



OBSTACLES TO ICT INTEGRATION IN MATHEMATICS AND SCIENCE CLASSROOMS

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Abstract

This paper argues that lack of School ICT policy is a major obstacle in the Integration of ICT in the classrooms. The elimination of this obstacle is one thematic area among others that should be addressed. The major crosscutting obstacle in the study was found to be insufficient digital learning materials in the form of learning objects, electronic content, syllabus, encyclopaedias and subject-enrichment CDs or DVDs .A survey design was employed to collect data from Mathematics, Science and ICT Teachers and school Principals using Second Information and Technology Education Study (SITES) adapted questionnaires. The results show that the elimination of this obstacle could possibly ensure sufficient funding, appropriate knowledge and skills, efficient leadership, proficient teachers and competent students.

Key words: Integration, ICT policy, thematic areas, Obstacles, Classrooms

SECTION 1.0

INTRODUCTION AND BACKGROUND

ICT is a vital tool for teaching and learning. The integration of ICT into the curriculum can benefit learners in at least two ways: firstly, by providing an opportunity to learn useful ICT skills and, secondly, by making it possible for learners to become creators of knowledge in their own right [13]. Case studies around the world have shown that the integration of ICT in Science learning can enable innovative classroom practices [26]. That ICT is a vital tool for teaching and learning in the classroom is reinforced by the World Bank's 2010 report, which envisaged that, because Eswatini is not naturally resource-rich, the acceleration of its growth and global competitive can be achieved through ICT [20].

This paper reports on a study that investigated the integration of ICT in form four Mathematics and Science classrooms. It begins with the purpose of the research (section 1.1). The statement of the problem and rationale is captured (section 1.2), followed by the research questions (section 1.3). The section on related studies and context is presented in section 2. This section covers concept clarification, further discusses the status of ICT and captures the introduction of ICT in Swazi schools using the three phase model. The review also compares the various ICT integration frameworks. The theoretical perspective is also presented in the same section followed by the methodology (section 3), presentation of results (section 4), discussion of findings (section 5), leading to conclusions (section 6), and recommendations (section 7).

1.1 Purpose of Research

The purpose of this study is to investigate how to integrate Information and Communications Technology (ICT) in Eswatini Mathematics and Science classrooms, both of which are core subjects. Lessons to be learnt from the integration of ICT in Mathematics and Science will lay the foundation for roll out to cover other learning areas. This will transform the country to an information society [24] and bridge the digital divide which exists between Eswatini and developed countries.

1.2 Rationale and research Problem

Low levels of ICT literacy are being experienced in the Kingdom of Eswatini, even though teachers and students have access to ICT resources. In many schools, teachers are grappling and struggling with the question of how to use ICT for instructional purposes [3], particularly at a time when an increasing number of computers that have been donated to schools by the Swazi government, the Computer Education Trust, the Coca-Cola Foundation and other corporate donors including world vision are lying idle or reportedly stolen.

1.3 Research questions

The study research questions were:

1. What is the ICT literacy status of teachers in Eswatini schools?
2. What obstacles prevent the integration of ICT in mathematics and Science classrooms?

SECTION 2.0 RELATED STUDIES AND CONTEXT

Although many studies have been conducted on ICT in education, the International Association for the Evaluation of Educational Achievement (IAEEA) has conducted the Second Information and Technology Education Study (SITES). The four instruments used in this study were adopted and adapted from SITES as an ordinance datum for this study.

The following aspects make SITES important to Eswatini:

SCOPE – SITES as an international study, covered about 37 countries

AIMS (i) SITES examined the extent of ICT integration in teaching and learning

(ii) SITES identified the factors for ICT integration

DESIGN – SITES instrument design process was collaborative

CONCEPTUAL FRAMEWORK – focused on ICT use in classroom

CONTEXT – Southern African context was covered

Based on the review of related studies the following concepts used in this study are described below:

CONCEPT	CLARIFICATION
DIGITAL DIVIDE	Disadvantages, obstacles, constraints (mostly educational, technological and financial) and increased disparity between individuals who have the means to access information and those who do not. [9]
ICT	Electronic and digital technologies for the storing, processing, transferring of information and communication [11]
INTEGRATION	The pedagogical use of ICT for Learner Centred Education [13].
RURAL DIVIDE	Disadvantages and constraints faced by rural people and rural segments of society which excludes them from accessing appropriate and timely information and communication technologies services [25].

2.1 ICT integration status

The pedagogical use of ICT in the Kingdom is conceptualised into three phases. The three phases of ICT integration are shown below.

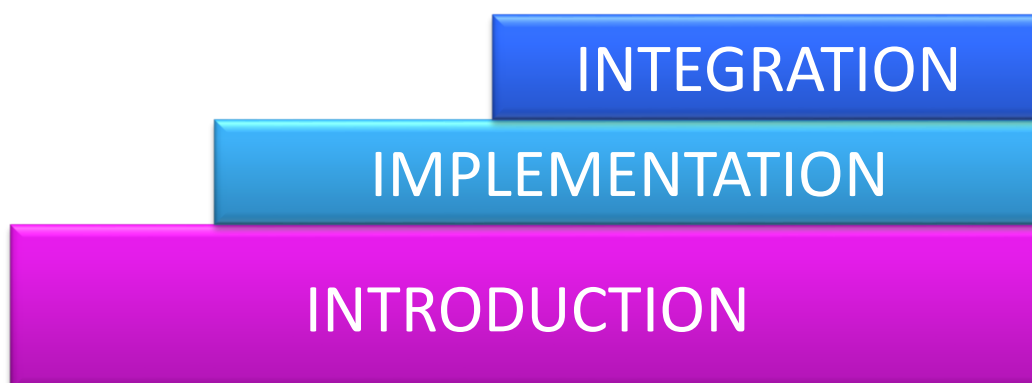


Figure 2.1: The Three Phase Model

In the introduction phase schools received a donation of 20 to 45 computers from the Computer Education Trust (CET), accompanied by students' training manuals, "likusasa lakho manuals' [15]. In the Implementation phase the Education

Management Information System (EMIS) unit in the Ministry of Education and Training (MoET) supplied 10 computers to the schools, and Principals were expected to write a letter to the Ministry to requisition. This project is sustained through funding from the Republic of China on Taiwan. It is expected under this phase that the schools should include ICT as a subject in the curriculum.

In the Integration phase schools should have an ICT policy, and purchase five computers per year to replace the old and refurbished ones from CET. In addition, ICT should be included in the curriculum as a subject and be examined by Cambridge International Examinations (CIE). Schools striving to be in this phase have invested in N-computing, whereby a number of terminals, usually 10 are linked to one systems unit. The schools register for Cambridge 0417 ICT syllabus.

2.2 ICT Integration Frameworks

ICT integration frameworks are categorised into achievement frameworks, cognitive frameworks, cross curricula tool frameworks, software frameworks, technology frameworks, pedagogical frameworks and evolutionary frameworks. Table 2.1 below presents a juxtaposition comparison of the three phases of ICT use in Eswatini with the various ICT integration frameworks. Most of the frameworks have four to six rationales, models, stages, uses, tools, taxonomies, levels and eras to bring about ICT integration yet the Swazi three phase model has three processes namely introduction, implementation and integration.

Table 2.1: Aligned ICT integration frameworks

SWAZI THREE PHASE MODEL PROCESSES / FRAMEWORK	ACHIEVEMENT FRAMEWORK (MILLERS MODEL)	INSTRUCTIONAL TECHNOLOGY FRAMEWORK	EVOLUTIONERY FRAMEWORK (ACOT)	SOFTWARE FRAMEWORK	PEDAGOGICAL FRAMEWORK	CROSS CURRICULAR TOOL FRAMEWORK	COGNITIVE FRAMEWORK (BLOOM)	TECHNOLOGY FRAMEWORK
INTRODUCTION PHASE	Social rationale / Introduction	Transmission model	Entry stage	Emerging Stage/ Topicality	Active use	Productivity Tool	Behaviourism theory & Remembering	CAI/ Computer Assisted Instruction development
IMPLEMENTATION PHASE	Entry	Participative model	Adoption stage	Applying Stage / Surrogacy	Collaborative use	Cognitive Tool	Cognitive theory & Comprehension	MM/ Multimedia Learning development
	Vocational rationale / Intermediate		Adaptation stage		Innovative use	Communication Tool	Objectivism theory & Applying	IT/ Information & Internet development
INTEGRATION PHASE	Pedagogical rationale / Penultimate	Learner centred model	Appropriation stage	Infusing Stage / Progression	Creative use	Problem solving Tool	Constructivism theory & Analysing	LMS / Learning management system development
	Catalytic rationale / Creation	Integrated model	Invention stage	Transforming stage / Pedagogic evolution	Integrative use	Research Tool	Performance support theory & Synthesis	CIE / Computer Integrated Education E-Learning / live online learning development
	Cost effective rationale				Evaluative use	Reflective Tool	Evaluation	DE –Ubiquitous / Distance learning development
PROPONENTS	Pam Miller	R. Bottino	David Dwyer	UNESCO Stephen Hepell	J.M.Voogt W.J.Pelgrum	Barron, Kemker, Harnes & Kalaydjian	John Keller Robert Kozma Richard Clark David Merrill Bloom Robert Gagne' Jean Piaget Lev Vygotsky	Seymour Papert Badrul Khan Tim Bernes Lee

2.3 Theoretical Perspective

The theoretical framework for the study was adapted from the “Four in Balance” Dutch Kennisnet model (see Figure 2.1, below). The Kennisnet model provides an up to-date overview of ICT developments in primary and secondary education. It assists in implementing ICT in schools in a balanced and lasting way, with inter-school comparisons [17]. Key to the Kennisnet model as a framework is that for pedagogical use of ICT to take place certain structures should be in place.

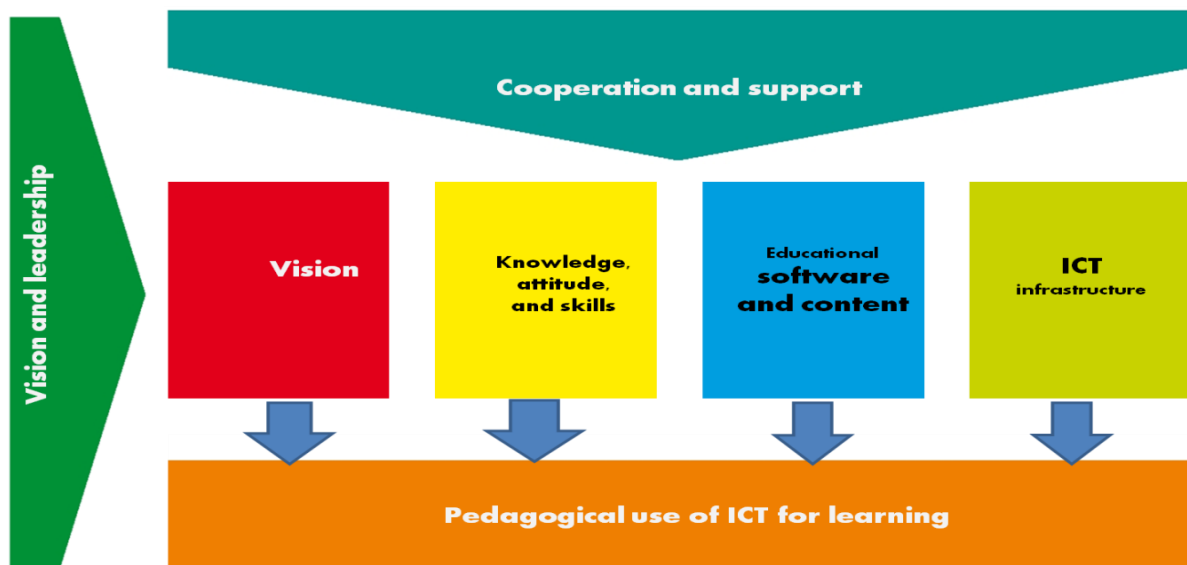


Figure 2.1: The Kennisnet Model

Source: Kennisnet -<http://www.ictopschool.net>

Vision and leadership as a structure is defined by ICT policy in schools [18]. Whereas the national vision on education guides the choices in respect of the use of ICT in the curriculum, the integration of ICT at school level starts with a vision.

It emerged in the course of the study that the kennisnet being a Netherlands model did not quite articulate the learners dimension and fully describe the factors that could possibly explain the pedagogical use of ICT yet [14] has aligned the kennisnet model with Kozma’s policy alignment, intellectual resources and distributed policies to come up with factors related to pedagogical use of ICT .The “Howie alignment Model” below (Figure2.2) has been used to provide the theoretical and conceptual basis for the analysis of data.

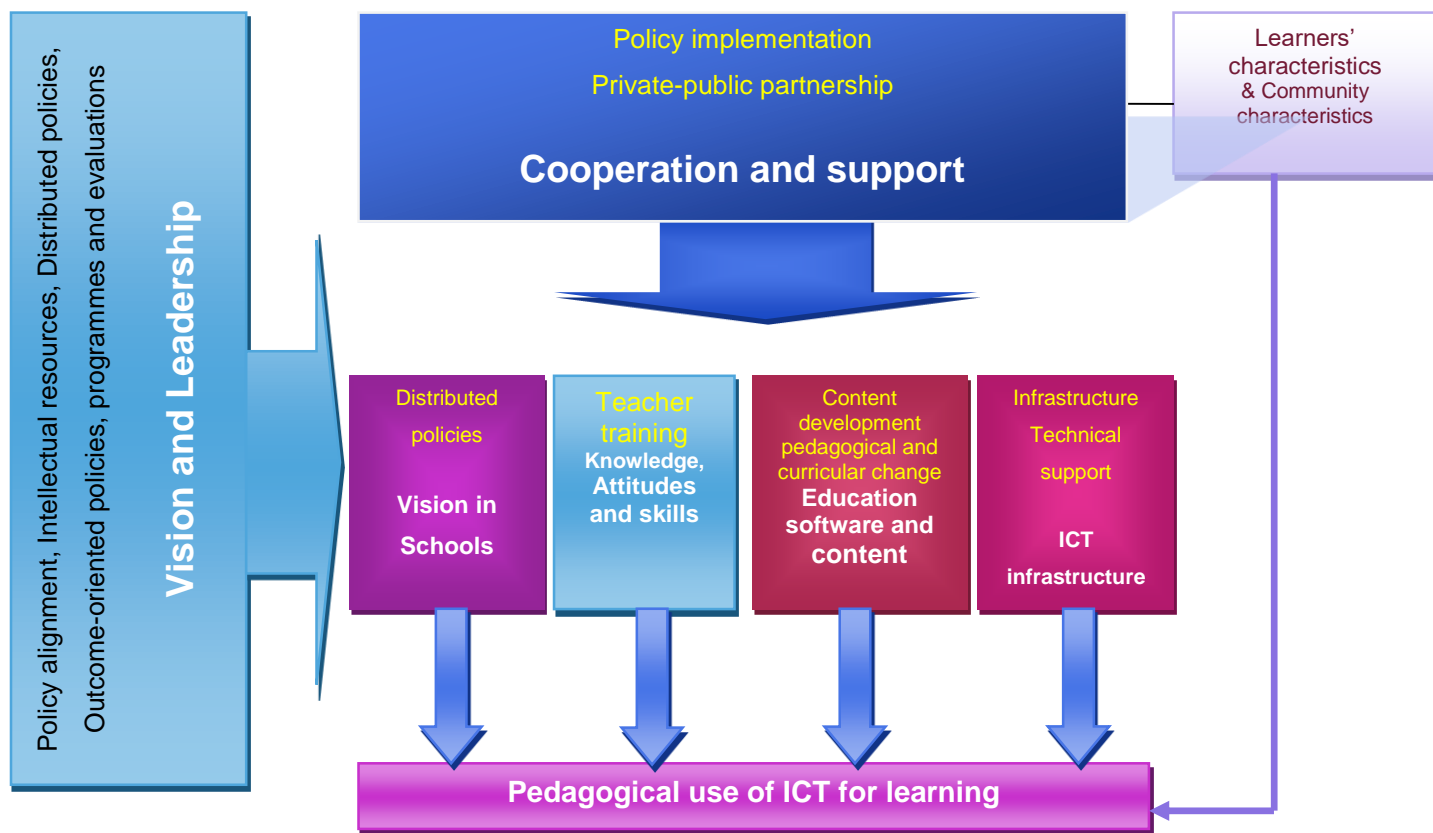


Figure2.2: Factors related to pedagogical use of ICT by Howie 2010

SECTION 3.0 METHODOLOGY OF RESEARCH

The research methods used in the study were quantitative [6], in the form of self-administered questionnaires. The preliminary activities of this inquiry included desktop research, document analysis, exploration of ICT materials from government and policy statements, interviews and content analysis of publications. Data was gathered from policy documents, teachers and principals, in line with the Kennisnet model

3.1 Research typology

A survey design was undertaken and the study was descriptive in nature, using measures of central tendency and multi-dimensional measurement analysis procedures [5]. The study was also exploratory, looking at individuals, groups, institutions, methods and materials in order to describe, compare, contrast, classify, analyse and interpret the entities and events to constitute the field of inquiry [6].

3.2 Research Procedures

The self-administered questionnaires were delivered and collected from the schools using a research-tracking form. The response rate was 87% (N=149). The SITES 2006 South African instruments were used in this study. The permission to use the STES module was obtained through the Centre for Evaluation and Assessment (CEA). Four questionnaires were used to collect data. The reliability was calculated from a Probability Proportion to Size (PPS) sample using the Statistical Package for Social Sciences (SPSS) and Chronbach Alpha was found to be 0.80, a very high reliability coefficient.

The sampling frame in this study was 43 schools in the Manzini region. The up-to-date list of schools was provided by the Education Management Information Services (EMIS) in the MoET. The selected schools had an ICT laboratory, ICT teacher and computers that were either purchased by the school, donated by the *Coca Cola Foundation*, CET or the government through the MoET. A sample was drawn up that included research participants in four groups, relevant to the operational research questions, namely the ICT teachers, Mathematics teachers, Science teachers, and school Principals.

3.3 Data Analysis

The Statistical Package for Social Sciences (SPSS) was used in the analysis of data, which was coded and analysed to derive meaning. Descriptive and inferential statistics in the form of factor analysis were used to factor out the principal components [8]. The findings were mostly presented in tables, graphics and narrative form to address the study research questions.

RQ1: What is the ICT literacy status of teachers in Eswatini schools?

This research investigated ICT literacy status (knowledge, attitudes and skills of Principals, ICT teachers, Mathematics and Science teachers), funding, budget priorities, availability of educational software and content (books, programs and syllabus), what types of computer hardware were available, by whom it was being used and for what purpose, and how Internet access was provided. . This question was addressed through questionnaires to the schools and measures of central tendency were generated from baseline data.

RQ 2: What obstacles prevent the integration of ICT in Mathematics and Science classrooms?

Related ICT obstacles and barriers were studied for a holistic investigation to present meaningful findings on what possible factors could explain the pedagogical use of ICT. There were three constructs, namely ICT infrastructure, ICT integration and ICT obstacles.

The overall factor analysis of the data by the researcher while drawing from the conceptual framework, produced the thematic areas on the integration of ICT in the Mathematics and Science classrooms.

SECTION 4.0 PRESENTATION OF RESEARCH RESULTS

The total number of respondents was 149, from four departments in 43 schools. The numbers of research participants by job category are shown in Figure 4.1.

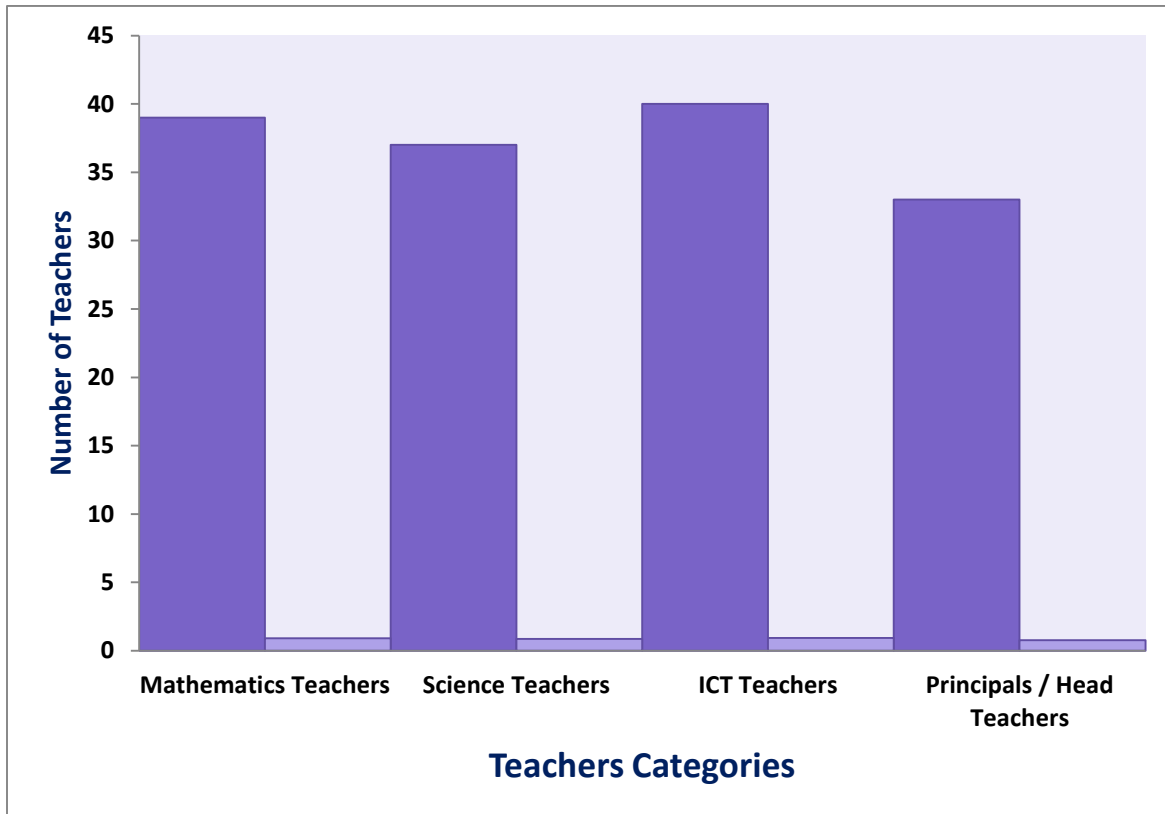


Figure 4.1: Research participants by job category

As shown in figure 4.1 above there were 39 mathematics teachers, 38 science teachers, 33 Principals and 40 ICT teachers who participated in the research. In terms of the status quo of ICT integration in Eswatini schools the findings revealed that the Principals and ICT teachers were mainly male (67% and 63% respectively), whereas the majority of Mathematics and Science teachers were mostly female (72% and 67% respectively). The age range was 46 to 55 years for Principals, 21-35 years for ICT teachers, and 30-39 years for both Mathematics and Science teachers. In terms of ICT literacy, 67% of the ICT teachers were diploma holders, whereas 72% of the Mathematics and 78% of the Science teachers had no ICT qualification.

4.1 Results on RQ. 1: What is the ICT literacy status of teachers in Eswatini schools?

It is evident from Table 4.1 (below) that most of the ICT teachers were diploma holders and most of the Mathematics and Science teachers had no ICT qualification. Very few ICT teachers (2) had a degree.

Table 4.1: Qualification of teachers

	Qualification	Science	Mathematics	ICT
Highest Qualification	High School	1	2	12
	Diploma	8	11	22
	Degree	26	23	2
	Honours	1	1	0
	Masters	2	2	0
ICT Qualification	None	28	26	12
	Certificate	7	8	4
	Diploma	1	1	22
	Degree	2	4	2

4.2 Results on RQ2: Obstacles to ICT Integration in Schools

There were major and minor crosscutting obstacles to ICT integration in the schools as shown in Table 4.2. The major crosscutting obstacle in the study was found to be insufficient digital resources, for instance digital learning materials in the form of learning objects, electronic content, syllabus, encyclopaedias and subject-enrichment

Table 4.2: Obstacles to ICT integration in schools

Obstacles	Count (No. of teachers) Science Teachers		Count (No. of teachers) Mathematics Teachers		Count (No. of teachers) ICT Teachers		Count (No. of teachers) Principals		Count (No. of teachers) Budget Priority	
	No	Yes	No	Yes	Somewhat	great extent	Somewhat	A lot	Low	High
Insufficient qualified personnel	21	15	21	15	5	12	5	16	3	17
Insufficient on Internet computers	24	12	19	18	<u>3</u>	24	<u>2</u>	24	3	18
Insufficient Internet bandwidth	22	14	19	18	4	20	3	19	6	15
Lack of special ICT equipment	24	12	24	13	<u>3</u>	9	3	8	4	16
Insufficient ICT equipment	24	12	11	26	9	19	9	15	9	11
Computers are out of date	24	12	19	18	11	12	3	11	3	18
Insufficient digital resources	<u>8</u>	27	<u>7</u>	30	6	22	10	18	4	16
Lack of ICT tools	10	26	11	26	9	21	12	13	3	14
Teachers' lack of ICT skills	21	15	23	13	7	8	5	19	3	17
Insufficient time for teachers	16	20	18	19	7	15	<u>7</u>	17	<u>1</u>	18
Curricula are too strict	17	19	22	15	5	<u>5</u>	3	5	10	12
Insufficient space for integration	17	19	21	15	9	10	6	6	3	14
Insufficient budget	<u>8</u>	27	19	18	10	10	5	8	3	18
School goal anti integration	20	16	26	11	5	9	<u>2</u>	4	3	14
Frequent power outages	17	17	19	18	11	9	3	8	9	11
Learners ICT skills	19	15	19	18	11	10	3	8	<u>1</u>	25
Access to ICT outside the school	22	14	19	18	<u>3</u>	24	3	19	<u>1</u>	18
Pressure of standardized tests	20	16	20	17	9	10	3	5	<u>1</u>	18
Insufficient confidence	18	18	25	12	7	8	5	19	3	17
Access to the required ICT tools	24	12	24	13	9	19	9	15	4	16

Loading components under Obstacles to ICT Integration

In total there were 35 loading components under ICT obstacles, as captured in Table 4.3, and as summarised in Figure 4.2 (below). The major loading obstacle in Mathematics teachers, Science teachers and ICT teachers’ “ICT worlds” was lack of ICT policy as the main thematic area to be addressed for the successful integration of ICT.

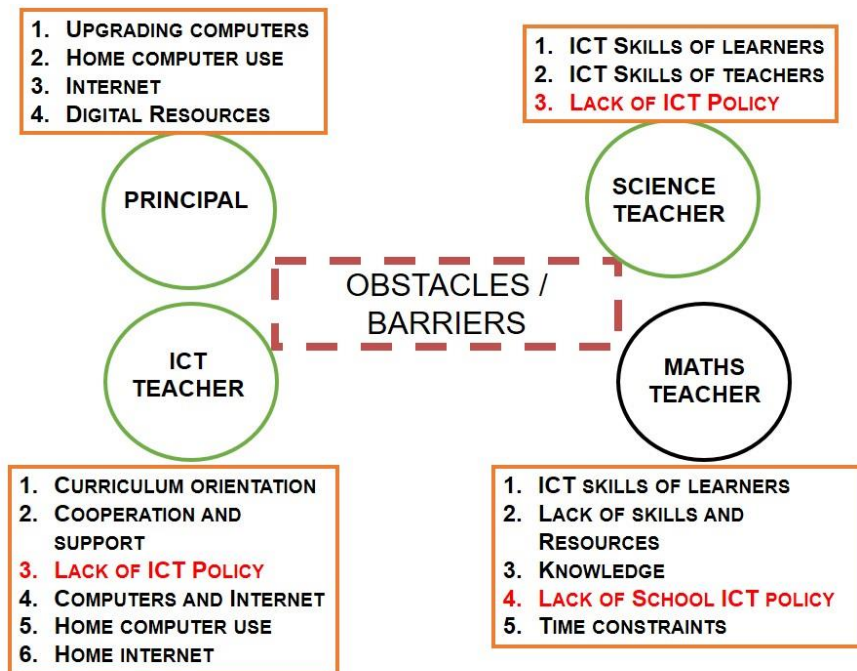


Figure 4.2: Obstacles in teachers’ “ICT worlds”

Table 4.3: Loading components under obstacles to ICT Integration

Factors	Description	Variables presented for F.A.	Response Options	Loading Components labels (Correlations Varimax)	Chronbach's Alpha (KMO)	Variables per component	Eigen values	BToS X ² (df)
1.Finance	Subject fee.	2	Actual numbers	<i>Computer fees (0.99)</i>	0.97(0.5)**	2	1.9	42.6(1)*
2.Head teacher Profile	Computer usage by the Head teacher	3	1-No 2-Yes	<i>Home computer use (0.76)</i>	0.38(0.5)**	2	1.2	1.3(1)
3. ICT teacher Profile	Computer usage by the ICT teachers	3	1-No 2-Yes	<i>Home Internet available (0.83)</i>	0.47(0.5)**	2	1.4	4.9(1)
4. Science Teacher Profile	Computer usage by the Science teachers	3	1-No 2-Yes	<i>Home computer use (0.87)</i>	-0.61(0.6)**	2	1.3	5.0(28)
5. Mathematics Teacher Profile	Computer usage by Mathematics teachers	3	1-No 2-Yes	<i>Home computer use (0.87)</i>	0.40(0.5)	2	1.5	5.5(3)
6. Science Learners Profile	ICT competences of Learners	9	1-Nearly none 2-Some learners 3-Majority of learners 4-Nearly all learners	<i>General skills (0.73)</i> <i>Popular skills (0.76)</i>	0.89(0.7)	5 4	4.8 1.1	169.3(36)*
7. Mathematics Learners Profile	ICT competences of Learners	9	1-Nearly none 2-Some learners 3-Majority of learners 4-Nearly all learners	<i>General skills (0.77)</i> <i>Popular skills (0.77)</i>	0.97(0.8)**	5 4	5.0 1.3	189(36)*
8.Curriculum orientation	The teaching style and paradigms in the various subjects	9	1-Never 2-Sometimes 3-Often 4- Always	<i>Basic subjects (0.86)</i> <i>Common subjects(0.74)</i>	0.90(0.7)**	5 3	5.2 1.4	173.2(36)*

* $p < 0.001$ significant correlations between items were sufficiently large for principle component analysis

** Acceptable sample size to yield reliable factors.

Table 4.3: Loading components under obstacles to ICT Integration continued

Factors	Description	Variables presented for F.A.	Response Options	Loading Components labels (Correlations Varimax)	Chronbach's Alpha (KMO)	Variables per component	Eigen values	BToS X ² (df)
9.Policies	ICT policies provide for the vision.	11	1-No 2-Yes	<i>Lack of School ICT Policy(0.12)</i>	0.55(0.5)**	2	1.4	6(1)
10. Head teacher Obstacles	Explains the usage of computers by the ICT teachers	15	1-Not at all 2-Very little 3-Somewhat 4-To a great extent 5-Not applicable	<i>Upgrading Computers (0.69)</i> <i>Internet Connection(0.89)</i> <i>Digital Resources (0.71)</i>	0.80(0.5)**	2 2 3	4.5 2.3 1.7	204.1(105)*
11. ICT Teacher Obstacles	Explains the usage of computers by the Science teachers	15	1-Not at all 2-Very little 3-Somewhat 4-To a great extent 5-Not applicable	<i>Curriculum Orientation (0.71)</i> <i>Cooperation and Support (0.81)</i> <i>Lack of School ICT policy(0.77)</i> <i>Computers and Internet(0.77)</i>	0.87(0.6)**	6 4 2 2	5.6 3.0 1.5 1.1	366.7(105)*
12. Science Teacher Obstacles	Explains the usage of computer by the Mathematics teachers	12	1-No 2-Yes	<i>Learners and Teachers ICT skills(0.73)</i> <i>Lack of School ICT policy(0.75)</i>	0.70(0.5)**	4 3	3.3 1.6	119.6(66)*
13. Mathematics Teacher Obstacles	Explains the ICT competes of Learners	12	1-No 2-Yes	<i>Lack of skills and Resources(0.65)</i> <i>Knowledge(0.77)</i> <i>Lack of School ICT policy(0.69)</i> <i>Time constraints(0.82)</i>	0.7(0.6)**	5 2 3 1	3.6 1.8 1.3 1.0	120.9(66)*

*p < 0.001 significant correlations between items were sufficiently large for principle component analysis

** Acceptable sample size to yield reliable factors.

SECTION 5 DISCUSSION OF FINDINGS

5.1 ICT Integration status of Eswatini Schools

Although more than half of the schools had up-to-standard computer laboratories, the study found that the student: computer Ratio (14:1) to be very high. Although comfortable with word processing, the Mathematics and Science teachers lacked general ICT skills and as such the pedagogical use of ICT. Most indicated that they would like to attend a professional development course in ICT training [1].

The maintenance of ICT infrastructure was found to be lacking. It was a disturbing finding of this research that the average number of broken computers per school was nine. The percentage of schools that had access to the Internet was 17.9%, with 64% of the schools indicated that they had a whiteboard.

5.2 Obstacles to ICT Integration in Mathematics and Science Classrooms

In this study the obstacles were insufficient digital resources, insufficient number of Internet computers, lack of ICT tools, insufficient ICT equipment, lack of access to ICT outside the school, and learners ICT skills. The major crosscutting obstacle in the study was found to be insufficient digital resources, that is digital learning materials in the form of learning objects, electronic content, localised syllabus, encyclopaedias and subject enrichment CDs, video CDs and DVDs., These obstacles to ICT integration emanate from lack of teacher confidence, lack of teacher competence, lack of access to ICT resources, lack of technical support, lack of resources, lack of time and effective training, resistance to change and negative attitudes [1]. Teachers with bad attitude wonder why they should abandon the safety and comfort of recognised subject pedagogy for the uncertainties and complexities that surround the use of ICT [16]. These teachers have labelled ICT as a “Trojan Horse” [16].

Researchers have shown that the integration of ICT into teaching and learning is a dauntingly complex and taxing process when school management is among the obstacles. [10].The school ICT infrastructure, professional activities and organisational features within secondary schools are among the major obstacles to integration of ICT [22]. The major obstacles are exacerbated by bad approach. The bottom-up approach is preferable to the top-down approach. Schools should look for the technology rather than it being imposed upon them. The top-down approach breeds resistance to ICT practice in secondary schools [21], and raises practical issues around sustainability and policy-related issues at national and school level [12]. In such settings, visionary principal leadership and availability of champion teachers, as well as ongoing Teacher Professional Development (TPD) coupled with a willingness to change, is important. Moreover, teachers need to adapt to change if they are to survive and keep pace with ICT. In line with the media debate between Clark and Kozma [4], the Swazi situation may confirm fears that computers in schools may be a waste of money.

The ICT obstacles as listed by the teachers, including the Principals, covered 18 thematic areas, with the lack of ICT policy emerging as a topical issue. This is a problem even in South African schools, where the Gauteng online project became "Gauteng offline" [7]. In Zimbabwe "lack of an ICT policy" at both Ministry and school level contributed to the non-use of ICT. Coupled with this was a top down management structure in which school heads, teachers and students were used to operating on directives. The schools expected a directive in the form of a Ministry ICT policy, but this was absent. In turn, school ICT policies were not in place to direct the way ICT infrastructures in schools could be used optimally. Thus, while some teachers expected to have their subject timetabled for the laboratory to use computers this was not the case in the schools [21]

SECTION 6: CONCLUSIONS

Conclusion 1 Status of ICT integration in Eswatini schools

The study found that Mathematics and Science teachers lacked general ICT skills, 65% of the schools had no ICT policy, no network, no Internet, no printers, no laptops, no security alarm, badly designed computer laboratory, no power backup, and no burglar proofing. In most of the schools the computers were found to be old and out of date.

Conclusion 2: Obstacles in the integration of ICT in Mathematics and Science

The lack of school ICT policy emerged as a major obstacle to the integration of ICT Mathematics and Science Classrooms.

SECTION 7: RECOMMENDATION

The Swazi government has to set up an education task force to focus on ICT education thematic areas [23]. Once in place, this should look at the relevance of the education sector policy, with an aim of aligning it to the country's ICT policy. This could create an enabling environment for distributed policies ([7], [14], and [23]). These policies, once implemented, should promote cooperation and support at all levels and in turn eliminate a number of obstacles to ensure sufficient funding, appropriate knowledge and skills, efficient leadership, proficient teachers and competent students, and thereby give impetus to ICT integration in Mathematics and Science classrooms.

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