Review Article

The Use of Technology among School Mathematics Teachers and Students; The New Wave of Recommended Instructions

Abstract

People in the early stages were even afraid to touch the computer, but nowadays almost everybody can use the computer and its tools. Integration of ICT in mathematics is not merely using computer for typing and printing questions, searching and delivering lessons via PowerPoint but rather using ICT in teaching various topics in mathematics. Integration of ICT in mathematics education also has a positive impact on mathematics teaching and learning. It is therefore necessary for teachers in mathematics to use technology in teaching, and also to encourage students to use technology in mathematics learning. This will enable the students to better understand the mathematics concept taught. With the teaching and learning of mathematics becoming more and more technology base these days to the younger generations, it is, therefore, crucial to throw more light on the use of technology among school mathematics teachers and students which is the new wave of recommended instructions.

Keywords: *Technology, ICT, Teaching and learning mathematic, Computer*

Introduction

For several countries around the world, the need to incorporate Information and Communication Technology (ICT) into education has become a major concern. It is believed that ICT is a transformative tool, and that it needs to be fully integrated into the school systems to prepare students for the information society they inherit (Hakkarainen *et al.*, 2000). Yelland (2001) believed that organizations that do not integrate the use of emerging technology in schools do not realistically claim to prepare their twenty-first-century students for life. It in line of this that the Ministry of Education, Youth and Sports (MOEYS) and Ghana Education Service (GES) (2002), integrating technology in classroom instruction ensures greater motivation, increases self-esteem and confidence, enhances good questioning skills, promotes initiative and independent learning, improves presentation of information/outputs, develops problem solving capabilities, promotes better information handling skills, increasing focus time on task, and improves social and communication skills. This suggests that the use of technology in mathematics classroom often

helps students to concentrate on strategies and analysis of responses rather than wasting time on boring calculations (Becta, 2003).

Technology allows for more ready use of real-world technologies in the classroom (NCTM, 2008). In addition, Kaino (2008) argues that Technology improves mathematics learning by furnishing visual representations of mathematical concepts, promoting data organizing and analysis, and efficiently and accurately computing them. In the sixth principle of the National Council of Mathematics Teachers (NCTM) (2000); the technology principle states that technology is important in mathematics instruction as it affects the teaching mathematics and improves the learning of the students. Technology use in mathematics instruction allows the learner to imagine the mechanism and concept function of symbols, which in calculus reach great heights (Tall & Ramos, 2004). The introduction of ICT devices such as computers and science calculators into mathematics teaching has the ability to fundamentally alter pedagogical methods and boost the learning result of individual students by changing social activities in the classroom (Forgasz & Prince, 2004; Goos, 2005). This is the reason many institutions including the Ministry of Education Youth and Sports (MOEYS) and Ghana Education Service (GES) proposed that the use of ICT in schools must:

a. Make sure students have ICT literacy skills before they move out of each educational stage.
b. Provide guidance for the introduction of ICT instruments at all education levels.
c. Provide means to standardize ICT resources in all schools.
d. Facilitate training of teachers and students in ICT.
e. Determine type and level of ICT needed by schools for teaching and administration purposes.
f. Promote ICT as a learning tool in the school curriculum at all levels (MOEYS & GES, 2002).

A Brief Background on ICTs Uses in Education

The efforts to introduce ICT in our educational system by the Ministries of Education, Agencies of Education Services, development partners and other private sector agencies cover over two

decade ago. In the early 1990's ICT was introduced in all the tertiary institutions as a general course dubbed "computer literacy" in most countries across Africa. Some of the Senior Secondary Schools had private computer laboratories where they sometimes had lessons in computer technology. For instance, to accelerate the programme in Ghana, the Government collaborated with Ghana Telecom to embark on a programme to provide more fixed lines to support extension of broadband connectivity to towns with Senior Secondary Schools and the Colleges of Education to facilitate extension of computer literacy in schools. Several positive achievements were noted during this period for example;

1. The initiative contributed to a wider number of teachers acquiring computer skills and developing strong interest in ICT, schools involved in the initiatives were motivated to expand the project and acquire more ICT equipment, a number of private-public partners, including Parent Teacher Associations and civic society collaborated in the efforts,
2. Lessons learnt from initiatives provided good examples for other schools to introduce their own ICT projects that are establishing computer laboratories.

Numerous research by mathematics teachers on the use of technology have identified a number of factors affecting adoption and implementation. These influential factors includes: skill and prior experience in the use of technology; time and learning opportunities; access to hardware and software; availability of suitable teaching materials; technological support; institutional culture; awareness about how to incorporate technology into teaching mathematics; perceptions about the role about technology in learning; and perceptions about mathematics and how it is learned (Fine & Fleener, 1994; Simonsen & Dick, 1997; Manoucherhri, 1999; Forgasz & Prince, 2001; Walen, Williams, & Garner, 2003).

There are several ways ICT is used by teachers and not necessary in instructions. Most teachers prefer using ICT in communication, storage of information, and preparing their documents to using it in their instructions (Yidana & Asiedu-Addo, 2001). They further stated that preparation of timetable, managing students and personal records are some of the documents most teachers prepare using ICT tools. According to Roblyer and Edwards (2006) a number of different, yet interrelated perspectives on the use of ICT in education by teachers have developed over the last fifty years. They went on to report that some teachers see the computers as an audio-visual system best used, instead of lectures and books, to deliver information and others build the

notion of the computer as audio-visual tool. The growing use of the internet as a tool for information access and communication in educational classroom are neglected by teachers and they instead use the internet for their private e-mails.

Usage of Technology in Teaching and Learning Mathematics

According to Ittigson and Zewe (2003) technology use in teaching and learning mathematics really has the ability to improve the way mathematics should be taught and enhances students' comprehension of basic concepts. The implementation of technology involves a new attitude on the part of teachers, a shift of mathematical focus, to a wider perspective of the consequences of the technology for the learning of the mathematics (Thomas, Tyrrell and Bullock, 1996). This suggests that teachers in mathematics need to gain knowledge which is knowledge of pedagogical technology content that will allow them to use technology in mathematics teaching.

Over the years, numerous studies have illustrated the use of technology by mathematics teachers in the maths classroom. For example, Loong (2003) undertook a study to investigate the use of the internet for teaching by mathematics teachers in Australia. Of the 63 mathematics teachers surveyed, the results showed that teachers use the Internet to find information such as research papers or professional queries, or as a source of data for students to examine in mathematics lessons. In the study, no statistically significant correlations between use and ability, professional development or years of teaching experience were identified. In a similar study conducted by Mereku *et al.,* (2009), they suggested that technology is used in all institutions in typing examination questions, and in some cases educators use technology in the processing of examination results for students. Furthermore their results suggested that very few Ghanaian teachers use technology in their teaching. However, no differences in the amount of time male and female learners are using technology for academic purposes were observed at the pre-tertiary level.

In addition, Forgasz (2002) in Australia surveyed Victoria's Year 7 to 10 teachers to find out how computers were being used in mathematics classrooms and to recognize factors that served as facilitators or obstacles to use. Most teachers felt confident or at least willing to use computers to teach mathematics and used computers with their classes in mathematics, but only rarely. A significant proportion of these teachers had been interested in computer education career development but most needed further training experience. Besides, Goos & Bennison (2008)

have conducted a study to determine the use of technology by teachers in secondary mathematics. Of the 485 studied mathematics instructors, 26% reported that they had participated in computer, internet and graphics related professional development courses, while 16.7% indicated that they had not completed any technical training in any of the three technology forms. But Boakye and Banini (2008) also conducted a study in Ghanaian schools to find out the readiness of teachers to use technology. Their findings showed that out of the 221 teachers surveyed, only 24 percent had undergone any sort of computer use instruction, with very limited training in technology pedagogy integration. This indicates that while teachers in mathematics have recognized the effect of technology in mathematics, they still need professional training about how to integrate it into their teaching.

While the use of technology in mathematics increases the teaching and learning of mathematics, the rates of technology use in mathematics fall below average. A survey by the National Center for Education Statistics (2005) indicated that 44% of American teachers used technology for classroom instruction, 42% for computer applications, 12% for practice drills, 41% required research using the Internet, 27% had students conduct research using CD-ROMs, 27% assigned multi-media projects, 23% assigned graphical presentations of materials, 21% assigned demonstrations, 20% required students to use technology to solve problems and analyze data, and 7% assigned students to correspond with others using the Internet. In a study, 320 secondary school teachers were surveyed by Bukaliya and Mubika (2011) to find out about their ICT competencies. The results showed that in computer-aided teaching only 7.5% of teachers were experienced and qualified. Their findings also showed that 43% of teachers used spreadsheets, 37.5% used internet and 46% used emails.

Thomas, Bosley, Santos, Gray, Hong, and Loh (2006) also conducted a study in the secondary classroom to examine the use of technology and maths teaching. The study concluded that only 36% of departments of mathematics had a technology policy, and while 68.4% of teachers used technology in their lesson, 31.6% did not. However, 75 percent of teachers would like to use the device more often, with the primary challenge being the availability of computers, and also significant lack of teacher preparation and confidence. This means the degree of technology utilization among mathematics teachers school is still at the lower side. A study by Faekah and Ariffin (2005) surveyed 554 Form Four students to assess gender gaps in their computer attitude

and competencies. Their results showed that the students had limited computer skills. Just 17.9% of the students send messages via email, 16.4% look for web-based information and 20.6 percent print or image documents.

Boakye and Banini (2008), however, conducted a study to examine Ghanaian students level of technology use. Of the 5048 students surveyed, 62 percent use the device for general information, while 13 percent use it for academic purposes, the findings indicate. Furthermore, their results showed that 13 per cent of students use it for communication while 10 per cent use it for research purposes. These results show that the use of technology is slowly gaining ground among students in Ghana. To investigate teachers' readiness for the use of technology in Ghanaian Schools in the same study indicated that, 71% of the teachers did not use technology in classrooms, 49% of teachers use technology to prepare lesson notes, 55% of teachers have some knowledge of web browsing, 71% use email, and 78% tried to make an effort to learn how to use the computer. These low figures imply that effective integration of technology into Ghanaian classroom instruction has yet to be realized and utilized (Boakye and Banini, 2008). Likewise, Kaino and Salani (2004) surveyed 40 students in Botswana to examine gender attitudes to the use of calculators in mathematics instruction. Their findings indicated that most students had used calculators and enjoyed working with them.

Similarly, a survey was performed by Keong, Horani, and Daniel (2005) to investigate the use of technology and the challenges to incorporating technology into mathematics education. Their findings indicated that mathematics teachers used less technology in their instruction. Majority of the mathematics teachers use technology for word processing (71.1%), spreadsheets (51.2%), internet activity (44.1%), search engines (44.1%), presentation software (36.9%) and databases (21.6%). Out of the 111 mathematics teachers surveyed, 39.6% of the respondents stated that they had not used technology at all and 32.1% of them stated that they use technology infrequently. On the other hand, 22.6% of them responded that they had integrated technology into specific areas of instructional units and 5.7% stated that they had fully integrated technology into their instructional programs (Keong, Horani, and Daniel, 2005). Waite (2004) claims that while teachers show great interest and enthusiasm in learning about the potential of technology, the use of technology is fairly low in practice and centered on a limited range of applications, with overwhelming use of word processing.

In furtherance, Lau and Sim (2008) also gave a self-administered questionnaire consisting of six sections to 250 high school mathematics and science teachers in Malaysia to explore the extent of adoption of technology among them. Their findings indicated that teachers use technology less frequently for peer communication (26%) and for personal development (12%), but often use internet for browsing purposes (53%). Their findings further revealed that the computer skills of teachers could be related to their regular use of word processing (71 percent), presentation software (50 percent) and courseware (63 percent) in the preparation of teaching materials and lecture presentations. Moreover, Slaouti and Barton (2007) conducted a study to find out the opportunity for newly qualified teachers to use technology in teaching and their findings revealed that technology most commonly used by teachers was word-processing, spreadsheets and to a limited extent, the Internet.

A research carried out by Cuban (2000) to investigate the degree to which technology is being used in teaching showed that very few teachers are serious computer users in the classroom. Research conducted by Koo (2008) to investigate the factors affecting teachers' perceived readiness for online collaborative learning. Out of the 86 mathematics teachers surveyed the findings revealed that, very few of them (24%) indicated they frequently use the Internet, 47% of them indicated they hardly (never or seldom) use it and the rest (29%) indicated they occasionally use it. In a similar situation, Abuhmaid (2011) surveyed 120 teachers to assess the extent of their use of ICT. The findings revealed that 45.2% of teachers reported online searching for additional sources, and 32.1% reported using ICT to prepare their lessons. However, ICT-based interaction in school culture seemed to be minimal among teachers, as only 4.3% of teachers reported using ICT for communication and 11.3% reported uploading files (e.g. lessons) to the Internet. Moreover, Yildrim (2007) conducted a study to examine the use of technology by teachers in Turkey. For the teachers surveyed, the results showed that teachers are primarily using technology to build handouts and assessments, rather than using it to encourage critical thinking skills for students and cultivate their cognitive skills for higher order.

Factors that Affect Technology Usage in Teaching and Learning Mathematics

Technology use in mathematics teaching and learning has become a major concern for educational stakeholders and policy-makers around the world. Several factors affect the use of technology in maths instruction. A study by Nor (2004) used a qualitative approach to research

conditions that promoted the introduction of incorporation of information and communication technology into the school curriculum at the secondary school level in Malaysia. The findings revealed that two sets of conditions were significant:

1. critical conditions such as availability of technology resources and technology knowledge acquisition and,
2. supporting conditions such as accessibility of technology resources, presence of support, desire for change among teachers, school practices, impact of external forces and commitment of teachers to innovation hugely influence the use of technology among teachers.

Elsewhere in California, Florida, Nebraska and New York, Norris *et al.,* (2003) surveyed rural and urban respondents to investigate the extent of technology use in K-12 in U.S. Of the 3,665 teachers surveyed; the study showed that sufficient access to technology resources is a key factor in the process of successful incorporation of technologies. The study found a significant connection between access to and use of the technology. In the same way, Crisan (2004) research categorized a variety of factors which influence the use of technology in mathematics into contextual factors and personal factors. He argued that contextual factors include the school background, the availability and access to technology facilities and resources, the technology skills of teachers, the professional growth of teachers 'technology, the departmental culture and key persons in encouraging the use of technology and the departmental policy regarding the incorporation of technology into the work scheme in mathematics. In addition, Goos and Bennison (2008) surveyed 485 Australian mathematics teachers to examine factors affecting the use of technology in mathematics education. Their findings indicated that factors affecting the use of technology in teaching and learning mathematics were pedagogical expertise and beliefs, access to hardware and software and involvement in professional development courses. Similarly, a review was performed by Mereku *et al.,* (2009) to investigate pedagogical ICT integration. Their findings showed that the availability of ICT syllabuses / manuals, computers and computer labs that can be accessed regularly were factors affecting the use of technology at Ghana's High school level.

In a bid for schoosl to be proactive in the classroom about technology, Williams (1998) suggests that the school should have a technology plan, updating the curriculum to suit the instructional

development requirements and ensuring that the staff has skills. He supports using school and community capital to ensure frameworks for sustainable funding. In a similar report, Valdez (2004) points out that if the enormous technology potential is to be exploited, educators and members of the community need to build a detailed learning and technology plan long before technology equipment begins to arrive. He further notes that most research studies on the introduction of technology indicate that much of the dissatisfaction with technology can be traced to inadequate or non-existent planning. In particular, sufficient preparation could be lacking in how technology is used to enhance learning and to decide whether teachers are obtaining professional development to help improve learning for students in many schools settings.

In South Africa Cassim and Eyono Obono (2011) surveyed 102 teachers in both rural and urban schools to find out the factors affecting the adoption of technology for the teaching of word problems in a maths class. Their findings suggested that the following demographic factors have a major impact on the perceived adoption of technology by teachers to teach word problems; teaching experience, computer access, internet access, and school location. In addition, Al-ghaith, Sanzogni, and Sandhu (2010) conducted a study to explore factors that affect the adoption and use of online services in Saudi Arabia. Of the 651 participants sampled, the results showed that the level of income, age, gender and geographic location have a significant effect on the access and usage of the Internet and its services by individuals. On the contrary, studies to investigate the factors influencing the effective use of technology among teachers in other jurisdictions such as Malaysia and United States revealed that gender, age, and teaching experience did not significantly influence teachers actual usage of technology (Kumar, Rose, and D'Silva, 2008; Norris *et al.*, 2003).

In a study to investigate gender, social influence on technology usage among students, Sarfo, Amartei, Adentwi and Brefo (2011) conducted a study to investigate attitudes towards information and communication technology among rural and urban students in Ghana. Of the 324 sampled SHS students, the results showed that the locality of the male and female students does not affect their attitudes towards technology. Their research further showed that there is no gender disparity between the attitudes of the students towards technology. However, on investigating gender and cultural differences in computer usage by scholars, it was revealed that

using computer is a male dominant activity and males have more positive attitudes towards the use of technology as opposed to females (Li and Kirkup, 2007; Lee, 1997). Likewise, Kahveci, (2010) conducted a study to find out the perceptions of students to use technology for learning. Out of the 158 students surveyed, the results showed that Female students were less optimistic than male students in using the technology. In a separate study conducted by Almekhlafi and Almeqdadi (2010) to examine the views of the teachers in the United Arab Emirates regarding technology integration. Of the 100 teachers studied, the results showed that the mean scores on technologies used by female teachers were all above 4.4, while the mean scores for male teachers ranged from 2.5 to 3.5. The statistical one-way ANOVA test further showed that there was a substantial gap between male and female teachers in the use of the technology. That implies that the use of technology by teachers is affected by gender.

Moreover, a study conducted by Martin and Lundstrom (2002) to investigate the role of teacher experience as a factor in the incorporation of computers in schools revealed that nearly 60% of teachers who had less than 10 years of teaching experience believed that computers in the classroom were important and were used extensively, while only 25% of teachers with more than 20 years of teaching experience believed that computers in the classroom were necessary. In furtherance, Lau and Sim (2008) conducted a study to investigate the level of adoption of ICT among high school teachers in Malaysia. Of the 250 mathematics and science teachers studied in secondary schools, the results showed that older respondents (over 45 years of age) used technology more often in schools on a five-point scale. The findings further showed on a five-point rating scale that young teachers under the age of 35 had a higher mean of competency than 34-45 years and over 45 years of age. Besides, Anderson and Maninger (2007) conducted a study to examine the skills, beliefs, and expectations of pre-service teachers with respect to technology integration. Their results showed that the self-efficacy beliefs of the students have a major impact on their plans to use software in their potential classrooms. They further revealed that the self-efficacy and expectations of students were linked to one another in a moderate way. They argued however that the best predictors of intentions were beliefs about self-efficacy, gender, and value beliefs.

Technology Effect in Teaching and Learning Mathematics

One cannot underestimate the important role mathematics plays in the individual's overall personal and intellectual development. Mathematics is viewed as an interrelated system of ideas, beliefs (principles) and processes and in teaching; it should create its relations between basic concepts to make learning simple for students (Reys, Suydam & Smith, 1998). Teaching and studying mathematics is essential to the world's knowledge economy's future, and deserves a special emphasis in education. Effective teaching of mathematics demands that students understand what they know and need to learn, and then encourage and help them to learn it well (NCTM, 2000). In addition, students need to understand mathematics, actively develop new knowledge from experience and prior knowledge. Teachers will therefore strive to make mathematics simple for students to grasp the various concepts taught with ease.

Students are now facing the need for a strong understanding of the mathematical skills and principles in the rapidly evolving and technologically based society. Technology is one of the main synergies of mathematics and it ultimately affects what happens in the mathematics classroom as technology progresses. Evidence suggests that technology plays an important role in mathematics teaching and learning, as it affects the mathematics taught and improves the learning of students (NCTM, 2000). Technology affects the teachable skills and improves the learning of the students. Therefore, technology can be used to assist mathematics learning. In doing so, NCTM (2000) suggests embedding technology into the mathematics curriculum, rather than offering it as a supplementary feature.

Technology helps the students to learn from feedback, according to Wahyudi (2008). Therefore, using technology in mathematics classroom provides the students with ample learning opportunities. The computer (technology) also provides students with fast and accurate feedback. It helps students to provide various examples when solving mathematical problems. Technology lets the students see trends and similarities. The computer allows ready communication with formulae, number tables and graphs. Using technology allows students to work with complex images that are not feasible in conventional teaching. Students can use computers to draw graphs and to dynamically manipulate diagrams. Technology helps students to interact with real data that can be interpreted in several different ways. This supports interpretation and analysis which lead students to mathematical thinking skills of higher order. A research by Roschelle, Pea, Hoadley, Gordin, and Means (2000) supports the use of technology in mathematics teaching and

learning. Their finding indicates that computer technology can support learning and is especially useful in improving the higher-level skills of critical thinking, analysis and scientific inquiry. The study examines the various ways in which computer technology can be used to improve how and what children learn in the classroom by helping students grasp core mathematical concepts. Computer-based mathematics, according to them, creates confidences and is a perfect method for remediating slower learners.

In addition, Collinson (1999) found that students are prevented from getting bogged down in the complicated computations by using technology in the mathematics classroom. This helps them to concentrate on learning the principles and how to bring them into practice. Technology also enables open-ended assignments where students are more likely to learn concepts through "discovery" and retain the concepts. Students can also experiment and view various outcomes and solutions methods to different problems. Students expend the bulk of their time and effort without the use of technology attempting to memorize rules and procedures by using sample exercises as templates for their homework problems.

The influence of technology contributes to profound improvements in instruction in mathematics. Dreyfus (1991) claims the ability to construct and run complex mathematical models and the simple exploration of "what if" questions by parametric variation has opened up new mathematical avenues. A study by Munirah (1996) also states that the teaching of calculus has undergone a drastic shift now that computer technology has changed practices such as data exploration or graphical data analysis. With this in mind, weaker students are also better able to excel with the help of technology, and therefore come to understand that mathematics is not just for their more capable classmates (Wimbish, 1992). In furtherance, there are many explanations why technology should be integrated into math instruction. Technology is critical in teaching and learning mathematics according to Ittigson and Zewe (2003). Technology strengthens the teaching of mathematics, and increases students 'comprehension of mathematical concepts. It de-emphasizes algorithmic skills resulting in an increased focus on mathematical concept growth. However, Becta (2003) summarized the key advantages of technology in mathematics instruction as follows: first, technology facilitates greater student cooperation and enables connectivity and information sharing. Second, technology provides students with timely and reliable feedback and this leads to positive motivation. Finally, the use of technology in mathematics often enables

students to concentrate on response approaches and explanations rather than wasting time on boring calculations. Technology also promotes constructivist pedagogy, in which students use technology to explore mathematical concepts and come to understand them. This approach encourages higher order analysis and techniques for better problem solving.

Summary and Conclusion

Computer technology have become more and more popular in instructional setting due to the availability of its numerous capabilities. Due to this view, many educators and policymakers, including government, are confident that ICT is the basis for quality education. The potential of using computer technology in teaching mathematics to solve some of the problems facing the subject's learning in this age of science has led many developed countries to invest massively in ICT. The use of computer technology is believed to have the ability to expand access to educational resources, and to enhance the quality of mathematics learning in the education system. This is because a computer's interactivity will encourage learners to participate more actively in a lesson. Many students feel motivated by using computer technologies, as they can learn and advance more independently.

The use of technology makes it easier for students to perform multiple rapid computations. In addition, students are able to easily and accurately test computations, thereby allowing them to verify and explore the validity of their conjectures. The computer application also offers quicker and more accurate feedback that is non-judgmental and unbiased.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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