

The Integration of ICT in Teaching Science and mathematics in Secondary Schools: with particular reference to SUDAN

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Abstract: This study is an investigation to explore the extent of integrating ICT in teaching and learning in mathematics and science in Sudanese secondary schools. The findings of this investigation are also analysed in relation to a number of selected countries (Chile, Slovenia, and South Africa). The study was confined to Khartoum State where 50 secondary schools, using ICT for educational purposes, were sampled. The study used a survey approach. The study used a questionnaire to collect the data from the science and math teachers. The data of this study was collected by applying a personal administration (paper-and-pencil) approach which is efficient when respondents are conveniently situated close at hand (i.e. not widely dispersed). The questionnaires were administered by personal administration approach by the researchers to all schools sample. The results of this study will enable policymakers to make judgments on the current situation regarding the use of ICT in education. In addition, the information presented in this study will help them to take bold new steps to utilize and integrate ICT more intensively in Sudanese educational system. The findings of the study indicate that Sudan is behind many countries internationally in integrating ICT into education. It is also clear that, the use of ICT in learner practices in the learning activities was very limited in the majority of Sudanese secondary schools. In addition, most teachers have positive attitudes regarding ICT integration in teaching and learning math and science subjects.

Keywords: ICT, Integration, Innovation, implementation, ICT use, secondary schools, Sudan.

Introduction

The purpose of this paper is to investigate the extent of integrating ICT in teaching and learning mathematics and science in Sudanese secondary schools. The findings of this investigation are also analysed in relation to a number of selected countries (Chile, Slovenia, and South Africa). The study was confined to Khartoum State where 50 secondary schools, using Information and Communication Technology (ICT) for educational purposes, were sampled. This study was a survey (such as “SITES Module 1 and 3” - Second Information Technology in Education Study) which was focused on assessing and evaluating the current status of Information and Communication Technology (ICT) in many countries throughout the world (Pelgrum & Anderson, 2001).

Today, many Sudanese secondary schools (particularly the private ones) strive to integrate appropriate ICT tools into their classrooms. Despite the numerous investments in hardware, software and supporting ICT resources, little is known about integration and in addition, it seems that teacher training is a constraint.

Although the ICT implementation policy for Sudan was launched in 2002 and most schools have computers and Internet connectivity, most principals, teachers and students do not really know what to do with the computers installed in their labs. This shows that the integration of ICT into schools was not carefully planned, and that such an implementation was a top-down initiative which did not take into account the involvement of local policies. Plomp, Anderson, Law and Quale (2003) mention that top ministry leaders down to teachers in their classrooms all face decisions about whether and how to integrate ICT into teaching and learning. Such decisions are not easy because the choices are complex, technically demanding, and the effects are often not known. Even for the lead-

ers in educational ICT, there is not enough research on which to base decisions. Furthermore, the integration of ICT in teaching and learning is a new domain in Sudanese schools, the technology keeps changing and there is very little literature and research regarding the ICT integration in Sudanese secondary schools.

Research objective

- Ascertain the extent to which ICT is integrated with teaching programs of science and math teachers at secondary schools.
- Determine the obstacles that prevent the integration of ICT in teaching process at Sudanese secondary schools.

Research questions

- To what extent have mathematics and science secondary schools teachers integrated ICT in classrooms?
- What are the obstacles that prevent the integration of ICT in teaching process at Sudanese secondary schools?

Literature Review

The researchers have planned to add knowledge of the integration of ICT in education in Sudan as well as the developing countries' context by conducting an investigation study of a large sample of schools that use ICT in their teaching and learning.

How is ICT incorporated into teaching and learning?

In this section, the discussion is about the process of using ICT to assist teaching and learning. This discussion will help to elucidate some of the key points that can become critical to integrating ICT in teaching and learning.

Wang and Woo (2007, p.149) state that “integration of ICT in education is basically a tool”. In the educational context they claim that it mainly refers to various computer-based resources and tools (software). Other researchers view the integration of useful tools that facilitate the link to various learning communities together in new and different ways (Taylor, 2000). The integration of ICT in teaching and learning is a complex process. Various competencies must be developed throughout the education system for ICT implementation and integration to be successful.

The SITES- M3 study (Plomp, Pelgrum & Law, 2007) reports that the incorporation of ICT in teaching and learning in schools is influenced by a number of factors external to the school, such as the visions and prescriptions that are reflected in the national curriculum and national policies on ICT in education. However, how ICT is integrated in teaching and learning depends within schools on factors amongst others such as (a) vision on education or the teaching/learning process, (b) knowledge and skills of the teachers, (c) availability of content (educational software) and (d) the hardware infrastructure.

Changing teaching strategies

Hooper and Rieber (1995) suggest that using educational technology means applying ideas from various sources to create the best possible learning environments for students. They note that educational technologists ask questions such as how a classroom might change or adapt when computer-based learning is integrated into the curriculum. They propose a simple model as a tool to help explain the patterns of adoption by teachers after they are first introduced to educational technology. The model describes five hierarchical stages for technology integration, through which all teachers must progress in order to integrate the technology effectively, those are: familiarization, utilization, integration, reorientation, and evolution (Hooper & Rieber, 1995, p.2).

Ways of integrating the use of computers into subject learning

The use of computers can be integrated into subject learning in various ways, depending on what learners actually do with recourses (Bialobrzeska & Cohen, 2005). This integration operates on three levels: functional practice, integrative level, and transformational practice. Bialobrzeska and Cohen (2005) propose a framework in which computers can be used for teaching and learning. They suggested that computer can be as: tutor, organizer, integrative, presentation agent, search agent, data processor, data logger, and remedial and extension (p.32).

Furthermore, at every level of schooling, ICT is not a closed or self-contained subject to be taught and learned independently from other subjects (Semenov, 2005). Relatively, ICT is a subject that, by its very nature, should be treated as interdisciplinary, integrative, and cross-curricular. Semenov (2005) claims that the project-oriented method of teaching and learning, initiated through the use of ICT, will help both teachers and students become more aware of their own capacities and responsibilities.

An important issue was discussed by Lim and Ping (2007) regarding the integration of ICT in education. Their article examines and analyses where and how ICTs are integrated in Singapore schools to engage students in higher-order thinking activities. The study is qualitative in nature and they employed methods such as observations, focus group discussions with students, and face-to-face interviews with teachers, ICT-coordinators and principals, to know how the activity systems within and between classrooms, and schools are generated. The study discussed essential issues regarding the learning environment; for example, classroom management and orienting activities, supporting school policies for effective ICT integration in the classroom.

Research Design and Methods

This study used a survey approach to investigate the extent of integrating ICT in teaching and learning mathematics and science in Sudanese secondary schools. The study used a questionnaire to collect the data from the schools teachers. Gay and Airasian (2003) refer to a survey research as a descriptive study to determine and describe the way things are and “survey data can be used to describe the status of things, show change and make comparisons” (Maree, 2007, p.48).

Population and sample

The population featuring in this study was drawn from secondary schools in Khartoum State in Sudan where there is a policy aimed at pedagogical practice. The population of this study was divided into subgroups of schools according to the regions of Khartoum, Bahri, and Omdurman. The samples were drawn randomly from each subgroup. A stratified sample of 50 schools was drawn from secondary schools in Khartoum State. Thirty-six of these schools were chosen for their relatively advanced use of ICT in teaching and learning. The remaining fourteen schools were considered because they owned a number of computers which they began to use for teaching and learning purposes at the time of the study.

Data collection and analysis

The data of this study was collected by applying a personal administration (paper-and-pencil) approach which is efficient when respondents are conveniently situated close at hand (i.e. not widely dispersed). Gay and Airasian (2003), claim that the paper-and-pencil method has definite advantages over others, such as interviewing. The questionnaires were administered by personal administration approach by the researchers to all schools sample.

The data analysis was done by using descriptive analysis with the aid of the Statistical Package for Social Science (SPSS) software. Processing entailed the use of frequencies, mean distributions, median, and percentages.

Limitation of the research

Two main limitations with study were encountered. These are sampling and research in developing countries. First, the 50 schools were not intended to be a representative sample of schools in Sudan, because of the lack of financial support and the political instability in Sudan. Rather, they were chosen as remarkable examples of using

ICT in teaching and learning. This sample is obviously insufficient if the objective is to yield significant statistical conclusions. Secondly, besides studies conducted in South Africa, there was a deficit of previous studies conducted in developing countries for comparison of ICT integration in teaching and learning.

Data presentation and Analysis

Profiles of schools and participants

This section presents the total numbers of schools in the three localities that were participated in this study as well as the total numbers of the participants (teachers).

Forty-eight schools out of fifty participated in the study (n= 50). Two schools from Khartoum localities did not respond to the questionnaires because of the time constraints caused by the Sudanese secondary school certificate examinations.

Regarding the sample respondents, Eighty-four of the teachers responded to the teacher questionnaire. Figure 1 shows the highest level of education for teachers in this study.

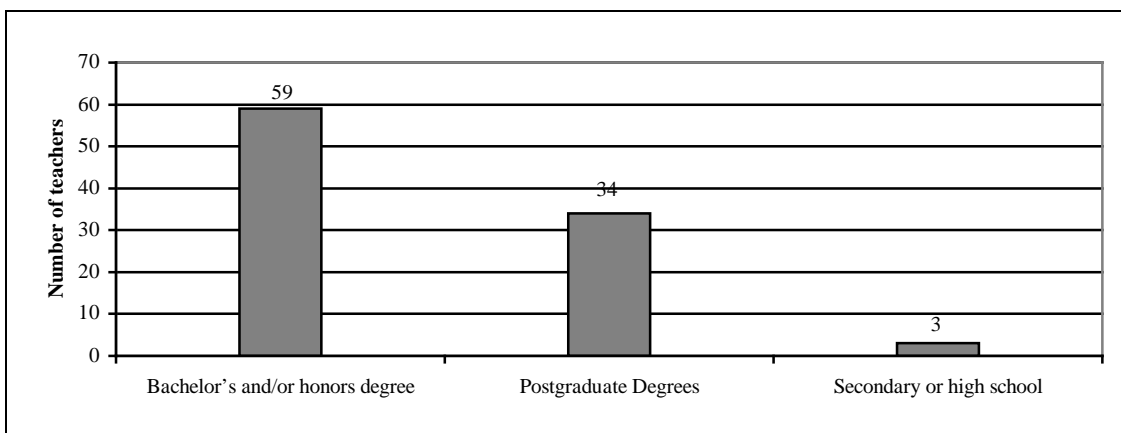


Figure 1: The highest level of education of the teachers

Figure 1 shows that more than half of the teachers (N= 59) have Bachelor's or honors degrees. A number of teachers (N= 34) have postgraduate degrees, while only few teachers (N= 3) are unqualified.

Regarding teachers' experience, Table 1 shows the teachers' responses to the years of experience that they have in teaching Mathematics or Science.

Table 1: Teachers' experience in teaching Science or Mathematics

Years of experience in:	N	Less than 2 years	2-4 years	5-9 years	10-19 years	20 years or more
Mathematics	84	4	35	14	19	12
Science	84	4	47	5	21	7

The largest group in both mathematics and science is that between two and four years experience. Few teachers have less than two years experience in teaching Mathematics and science.

Table 2: Teacher access to and use of computer

Teacher access to and use of computers	N	Computer at home	Teaching - related	Connect to the Internet
	84	49	28	21

Table 2 shows that more than half (N= 49) of the teachers have access to a computer at home. One-third of the teachers use computers for teaching-related activities. Only a few teachers have accessed to the Internet.

Integration of ICT into mathematics and science classrooms

Teacher practices

This section provides information regarding the teachers' ICT activities in the scheduled learning time. In addition, it presents data on the use of ICT in assessment.

ICT activities in the scheduled learning time

The respondents' teachers were asked whether they had used scheduled learning time for the activities, as well as whether they use ICT when these activities took place.

Table 3: Mean scores for the ICT activities in the scheduled learning time in the schools

Learning activities	Learning activities			ICT use	
	N	Mean	Std. Er.	Mean	Std. Er.
Extensive courses	84	1.89	0.102	1.23	0.046
Producing creative works	84	1.62	0.081	1.14	0.038
Self-accessed courses / learning activities	84	2.14	0.103	1.17	0.041
Scientific, research	84	2.02	0.066	1.32	0.051
Teacher's lectures	84	2.13	0.111	1.19	0.043
Exercises to practice skills and lesson procedure	84	3.11	0.110	1.14	0.038
Discovering mathematics principles and concepts	84	2.76	0.109	1.18	0.042
Studying natural phenomena through simulation	84	1.88	0.092	1.14	0.038

Table 3 shows that the ICT activities used in scheduled learning time were *the exercises to practice skills and lesson procedure* (mean= 3.11(0.110)) and *discovering mathematics principles and concepts* (mean= 2.76(0.109)). The table also shows that *producing creative work* presented as the weakest activity in scheduled learning time. However, overall the use of ICT in all these activities was very limited.

The use of ICT in assessment

This section presents the mean scores of the use of ICT in various assessment methods used by teachers in the school sample.

Table 4: The use of ICT in assessment

Assessment methods	Present assessment			ICT use	
	N	Mean	Std. Error	Mean	Std. Error

Written test/examination	84	2.00	0.000	1.20	0.044
Written task/exercise	84	2.00	0.000	1.10	0.032
Individual oral presentation	84	1.87	0.037	1.07	0.028
Group presentation (oral/written)	84	1.85	0.040	1.08	0.030
Project report and/or (multimedia) product	84	1.21	0.045	1.10	0.032

Table 4 shows that the most common assessments used in the school sample are *written test or examination* (mean= two (0.00)) and *written task or exercise* (mean= two (0.00)). The table also shows that few teachers use *project report and/or (multimedia) product assessment* (mean= 1.12(0.045)). However, the table shows that only a few teachers used ICT in these assessments.

Learning resources

This section presents the data of the learning resources used by the school sample teachers in the learning activities or assessments.

Infrastructure

The teachers were asked to indicate if they used ICT tools in their teaching and learning. Table 5 presents the teachers' responses.

Table 5: Learning resources used by the teachers in teaching and learning

Learning resources	Assessment methods using ICT		
	N	Mean	Std. Error
Tutorial/exercises software	84	1.54	0.071
General office suite	84	2.00	0.000
Multimedia production tools	84	1.21	0.059
Simulations/modeling software/digital learning games	84	1.19	0.049
Digital resources	84	1.20	0.063
Mobile devices	84	1.17	0.044
Smart board/interactive whiteboard	84	1.11	0.045

Table 5 shows that *general office suite* represents the higher mean score for the ICT learning resources used by the teachers (mean= two (0.000)). The lowest mean score of the learning resources used by the teachers is *smart board and/or interactive whiteboard* (mean= 1.11(0.045)).

Learners' practice

The teachers were asked to indicate to what extent their learners engage in class activities and if their learners used ICT for these activities. Table 6 below shows the results.

Table 6: Learner practice

Learner practice	Present		ICT use	
	N	Mean	Std. Error	Mean

Learners learning during lessons at their own pace	84	2.51	0.106	1.83	0.041
Complete worksheets, exercises	84	2.90	0.094	1.08	0.030
Give presentations	84	1.79	0.094	1.05	0.023
Determine content goals for learning	84	2.02	0.090	1.13	0.037
Explain and discuss ideas with teacher and peers	84	2.64	0.091	1.12	0.036
Answer test or respond to evaluations	84	3.19	0.090	1.08	0.030
Self and/or peer evaluation	84	2.46	0.113	1.06	0.026
Communicate with outside parties	84	1.62	0.081	1.10	0.032

As shown in Table 6, most learner practices used in class activities are *answer test or respond to evaluations* (mean= 3.19(0.090)) and *complete worksheets, exercises* (mean= 2.90(0.094)). The table also shows that *communicate with outside parties* represents the weak mean score of the learners' practice activity. However, the use of ICT in all learners' practices in class activities was very limited.

The interview showed that the majority of the respondents complained that they had inadequate skills and insufficient ICT facilities to think about ICT integration. They asserted that it is too difficult for them to integrate ICT tools in teaching and learning activities. The following views epitomize their negative attitudes: *I think it is a dream to integrate ICT in teaching...I do not care. I am too old for ICT integration.*

Discussion

This section presents the analysis and discussions of the data provided by the survey questionnaires and interviews, which are conducted with the respondent sample.

To what extent have mathematics and science secondary schools teachers integrated ICT in classrooms?

Teacher's practices

ICT activities in the scheduled learning time and their place

This study has found that the activities mostly used in scheduled learning time were *the exercises to practice skills and lesson procedure*. In contrast, *producing creative work* presented the weakly. However, most maths and science teachers are not familiar with, and do not use ICT in these activities (Table 3). The utilization and integration of ICT tools can definitely assist teachers and their students in acquiring mathematics and science competency as well as enhancing the quality of their learning experience. The integration of ICT tools in the teaching and learning of Maths and science were found to bring other benefits too. For motivating learner and raising self-esteem and confidence, ICT can enhance learner interaction, verbalization and involvement in collaborative learning.

The success of ICT integration in teaching and learning activities largely is dependent on the support given by the school principal (Pelgrum & Anderson, 2001). The interview yielded that the majority of the respondents noted negative experiences in relation to support from the principals. One teacher commented, *My principal is more concerned about the examination results rather than ICT integration*. Another commented *...my headmaster all the time talks about better grades for the Sudanese Secondary Certificate. He is not interested in using computer in teaching and he doesn't repair computers which are out-of-order*.

The use of ICT in assessment

Assessment is an important driver in education and, if not well managed, can become an obstacle to innovation. As ICTs are embedded in learning and teaching reform processes, they can be effectively used, in conjunction with other methods in assessments. The present study (Table 4) shows that the most common assessments used in the school sample are *written test or examination* and *written task or exercise*. Very few teachers use *pro-*

ject report and/or (multimedia) product assessment. However, schools have few teachers who use ICT in these assessments.

Many authors (e.g. Pelgrum & Anderson, 2001; Pelgrum & Law, 2005; Kozma, (2002) report that ICT has been used as an instructional aid (i.e., computer-assisted instruction) to help learners learn other subjects, and to help teachers in their administrative works. Kozma (2002) states that in some countries, ICT is now at the center of education reform efforts that involve its use in assessment, coordination with changes in curriculum, teacher training, and pedagogy.

The findings of the present study show that although there are a number of assessments used by teachers in the schools, such as written tests/examinations, written tasks/exercises, group presentations (oral/written), assessment of group performances on collaborative tasks and multimedia products, very few numbers of teachers use ICT in these assessments.

Learning resources (ICT Infrastructure)

The study found that *general office suite* represents the higher mean numbers for the ICT learning resources used by the teachers. However, many teachers did not use other ICT learning resources tools in their teaching and learning. The lowest mean numbers of the learning resources used by the teachers is *smart board and/or interactive whiteboard*. Concerning the link between ICT integration with the aspect of ICT infrastructure, Lim and Ping (2007) suggest that the availability of ICT tools in the school create a conducive learning environment for the effective integration of ICT in schools.

Learners' practice

This study has found that the most learners' practices in the class activities are that *answer test or respond to evaluations* and *complete worksheets, exercises* (Table 6). However, the use of ICT in all learners' practices in the class activities was very limited. If we compare this result with South African and Slovenian secondary schools regarding the integration of ICT in their educational system, Khartoum schools have far to go.

Obstacles to the integration of ICT in teaching process

The findings of the present study found that the most frequent problem was the insufficient number of computers. This finding is similar to the findings of the study conducted by Pelgrum, (2001) who points out that apparently most countries have not yet succeeded in realizing sufficient facilities to keep teachers up-to-date with new technologies to integrate these in teaching and learning. The study also shows other non-material obstacles that most teachers have found difficulty in integrating in ICT in instruction: scheduling enough computer time for students, insufficient teacher time, and the lack of supervisory and technical staff.

The attitude of teachers using computers was an important factor. Pelgrum and Plomp (1991) point out that attitude was the key of success for the implementation and integration in instructional purposes. Interestingly, in this study, the interview showed that most teachers' attitude toward using computers was negative. Pelgrum (1993) indicated that teachers with a positive attitude toward using computers were more likely to use computers frequently and intensively in their teaching subjects. The interview yielded that the respondent teachers asserted that it is too difficult for them to integrate ICT tools in teaching and learning activities.

Findings, conclusions and recommendations

The purpose of this study is to investigate the extent of integrating ICT in teaching and learning mathematics and science in Sudanese secondary schools. The findings of this investigation are also analysed in relation to a number of selected countries (Chile, Slovenia, and South Africa). This will enable policymakers to make judgments on the current situation regarding the use of ICT and to reflect upon possible improvements that could be effected in the near future.

A summary of findings that were established from the previous sections (the analysis and discussion of the data) with respect to the purpose, objectives and the research questions that guided the study. Insight from the literature is also presented.

1. The majority of the teachers did not integrated ICT in science and mathematics classrooms.
2. None of the school sample used computers in the learning activities for their students after scheduled school hours.
3. The majority of the principals did not support their teachers in integrating ICT into the teaching and learning process.
4. The majority of the school sample teachers did not use ICT in assessing their learners.
5. The use of ICT in learner practices in the learning activities was very limited in most of the school sample.
6. Most teachers have positive attitudes regarding ICT integration in teaching and learning math and science subjects.
7. There are many problems and obstacles mentioned by the teachers when integrating ICT in teaching and learning, these are: lack of support from the school administrators, lack of training courses to use ICT, limited time for planning, exam pressure and fear of not being able to complete the syllabus, inadequate classrooms to use computers in teaching, no Internet connectivity, absence of any kind of ICT management system in most schools, and negative attitude of some teachers.

Conclusions

It is noted that the small sample size limited the generalizability of the study. Therefore, the researchers cannot claim to generalize the findings of this study to all Sudanese states. But, because the Sudanese secondary schools in other states are equally or less developed than the secondary schools in Khartoum state, the researchers can generalize the findings of this study which was drawn from 50 secondary schools in Khartoum State to the all secondary schools in other Sudanese states.

The conclusions of this study are summarized in two main conclusions, these are:

- Sudan does not yet have the necessary infrastructure to integrate ICT into education and is well behind many countries internationally in integrating ICT into education.
- Schools in Sudan need more support and guidance from the Ministry of Education in order to integrate ICT effectively in teaching and learning process.

Recommendations

The researchers offer a set of general recommendations for policy makers and schoolteachers regarding ICT integration.

- Develop a strategic plan to provide all secondary schools with good infrastructural facilities for successful ICT integration.
- Improve the quality and functionality of the ICT equipment in schools (e.g. multimedia facilities CD-ROM, CD-WRITER, Sound card, Video card, Modem, USB driver etc.) and provide Internet access to students and teachers for instructional purposes.
- Encourage and support the development and design of educational software for all subjects. This process needs to be done concurrently with the revision of the Sudanese curriculum in order to adapt it for integration with ICT.

- Develop and promote a better understanding of pedagogical paradigm practice changes and evaluate existing strategies and initiatives in the context of achieving such changes;
- Provide professional development support to school leadership teams including principals, teachers and computer coordinators for strategic planning in managing change and then to offer opportunities for staff development.

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