt that e-learning could support them in more innovative reaching, while a greater percentage believed that e-learning could enhance instruction.

Criterion A2: Pedagogic Rationale

Apart from technology factors based on human and social rationale, the teachers answered questions on their perceptions of the pedagogic rationale for integrating ICT and e-learning into class-based teaching and learning. For example, they were required to indicate if technology is merely a tool to help students do things and that it cannot help them to develop higher-order thinking skills. In answering the question for **Criterion A.II.2.2)**, only two teachers (both from the SchoolNet Project) believe that higher-order thinking skills could not be developed in students by use of ICT. Answering a negatively-phrased question such as this, calls for discerning thought in response, but among STIC and E-School teachers, there was a strong conviction that e-learning can improve students' development of cognitive skills.

Qualitative data confirmed these sentiments. In the interviews, it was noted that teachers who had attended the orientation sessions and subsequent training, discussed their perception of teaching and learning with technology and the integration of ICT into subject teaching, i.e. e-learning focused on the curriculum, with more realistic and optimistic views. A teacher who had attended almost all the workshops and had become familiar with different forms and methodologies of e-learning commented: *'I am sure everyone will agree that teaching and learning with technology is the best way ever, if one want to improve his work. Two years ago when I was introduced to this concept, I thought this will be just one more way of wasting my time, ... I can assure you (that now) without technology I would hardly teach'*.

Despite teachers' generally positive perception of the usefulness of ICT and e-learning, they also list barriers hindering technology adoption, as discussed in the next section.

Criterion B ~ Barriers to ICT Integration

On criterion B, results are consistent with the findings of research by Kalanda and de Villiers (2008) which reports a lack of, or limited, professional development as being among the main barriers to ICT use in schools in Lesotho. However, 90% of the respondents in this study consider that, if proper professional development programmes were in place and learning resources were adequate, in terms of both hardware and software, it would contribute notably to helping teachers integrate e-learning into their teaching. This in turn, would enhance the learning outcome for students. For example, from the data in response to **Criterion B12**, it appears that teachers in rural areas are not exposed to any form of professional development. When asked about the type of ICT professional development programmes offered in their school, five (24%) indicated they had never attended any

internal training, nor workshops or seminars of any kind. Among them were three SchoolNet participants (out of the four from SchoolNet) and two from E-School. All five were employed in rural schools. This might explain why SchoolNet teachers had negative perceptions of ICT in improving students' attitudes, acknowledging that their own views of technology impacted on the students (**Criterion A.I.3.1**). In responding to **Criterion B.2.1**, teachers disagreed or strongly disagreed that sufficient time was allocated to school period in which technology was used. In answers relating to **Criterion B.3.2**, they felt that they should have computing skills before using e-learning for subject-related activities. From the interviews, it correspondingly emerged that a number of teachers felt their own skills were not adequate for what was expected of them.

Finding from this study's observation also show an inconsistency between the software facilities used in administration and preparation and those used for teaching and learning. The researcher also noted with concern that difficulties with software licences and incompatibility due to upgrades, were preventing use of all the technologies available.

Results from statistical regression analysis (Tables 5 and 6), determine the variance between the two variables and indicated a strong relationship between the dependant variable (Teachers' Perception) and independent variable (Teachers' ICT Use). It also indicates that the statistically significant predictor accounted for close to half of the variance in attitude toward ICT integration (R^2 = .418). The coefficient is significant at 5 percent level of significance i.e. the *p-value* is 0.05. The coefficients of the model indicate that Teachers' Use of ICT accounts for 43.8 percent variation in the Teachers' Perception of ICT integration. Since the sign of this coefficient is positive, it can be concluded that the more time teachers spent using computers, the more their perception improved toward ICT integration in school, i.e. barriers can be broken down..

Table 5: Descriptive Statistics ANOVA(b)

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	4.159	1	4.159	4.021	.059(a)
	Residual	19.651	19	1.034		
	Total	23.810	20			

a Predictors: (Constant), Teachers' ICT Use
b Dependent Variable: Teachers' Perception

Table 6: Descriptive Statistics Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.262	.849		2.665	.015
	Teachers' ICT Use	.437	.218	.418	2.005	.059

a Dependent Variable: Teachers Perception

Results for the Pearson Correlation Coefficient analysis involved measuring the strength of a linear relationship between two variables. The results show that there is a positive correlation between teachers' perception of ICT use in class and actual ICT use by teachers valued at 0.42. This indicates that as teachers' perception of using ICT improves, it tends to impact positively on ICT integration in the school in general, reflected by actual usage.

A positive correlation (r = .041) is evidence of a general tendency that high values of independent variable (X) are associated with high values of the dependent variable (Y). This suggests that increased use of computers in education is linked to a more positive perception. This is in agreement with previous studies which found that pre-service teachers' frequency of technology use are a key factor in predicting the attitude toward computers (Kalanda and Oliphant, 2009).

Criterion C ~ ICT in Science Classrooms

According to a study by Slaouti and Barton (2007), 90% of teachers agree that the use of ICTs makes them more effective in their teaching of science and enhances their students' performance to meet changing needs. Similar findings emerged here. An important finding from **Criterion C3** is that most teachers (90%), including those in rural areas, believe that current e-learning applications allow them to demonstrate various scientific phenomena to their students (**Criterion C3)**. Only two teachers were not sure. These two were among the five who had never attended professional development. **Criterion C1** investigates whether the use of animations and simulations facilitates students' acquisition of scientific skills. Nearly all teachers (95%), except one, agreed.

Moreover, the teachers in the Slaouti and Barton study found that, with access to the Internet and related technologies, their science lesson plans were richer. They reported that when ICT was properly integrated into the curriculum, it could motivate students by bringing variety into lessons and stimulating the teachers' own interest in teaching.

Table 7 demonstrates that the situation regarding ICT tools in Lesotho high schools and their use, has improved.

Table 7: **Computer Tools Available, Tools Used by Teachers, and Tools Used by Student.**

	Available in Schools		Used by Teachers		Used by Students	
	Total	Perc.	Total	Perc.	Total	Perc.
Computing Tools						
Word Processing	17	80%	17	80%	8	38%
Spreadsheet	16	76%	15	71%	8	38%
PPt Presentation	14	67%	8	38%	9	43%
Database	3	14%	1	5%	2	9.5%
E-learning Software						
Tutorials	11	52%	9	43%	6	28%
Drills	12	57%	9	43%	6	28%
Simulations	10	48%	9	43%	5	24%
Educational Games	13	62%	10	48%	6	28%
Internet / E-mail	10	48%	9	43%	4	19%
Video Conferencing	0	0%	0	0%	0	0%
Smart board	6	28%	5	24%	3	14%
Digital Camera	6	28%	6	28%	7	33%
Computers	21	100%	20	95%	11	52%

For example, from an almost total absence of Web-based, educational games in earlier studies, 62% of the teachers in the Main Study reported that educational games were available to them and 48% of the teachers were using them in their teaching. Yet only 28% of teachers indicated that their students were using them. There appears to be a pattern, in which teachers use e-learning software for preparation and for demonstrations in class, but students personally have very little interactive hands-on exposure to these tools. Although 76% report availability of spreadsheets and 71% of the teachers were using them, only 38% were aware of students using them. This is unfortunate, because spreadsheets can play a useful role in recording and processing scientific data. Regarding tutorials and simulations, which assist students in learning and exploring phenomena, 48% and 52% of teachers, respectively, had availability, and for both tools 43% of teachers were using them; yet only 28% and 24%, respectively, were aware of students using them.

In contrast, the reported student use of video cameras in Table 7 was 33%, more than teachers' use, which was 28%. Availability was also only 28%. In observing sessions where students presented science projects, the researcher saw several students showing videos they had made. The figures (with student use higher than availability) imply that some of the videos were made on cameras not belonging to the school or possibly taken on cell phones.

CONCLUSION

The broad objectives of this research in nine selected schools were to study the progress and effectiveness of ICT integration in the teaching and learning of science in Lesotho. In support of this quest, perceptions of Lesotho high school science teachers were investigated regarding the use of ICT and e-learning in the classroom. Barriers to ICT implementation in schools were studied. Principals and teachers were queried on ICT professional development programmes and, finally, the ICT infrastructure supplied to schools was ascertained and to what extent it was used by teachers and students. Multiple research methods were used to obtain quantitative and qualitative data: namely, questionnaires, interviews and observation, within a variant of action research that was employed as the underlying research design.

It was established that Lesotho schools are improving in terms of the extent and use of ICT tools in schools, although there is a lag in rural regions. The findings of the Main Study in the action research process, show that it is insufficient merely to equip schools with computers and educational software; these tools should be employed in optimal ways, ensuring that students have opportunities for hands-on interaction. For teachers to maintain and increase their competence in the use of technology and the motivation to use ICT and e-learning, they should receive ongoing professional development and be supported in appropriate pedagogy. It should therefore be a priority for national education stakeholders to prepare a new generation of teachers who will use technology in innovative ways to enhance learning across the entire kingdom. Although the application area of this research is science education, the conclusions and recommendations are transferable to other disciplines and curricula.

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