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Information Communication Technology Pedagogical Integration in Mathematics Instruction among Teachers in Secondary Schools in Kenya

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Abstract
This paper reports finding of the study that sought to ascertain the extent of ICT-pedagogical integration in mathematics instruction among secondary school teachers in Kenya. Information was sought on professional development experiences and needs in computer technology use in mathematics instruction, the type of computer software used in mathematics curriculum content delivery, the influence of accessibility to ICT infrastructure and technical support, teachers' competence and confidence on ICT integration in mathematics teaching and learning. This was a descriptive survey of explanatory nature that involved 200 mathematics teachers from schools who were selected using proportionate stratified sampling techniques. Data was collected using questionnaires, interview and observation schedules. The data collected was analyzed using descriptive statistics involving computation of frequencies and percentages and inferential statistics that included Pearson correlation and multiple regression analysis. Results show that there is limited use of ICTs in mathematics instruction which is attributed to low self confidence and incompetence in use of ICTs and inaccessibility to appropriate software materials and technical support. There is need to equip schools with the necessary ICT infrastructure including content specific software and technical support. There is also need for professional development of teachers in ICT pedagogy as they require the knowledge and skills to put these tools in practice.
Keywords: ICT; Computer; Technology; Pedagogy; Profession; Innovations

1. Introduction

The introduction of ICT in education is part of the more fundamental objective to improve education globally and to make it accessible to everyone. The use of ICT in education has the potential to enhance the quality of teaching and learning, the research productivity of teachers and students, and the management and effectiveness of institutions (Kashorda et al. 2007). The importance of pedagogical integration of ICT in Kenya and globally cannot be overemphasized. It is becoming increasingly apparent that all aspects of people's lives including the way education is taught and delivered are greatly influenced by developments in Information and Communication Technologies (ICTs).

The Government has put in place the National ICT Policy and E-Government Strategy that provides guidelines for transformation of the Kenyan into a digital society. In both documents the Government recognizes that an ICT literate workforce is the foundation on which the nation will become a knowledge-based economy. Against this background the government will make education a platform for equipping the nation with ICT skills in order to create dynamic and sustainable economic growth.

In recent years there have been numerous efforts and resources directed at improving teachers' competence and confidence in using ICT effectively in classroom teaching and learning. Ministries of education are developing policies on ICT in education and running in-service programmes for practicing teachers. Teacher-training institutes are incorporating ICT education in their pre-service programmes. And many schools are organizing in-house school-based training for their teachers, while worldwide an increasing number of private providers are developing ICT training materials and courses for teachers.

Research has shown that the traditional instructional approaches whereby teachers are the ultimate sources of knowledge while students passively receive and record this knowledge in memory are not effective (Bransford et al 2000; Moon 2004; Kozma 2005). Kozma, among others, suggests that the professional development of teachers needs to be approached as a human capital in business. He argues that the productivity of education can be significantly improved by upgrading the skills and knowledge of teachers and their ability to apply these in the classroom. Researchers advocate an approach to teacher professional development that builds a community of practice focused on continuous improvement (Bransford 2000 cited in Kozma 2005).

The adoption of ICT into the practice of education is not something that began with the emergence of the new digital technologies; technologies such as radio, telephone and television have been and are still being used at present; what is new are the many ways that they can be combined and mixed with the new technologies which mainly consider use of computers (Farrell, 2007).

Research has shown that despite reports on teachers' increasing knowledge of and familiarity with technology and there being infrastructure to support it, many mathematics teachers are still not effectively

integrating technology into their teaching (Foley and Ojeda, 2007). The international evidence suggests that one reason for the teachers not embracing technology is the fear that it might replace teachers in the school system (Li, 2007). The ineffective integration of technology is attributed to the lack of adequate knowledge about when and how computers could be used in mathematics instruction, and lack of sufficient training (Jamieson-Proctor & Finger, 2008). This ineffective integration is disturbing given the benefits that are attributed to integrating technology into the classroom.

Several studies have revealed that mathematics teachers are also faced with inhibiting factors or barriers to computer use. One of the barriers inhibiting use of ICTs in mathematics is the lack of professional development in technology. To address this issue, several authors prescribed different types of professional development in the use of technology. This can be in the form of formal training in technology courses (Swan and Dixon, 2006); training of teachers in the use of software packages (Toumasis, 2006); instructional strategies (Sorkin et al., 2004); and lesson planning integrating technology in mathematics (Hardy, 2004). In line with the need for on-going professional development (Wells, 2007 and Sprague, 2007); further training in software use (Sorkin et al, 2004) and teachers' preferences about who should provide training are some issues that should be looked at.

Research findings across the country have revealed that there are ICT facilities in the secondary schools such as computers, computer laboratories, internet connections, alongside the traditional methods of telecommunication. Further research has revealed that teachers do not make real use of ICTs at their disposal hence weak integration and usage in classroom activities-teaching and learning. This is attributed to challenges in pedagogical integration of ICTs in mathematics instruction. This paper seeks to address this aspect of pedagogical integration of ICT in teaching and learning by examining the pedagogical preparedness of mathematics teachers in the use of ICT in teaching and learning in Kenyan schools. The findings reported in this paper are based on a research carried out in selected Kenyan educational institutions on the factors affecting integration of computers in mathematics instruction.

2. Purpose and Objectives

The study sought to establish extend of ICT pedagogical integration in mathematics instruction. Specifically it sought to:

1. To ascertain professional development experiences and needs in computer technology use in mathematics instruction.
2. To establish how integration of computer software in mathematics curriculum content delivery is accomplished in schools.
3. To ascertain the influence of accessibility to ICT infrastructure and technical support on use in mathematics instruction.
4. To establish the influence of teachers' competence and self confidence on ICT integration in mathematics teaching and learning.

3. Theoretical Framework

The study was based on Roger's theory of Diffusion of Innovations. The theory that seeks to explain how, why, and at what rate new ideas and technology spread through cultures. Innovation diffusion research has attempted to explain the variables that influence how and why users adopt a new information medium, such as the Internet. The diffusion of information technology and telecommunications hardware, software, and services turns out to be a powerful driver of growth, having an impact on worker productivity (Bollou, 2002). Robinson 2009 observes that, instead of focusing on persuading individuals to change, the theory sees change as being primarily about the evolution or "reinvention" of products and behaviours so they become better fits for the needs of individuals and groups.

This theory has four elements: (i) Innovation-is an idea, practice, or object that is perceived as new by an individual. (ii) A communication channel- is the means by which messages get from one individual to another. (iii)Time- is the length of time required to pass through the innovation-decision process. Rate of adoption is the relative speed with which an innovation is adopted by members of a social system. (iv) Social system- is defined as a set of interrelated units that are engaged in joint problem solving to accomplish a common goal.

Each member of the social system faces his/her own innovation-decision that follows a 5-step process; Knowledge – person becomes aware of an innovation and has some idea of how it functions, Persuasion – person forms a favorable or unfavorable attitude toward the innovation, Decision – person engages in activities that lead to a choice to adopt or reject the innovation, Implementation – person puts an innovation into use, Confirmation – person evaluates the results of an innovation decision already made (Orr2003, Sahin 2006). This compels the user to continue adoption or later reject the technology. The adoption or rejection of innovations is characterized by; the relative advantage, compatibility, simplicity, trial-ability and observability. So the understanding and utilizing diffusion networks can aid strategy aimed at quickly inducing system-wide change

(Orr 2003, Robinson 2009, Sahin 2006).

Given that the education stakeholders are aware of the ICT innovations across the world, the rate of adoption is still very low and especially in the developing states. Rogers' diffusion of innovations theory was found the most appropriate for investigating the adoption of technology in higher education and educational environments (Medlin 2001; Parisot 1995). The study addressed the ICT pedagogical integration in mathematics instruction among teachers in secondary schools in Kenya.

4. Methods and Materials

In this study the descriptive survey research design of explanatory nature was adopted and involved collection of quantitative and qualitative data in an attempt to answer the research questions. Creswell (2003) suggests that explanatory studies are advantageous when not much has been written about the topic or the population being studied. The target groups were mathematics teachers in secondary schools in Kenya. Proportionate stratified random sampling technique was used to select a sample of 200 teachers drawn independently and randomly from the stratum of secondary schools in Kenya. Data was collected using questionnaires, interview schedule and observation checklist. Data was analyzed using both descriptive and inferential statistics. Descriptive statistics used involved computation of frequencies and percentages from which interpretations and recommendations were made. Inferential statistics used was Pearson correlation and multiple regression analysis which was used to make a prediction about the computer use based on its covariance with all the three independent variables.

5. Results

5.1 Professional development experiences and needs in computer technology

Information was sought on the teacher's professional experiences and needs in computer technology use in instruction. Most teachers noted that they had made own initiatives to learn how to use ICTs in instructional as they lacked formal training during teacher training at pre-service. However, they indicated experience of several barriers which included lack of time to undergo training; need for technology support; issues in relation to the compatibility of hardware and software; lack of confidence in using the software; lack of knowledge of teaching strategies using computers; inability to trouble - shoot problems with computers; and lack of lesson plans using computers in mathematics.

Results reveal that support in professional development for ICT use has been the major issue of many teachers in schools. The data reveals that teachers who used ICTs at an instance are more likely to require on-going support than those who do not use these tools. While 88% of those who used ICTs want an on-going support to use them in mathematics, only 59% who do not used these tools want on-going support.

When asked about the preferred sources of training, the teachers mentioned Head teacher, Computer Teacher, Conference/seminars, The Internet, District Office and Education Department Training Program. The teachers asserted that the Internet is negatively associated with computer use and the Head Teacher is positively associated with computer use. This was due to the attributed roles to the head teacher as acquisition of ICT infrastructure, provision of incentives and rewards, opportunities to attend seminars and workshops as most teachers indicated lack of pre-service training on these tools.

The teachers revealed that the student's need to be encouraged to enjoy learning is positively associated with the need for ongoing support for the inclusion of computers in mathematics teaching. On the need for formal training, results reveal that the use of computer to help students develop higher-order skills is associated to teachers' formal training but not to computer use. Software packages that are positively associated with the beliefs predicting professional development for teacher training on software use were identified by the teachers. These include Word, Access, EXCEL, Publisher, the Internet, Programming, Front Page, Power Point and Paint Shop.

5.2 Integration of computer software in mathematics curriculum content delivery

The study sought to find out how Table 1. When asked about computer application most frequently used either on daily or weekly basis, their opinions were collected and presented as summarized in table 1.

Table 1 Use of Computer Technology in Instruction

	Number of Teachers	Percentages (%)
Word processing	40	20
Simulation programs	16	8
Graphical tools	20	10
Spreadsheets	24	12
Internet browsing	60	30
Presentation tools	28	14
Geogebra courseware	6	3
Visual basic courseware	6	3
Total	200	100

Results in Table 1 show higher rating given to internet browsing (30%), followed by Word processing (20%), presentation tools (14%), spreadsheets (12%), graphical visualizing tools (10%), simulation programmes (8%) and Visual basic (3%)and Geogebra teaching courseware (3%). The results indicated that teachers considered themselves to be more conversant with the use of internet, word processing and presentation tools. It might appear that most teachers do not make use of drill and practice soft-wares including Geo-gebra, graphical visualizing tools, multimedia and simulation programmes could be because they consider the applications to be specialized software and require advanced skills from users. This suggests that teachers need training in a wider range of computers applications for them to make full use of technology in teaching.

5.3 Teachers' Competencies and Use of ICTs in Mathematics Instruction

The mathematics teachers' competencies on computer use were categorized into four namely very high competences, high competence, low competence and no competence. The findings showed that the teachers who had very high competence in computer use in a variety of applications were the least (12.73%), followed by those who had high competence (26.26%) then the ones with no competence (29.46%) and finally those categorized as having „low competence" carried the highest respondents (30.11%). The highest number of respondents (34%) among those with very high competence was comfortable in one application namely use of the internet in communication. In general majority of the teachers (59.57%) represented those with „low competence plus those with no competence. Therefore just a few of the respondents (12.73%) have the competencies required for application in mathematics instruction.

5.4 Teachers' Self Confidence and Use of ICTs in Mathematics Instruction

The results show that teachers' self confidence has a significant positive effect on computer use. That is the more the teacher feels at ease, liking and confident, the easier he or she feels the need to use computer as an instructional tool. They asserted that they are not the type to do well with computers and most of them indicate to get a sinking feeling when they think of trying to use a computer. When asked on whether figuring out computer problems appeals to teachers, most respondents (61%) agreed. However, most teachers find it difficult in making a computer instructional programme. This could be attributed to the teacher's feelings about computers as complex tools which can't be manipulated with ease and that they lack the necessary skills and competence for their use. This perpetuates their lack of confidence in using computers for instruction purposes.

5.5 Accessibility to ICT infrastructure and technical support and Use as Perceived by Teachers

The results revealed that only a few of the teachers (8%) accessed to ICT infrastructure and technical support at school and yet the same resources are to be used in mathematics instruction. Comparatively, responses indicated that the highest number of teachers 72 (43%) made frequent use of computers mostly in cyber cafés followed by 34% at the university when they were training, then 8% at schools where they teach and lastly the least number of respondents (5%) used computers at home.

Table 2: Teacher's Competence, Self Confidence and Accessibility to ICT infrastructure

Factor	Number of Teachers	Percentages (%)
Low self confidence in use of ICTs	42	21
Incompetency in ICTs use	59	29.5
Inaccessibility to ICT infrastructure and technical support	99	49.5
Totals	200	100

The findings show that teachers view inaccessibility to ICT infrastructure and technical support (49.5%) as a major factor hindering teachers from using computers in mathematics instruction. These findings are consistent with those of Ndiku (2003) and Fulton et al (2003) who assert that insufficient number of computers in schools is one of the factors hindering teachers from using computers. The teacher incompetency in computer

use came second with (29.5%). Lastly, 42 pre-service teachers (21%) shared the opinion that poor attitude of teachers towards computer use was the main hindrance to computer use in mathematics instruction. These findings agree with those of Baylor and Ritchie (2002) who argue that regardless of the amount of technology and its sophistication, technology will not be used unless the teachers have the skills, knowledge and attitudes necessary to use computers in classroom instruction.

Correlations

ICT use	Pearson correlation	1				
	Sig. (2-tailed)	.				
Teacher's self confidence	Pearson correlation	0.45252	1			
	Sig. (2-tailed)	0.07182	.			
Teacher Competencies	Pearson correlation	0.4416	0.026119	1		
	Sig. (2-tailed)	0.084204	0.0097880	.		
Accessibility to ICT	Pearson correlation	0.3411383	0.1023927	0.3502879	1	infrastructure
and technical support	Sig. (2-tailed)	0.06489888	0.002962793	0.0002323	.	

The variables (teacher's self confidence and ICT use) exhibited a correlation of 0.45252 significant at 0.0718. The variables (teacher competencies and ICT use) had a correlation of 0.441 significant at 0.0842. The variables (accessibility to ICT infrastructure and technical support and use) exhibited a positive correlation (0.341) significant at 0.0648. This implies that there is statistically significant relationship between teacher's competencies, self confidence, accessibility to ICT infrastructure and technical support and use of these tools in mathematics instruction.

Multiple Regressions Analysis

Multiple regressions were used to evaluate the relationship of the dependent variable (ICT use) and a set of independent variables (teacher competencies, self confidence and accessibility to ICT infrastructure and technical support).

Table 3: Regression Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.804(a)	.788	.764	.57403

Predictors: (Constant); Teachers' self confidence, competencies in ICTs use, and accessibility to ICT infrastructure and technical support.

According to the results in table 3, an R squared of 0.788 is an indicator of a strong correlation between the variables signifying the factors studied explain 78.8% of the factors influencing the use of ICTs in mathematics instruction.

Table 4: Regression Analysis Results of Relationship between Teachers' Competencies and Use of ICTs

Variables	Unstandardized Coefficients		Standardized Coefficients	T
ICTs use (Y)	B	Std. Error	Beta	
Constant	32.564	.756		6.032
Teachers competencies in ICTs	2.658	.123	.314	-3.890

A Dependent Variable: Use of computers

Regression results in the table 4 show that teachers' competencies in ICT use had a regression coefficient of 2.658. This shows a strong relationship between competencies of teachers and ICT use. This implies that a change in computer competencies of mathematics teachers significantly impact on Computer use.

Table 5: Regression Analysis Results of Relationship between Teachers' Self Confidence in ICTs Use and their use in Instruction

Variables	Unstandardized Coefficients		Standardized Coefficients	T
ICTs use (Y)	B	Std. Error	Beta	
Constant	32.564	.756		6.032
Teachers Self Confidence in use of ICTs	2.531	.249	2.472	10.151

A Dependent Variable: Use of ICTs

According to regression results in table 5, teachers' self confidence in the use of computers had a regression coefficient of 2.531. This shows a strong relationship between computer use and the teachers self competence. This implies that a change teachers' self confidence in use of computers significantly impacts on the Computer use.

Table 6: Regression Analysis Results of Relationship between Teachers' accessibility to ICT infrastructure and technical support and ICT use in mathematics Instruction

Variables	Unstandardized Coefficients		Standardized Coefficients	T
ICTs use (Y)	B	Std. Error	Beta	
Constant	32.564	.756		6.032
Accessibility to ICT infrastructure and technical support	3.584	.296	-.162	-.1706

A Dependent Variable: Use of ICTs

The results in table 6 show that computer accessibility had a regression coefficient of 3.584. This shows a strong relationship between accessibility to ICT infrastructure and technical support and use in mathematics instruction as perceived by mathematics teachers. This implies that accessibility to ICT infrastructure and technical support significantly influences computer use.

Both correlation and regression results revealed that there was a strong relationship between the mathematics teachers competencies, self confidence, accessibility to ICT infrastructure and technical support and the use of ICTs in mathematics instruction. This indicated that mathematics teacher's competencies in ICTs influence their use in mathematics instruction.

6. Implications

The influence of mathematics teacher's competencies, self confidence, accessibility to ICT infrastructure and technical support on use of ICTs in mathematics instruction has been investigated. Individual teachers should think of ways of overcoming them. Pre-service curriculum should put a stronger focus on pedagogy, application of theory and computer technology skills development for delivery rather than strictly mathematical content knowledge. The in-service courses such as SMASSE must be taken seriously because they add value on pre-service training by training teachers to focus on pedagogy, application of theory and computer skills development for delivery of mathematics instruction rather than strictly mathematical content knowledge.

These findings create awareness to teacher trainers about the preparedness of their products (pre-service teachers) to apply information communication technology in teaching and hence improve their pre-service training. The findings of the study reported in this paper demonstrated that professional development offered to mathematics teachers in the past has not addressed their needs as mathematics teachers. Therefore future courses both pre-service and in-service should be designed to help teachers to use ICTs effectively in mathematics instruction. There is also need for teacher training institutions to focus on the application of ICT pedagogical content knowledge (ICTPCK) and content knowledge. This is perceived to model teachers towards proficiency in use of ICTs and ability to develop lesson plans and content specific software for use in the mathematics classrooms. In addition, there is need for establishment of professional learning communities among teachers and mathematics educators in training institutions with focus on ICT pedagogical integration in mathematics instruction.

The government of Kenya is forging ahead to realize integration of ICTs in subject specific areas in secondary school curriculum. This is probably going to be a success only if teachers are trained in use of these tools in their teaching. The MOEST officials, book authors, and curriculum developers such as K.I.E have to put in place modalities that would enhance effective use of technology in mathematics instruction. Other stakeholders such as the NGOs should provide grants to schools to be used for acquisition of the necessary ICT infrastructure and technical support to teachers. The initiators of NEPAD e-learning project and other similar projects in progress should know the willingness, abilities and capabilities of the potential implementers of their projects in secondary schools in Africa. The society needs sensitization and awareness about the need to have knowledge and skills in ICT use.

7. Conclusions

This paper specifically focused on the use of ICT to improve mathematics learning by focusing on ICT pedagogical integration in mathematics content delivery. This paper is gleaned from a doctoral study conducted among teachers in secondary schools in Kenya 2007 to 2010. The studies focused on extend of ICT pedagogical integration in mathematics instruction. The results show that teachers need support for ongoing professional development experiences in computer technology use in mathematics instruction. The teachers were conversant with use of internet, word processing, excel, access and presentation tools for lesson preparation, tutorials and assessment. However, there was minimal use of drill and practice soft-wares including Geo-gebra, graphical visualizing tools, multimedia and simulation programmes in mathematics instruction. The results show that teachers' competence and self confidence, accessibility to ICT infrastructure and technical support is positively associated with the use of ICTs in mathematics instruction.

These results indicate that current ICT policies and professional development programs integrating the use of ICT in education seem to be not effective in making teachers adopt the use of ICT technology in their

teaching practices. There is need for government subsidy to schools to enhance acquisition and accessibility to ICT infrastructure and technical support. There is need for adequate preparation of teachers in ICT pedagogy for actual use of technology in the classroom. This could be through ongoing support and training of teachers in computer programming languages for software development, lesson planning and through hands on experiences in professional learning communities. The government should also organize in-service courses to enhance teacher's competence in ICT pedagogy. This point to the need for teacher initiatives of learning the necessary skills for ICT use in instruction. On the other hand, teacher training institutions and universities need to offer professional training required for ICT use in instruction. There is need for adoption of specialized software and applications like UNESCO modules on ICT pedagogy integration in schools, pre-service training and in-service courses. There should also be a thorough monitoring technique or strategy that includes implementation, feedback and evaluation of technology plans by the stakeholders of the education sector. Possibly a more structured and ongoing professional development programs for mathematics teachers should be started and aligned to their needs and beliefs.

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