

Teaching Mathematics with Technology: A Survey on Teachers' Knowledge and Technology Integration

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Abstract: *The study investigated the integration of technology in the teaching and learning of mathematics in selected senior high schools in Ghana. Using a descriptive research survey design with a purposive sampling size of one hundred and five (105) mathematics teachers in the West and East Sunyani Municipality, the following were the key findings: there was moderate supply of computers in the schools where the study was conducted. In addition, senior high school mathematics teachers had fundamental knowledge on computer to enable them integrate it into teaching mathematics. The results of the study further showed that very few mathematics teachers in this study area integrated technology in the teaching of mathematics in the classroom. The recommendations being made are that more computers need to be supplied to the schools and that teacher preparation programmes in the universities and Colleges of Education need to put premium on training and encouraging teacher trainees on how to incorporate their knowledge of technology use into planning, teaching and evaluating their teaching of mathematics.*

Keywords: Technology, Integration, Knowledge-base, Mathematics

1. Background to the Study

Quality education remains a major concern of any country which places much focus on the country's economic growth. Through education, peoples are provided with knowledge and skills needed for their sustenance. As the world becomes technologically inclined, so also more emphasis needs to be placed on the use of technology in the teaching and learning in school disciplines particularly mathematics. Improving educational quality requires embracing and using technology in the classroom to strengthen and enhance classroom instructions. (Copriady 2015; Tomljenovic & Zovko, 2016). Sultana and Md. Shahabul (2018) contend that technology use in education has the potential to cause dramatic change in the classroom by creating a powerful learning environment for effective teaching and learning through students' active participation. Mathematics as a subject permeates almost all other subjects of study in the educational curricula. It is often described as backbone of all scientific disciplines and technological explosions (Ntow, Ampiah, Asare-Inkoom & Sokpe, 2011). With the influx of technology and its impact on all spheres of life, major attentions seems to be drawn on how technology can be integrated into teaching and learning in the classroom especially in subject such as mathematics. Mathematics teaching aims at developing understanding of basic mathematical concepts, problem solving skills, abilities of critical analysis of issues and application of knowledge to solve daily problems encountered in life. Understanding and retention form part of the important constructs that teachers aim to develop and maximize which leads to improved achievement among students (Msila, 2015; Tomljenovic & Zovko, 2016; Iji, cited in Anigbo & Ebuoh, 2017). Iji adds that ability to retain what is learnt has significant influence on achievement. It is believed that using media and technology in teaching holds the potential of inculcating this basic aim of enhancing understanding and retention of mathematics concepts and knowledge into learners in an easier and fascinating manner (Abedalaziz, 2011; Mistretta, 2005; Parks, Koh & Hadden, 2015). Professional teaching

standards framework describe technology integration as an important knowledge base for the teaching profession (Abedalaziz, 2011).

Teaching is a complex task that draws on several knowledge-base of the teacher. Good teaching relies heavily on the interweaving several specialized knowledge such as subject matter knowledge, pedagogy, technology, learner characteristics and knowledge of the curriculum (Shulman, 1986; Koehler & Mishra, 2009). Good teaching enables teachers to demonstrate their scientific and artistic knowledge in a high level of complexities in a lively and self-motivated context with the aim of improving students understanding (Koehler & Mishra, 2009; Koehler, Mishra, Cain, 2013). Integrating technology into teaching enables teachers to be more creative and innovative in their work dispensation. Teachers' use of technological tools (ICT) contributes to technological literacy, creation and deepening of knowledge, improved teaching skills, professional development and curriculum assessment (UNESCO, 2008). Wenglinsky (2000) reported the results of National Assessment of Educational Progress (NAEP) to explain how appropriate use of instructional technology significantly contributes to the development of higher order thinking skills in learning mathematics. Teaching with technology puts the teacher in a position of knowledge facilitation instead of imparting knowledge through teacher-centered approach to teaching which usually does not result in conceptual understanding.

Technology plays an important role in the learner's perspective. Technology use enables students to be placed at the center of instructional process enables students interest to be aroused, participate, construct knowledge and enhance retention and recall of learned materials (Msila, 2015; Anigbo & Ebuoh, 2017). It also ensures active participation of the learner and provides systematic and quick responses to learners (Tella *et al*, 2007).

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2. Statement of Problem

The increasing demand for technological literacy as a result of its impact on almost all human activities has caused stakeholders of education worldwide to have a look at how it can be integrated into teaching and learning. This has brought changes into the education sector and the classroom in particular where teaching and learning takes place. As mathematics is often described as the backbone to all scientific and technological advancement, attention has now shifted to how mathematics is taught nowadays. According to Abedalaziz (2011), media and technologies play an important role in mathematics teaching and learning by reducing its abstractness to more visible and improve its realistic nature of learning. Many Governments in developing countries have shown their commitment in investing heavily into ICT education to its citizens (UNESCO, 2008) to which Ghana is no exception. This has resulted in its policy formulation for ensuring that ICT is taught as a discipline in itself and is also used as a tool for teaching and learning in all other subjects of study in our schools (MOESS, 2010). It is therefore expected that teaching all forms of subjects in our school must take into consideration the inclusion technological tools as means of instruction.

Specifically, the technological consideration among the general aim of designing the SHS mathematics syllabus is to enable students to:

- 1) Use the calculator and the computer for problem solving and investigations of real life situations
- 2) Appreciate the connection among ideas within the subject itself and in other disciplines, especially Science, Technology, Economics and Commerce (MOESS, 2010)

These objectives can be realized when teachers have the requisite knowledge in technology and are able to use technological tools as a means of instruction. Not many studies have been conducted to survey teachers' knowledge, possessed and use of technology in teaching mathematics in many parts of Ghana. It is this gap in the literature that precipitated the need to conduct this study of teachers' knowledge about technology and its integration into teaching and learning of mathematics.

3. Research Questions

The following research questions are formulated to guide the study.

- 1) What is the availability and accessibility of technological tools in schools in the study area?
- 2) What are perceived teacher competences with using the technological tools in the study area?
- 3) What is the extent of these teachers' integration of technology in teaching mathematics?

4. Literature Review

This literature review is organized along the following thematic strands: a) Technological Knowledge; b) Contribution of ICT in Teaching and Learning; c)

Technology and the Mathematics Curriculum; and d) Teacher Competence and Teaching with Technology.

Technological Knowledge

The instability nature of technological knowledge makes it difficult to define (Koehler, Mishra, 2009) since any definition of technological knowledge put forth is in danger of becoming outdated with the passage of time. According to the authors, the definition of technological knowledge is similar to that of Fluency of Information Technology (FITness), proposed by the Committee of Information Technology Literacy of the National Research Council. They contend that FITness extend beyond traditional view of computer literacy to include adequate understanding of information technology to "apply it productively at work and in their everyday lives, recognize when information technology can assist or impede the achievement of a goal, and to continually adapt to changes in information technology" (p. 64). Thus knowledge of technology requires one to possess understanding and mastery of technology that enhance information processing, communication and problem solving skills (Koehler, Mishra, 2009). Knowledge of technology is important in all endeavors of life as a result of unprecedented changes that are taking place in the world today. Meeting the demands of this ever-changing world requires the ability to possess adequate knowledge, skills and use of technology to solve routine and novel mathematical problems.

Contribution of ICT in Teaching and Learning

ICT Policy

There is a growing demand to many countries worldwide to integrating technology into education due to its significance in developing human capacity for nation building. This has made many countries to put in place ICT policy for their educational provision. For instance ICT was introduced into Ghanaian school curriculum as a tool for instruction in 2007 as a result of the ICTAD document and the 2002 Anamuah-Mensah National Education Review Committee Report (Agyei, 2012). In addition, the new educational reform places high degree of emphasis on teaching all subjects through the use of technology (MOESS, 2010). The ICT policy in Ghana was to: enable all pupils or students to be equipped with ICT literacy skills before completing each level, give directives to how ICT can be integrated at all levels of education, train teachers and student in ICT, etc. This policy demands that all schools at each level be equipped with technological tools such as computers, printers, projectors, television sets, ICT laboratories, and many more for successful implementation of the policy.

Technology and the Mathematics Curriculum

In this technological era, teachers must not teach today's students as the way they taught yesterday or how they were taught earlier, else students will be robbed of many future opportunities (Dewey, www.goodreads.com). The fast-growing changes occurring in our society today requires a change in instructional delivery in our educational system (Eze, 2016). Students need to demonstrate adequate knowledge on the use of technology to solve emerging problems in the future. According to the Ontario Mathematics Curriculum Documents, today's mathematics

curriculum must equip students with the knowledge and skills they would need for their future roles and responsibilities in the society (www.edu.gov.on.ca/eng/curriculum/secondary/math.html). Selecting mathematical concepts and skills for instruction must be preceded with considering new ways of doing things. The document states that technological tools provide new teaching strategies for teachers and support students' learning in mathematics. Integrating technology into the curriculum initiates changes in teaching and learning (Mistretta, 2005). It puts teachers in facilitative position in teaching instead of the traditional approach to teaching where teachers behave as the only source of knowledge (Tay& Mensah-Wonkyi, 2018). According to the authors, utilization of technology into mathematics teaching environment builds lessons that focus on student-centered approach to learning which enhances students' ability to engage in reflective activities, problem solving and reasoning skills. Technology use can enable teachers to present instruction to meet the diverse learning needs of the students (Shulman, 1986). It offers teachers the opportunity to design instructions that cater for students as individuals or as members in a group. There are lots of studies reporting that teaching mathematics through interaction with technological devices has positive impact on student learning (NCTM, 2000; BECTA, 2003;Kaino, 2008) and results in an increase in their learning gains (Wright, cited in Mistretta, 2005; Tay& Mensah-Wonkyi, 2018). Teaching through technology enables students to see the connections among what is learnt and manipulate diagrams that may not be possible through traditional teaching method. It also helps students to develop higher order reasoning skills in learning. According to BECTA (2003), technology use in mathematics instruction has the potential to promoting greater collaboration among students through communication and sharing of ideas. In addition, technology use offer instant feedback to learning and develops their interest and motivation in learning mathematics. It also allows instructions to develop along individual's learning pace (Eze, 2016). In connection to teaching mathematics with technology, the Mathematics Association of Ghana (MAG) encourages and supports its use with the view that the use of technology as a teaching tool transforms mathematical concepts for students' visualization and understanding (Tay & Mensah-Wonkyi, 2018). According to Tomljenovic and Zovko (2016), students find it motivating when taught mathematics using technology which develops their interest in learning and improves their acquisition of new knowledge and skills.

Teacher Competence and Teaching with Technology

The demand to integrate technology into teaching all subjects in the educational curriculum especially in mathematics challenges mathematics teachers to possess high caliber of knowledge in technology for teaching. According to Enu *et al* (2018), technology integration into pedagogical practices cannot be attained if teachers have inadequate knowledge of ICT. The authors add that teachers play a key role if ICT is to be used in the classroom. It is a common belief that mathematics teachers instructional choices are often influenced by what they know about the subject (Msila, 2015). Teachers have to possess adequate knowledge about the subject matter and how to bring to

venture of knowledge among students (Resnick & Ford, 1984). According to Agyei (2012), meaningful integration of technology into teaching requires teachers to develop adequate knowledge and skills to enhance sustainable approach for teaching in a specific subject matter context. Mistretta (2005) and Sultana and Md. Shahabul (2018) add that teachers need to be confident in their ability to teach mathematics using technological devices and how to operate and use them in a sound pedagogical ways to promote learning. Selecting appropriate technological devices to support teaching of a particular mathematics concept is a critical component of effective integration of technology into teaching. Teachers' knowledge of how to integrate technology into instruction is considered important in teachers' knowledge domain. Teachers need to possess technological content knowledge before they can confidently incorporate technology into teaching to enhance understanding (Koehler, Mishra, & Cain, 2013). The full benefit of computer integration in teaching and learning would not be realized if teachers have deficient knowledge in computing (Enu, *et al*, 2018). Technological devices does not conduct teaching, they function ultimately as a result of the teachers knowledge. To determine whether indeed the influx of technology has changed the mode of mathematics instruction, Odogwu (2011) conducted a study in which 227 teachers participated in the study. The study revealed that about a quarter of the study participants were found to be competent in use of computers. However, only few (8.4%) of the teachers indicated they had used computers in teaching mathematics.

5. Methodology

Research Design

The design adopted for this study was the descriptive survey. This design was used in connection with the purpose which sought to assess the senior high school mathematics teachers' integration of technology into teaching. As a result, the researcher collected data from large group of people to enable the purpose of the study to be achieved. In addition, the researcher was interested in obtaining practicing views of the participants on the research focus (Best & Kahn, 1995; Sarantakos, 2005).

Population

The target population for the study was all mathematics teachers in senior high schools located within both east and west Municipality of Sunyani. The accessible population however were mathematics teachers selected from nine senior high schools using the simple random sampling technique. Simple random sampling was used in selecting the teachers to allow equal opportunity of taking part in the study and also to make possible generalization beyond the schools studied.

Sample and Sampling Techniques

The study sample comprised of 105 mathematics teachers from the selected schools. The study participants were selected using computer generated random numbers. This sampling technique was used to enable teachers to have equal chances of being selected to take part in the study (Best & Kahn, 1995; Babbie, 2005). Preceding the selection of the study participants, a letter was sent to the various

schools selected for the study. The purpose of the study was explained and permission was sought to conduct the study in the institution. This was to ensure that authorities will not oppose the idea of conducting the study after the schools have been selected.

Data Collection Instrument

A questionnaire was the instrument used to collect data. The questionnaire which was developed by the researcher was in two sections. The first part requested for biographic data of the participants and the second part focused on the availability of technological tools in their schools, their competence in using such tools and their ability to use such tools in teaching. Some of the items of the questionnaire demanded participants to choose from a 4-point Likert type on a scale of Strongly Agree, Agree, Disagree and Strongly Disagree, while other items required to compose the response on their own. The quality of the items developed was determined by giving the questionnaire to some lecturers of Catholic University College of Ghana to determine the clarity and validity of the items measuring the various constructs in the study. The questionnaire was further pilot tested to enable the internal consistencies of the items to be determined. Based on the feedback obtained from the lectures and the estimated Cronbach alpha, few item that needed further clarification were revised to make it more appropriate for the study.

Data Collection Procedure

Data collection took place in the various senior high schools from which authorities offered permission for the study even before their selection. The questionnaires were administered to the study participants. Some of the participants filled the questionnaire instantly and submitted while others were given some time and were later collected within a week. 96% rate of returned questionnaire was achieved.

Data Analysis Technique

The data obtained from the study were coded and entered into SPSS version 20 for analysis. Descriptive analysis was conducted using the percentages, mean and the standard deviation as the specific tools.

6. Results

Research Question 1: *What is the availability and accessibility of technological tools in schools in the study area?*

Research question one sought to determine the availability of technological devices in the schools that were involved in the study. It also focused on the accessibility of such tools to the teachers. These quests were deemed necessary because there may not be a point in assessing one's technological integration in teaching without first determining what tools were in their reach. To respond to this, a questionnaire was presented to teachers to tick which of the technological tools were available in their schools. Responses to this question were analyzed using the frequencies and percentages. The result is presented in Table 1.

Table 1: Technological Tools available in Schools

Technological Tools	Percentage (%)
Computers	93
Printers	29
Scanner	24
Internet Services	23
Projectors	48
N = 105	

Table 1 shows the responses obtained from the participants on the technological tools available for teaching purposes. Out of 105 teachers who participated in study, 93% of them indicated computers as the most available devices in their laboratory. The participants further indicated through their responses that there are few printers and scanners in the school and even those available are only found in the various offices for administrative use. Some of the participants indicated that there is however only one printer in the computer laboratory which is meant for ICT lessons. Participants also indicated that the schools have projectors but are fixed or mounted at the computer laboratory. Some schools did not even have any projector for use. With regard to internet connectivity, few of the participants indicated that their schools have internet connectivity which enable them to readily access materials on the internet. Majority of them indicated unavailability of such facility in their school. On item requiring how they access the internet, some indicated that they have their personal modem for use and others make use of hotspot connectivity on their mobile phones.

Participants were asked to indicate their accessibility to these tools for their usage in lesson planning and instructional purposes. Almost all the teachers indicated that all resources apart from computer are in scarcity in the school. The item of accessibility to technological tools recorded 96% of no access. To them they even consider them unavailable since they do not have access to them. Even the computers according to the participant were not enough and the little available are always in use for ICT lessons. Hence they hardly get access to such materials for use in preparing for lessons. This even discourages them from planning for its use in teaching mathematics.

Research Question 2: *What are perceived teacher competences of using technological tools in the study area?*

Research question two sought to determine teachers' competence in working with technological tools. Responses to these items were analyzed using means and standard deviation. Decision was taking with 2.5 being the yard stick. Interpretation was assigned based on the degree of their competence of skills possessed. Hence, scores less than 1 was interpreted 'low', scores between 2 and 3 was interpreted 'moderate', and scores above 3 was interpreted 'high'. The responses are presented in Table 2.

Table 2: Teachers Responses to their Competence in Basic Skills in Computing

Item	Mean Response	Std Deviation
Can work well with MS word	3.23	0.60
Capable of developing PowerPoint for presentation	2.21	0.89
Capable of working with the spreadsheet	1.99	0.90
Can download information on the internet	3.66	0.56
Can set a printer for use	2.54	0.76
Can send and access received e-mails	3.69	0.55
Can set up a projector for use	2.13	0.79
Mean of means	2.78	0.66

Score Interpretation: less than 2 – low, between 2 and 3 – moderate, greater than 3 – high

Table 2 shows teachers responses with regard to their abilities in computer use. Teachers’ competence was measured by seven items. The table shows that three out of the seven items had a mean response exceeding 3, which means teachers who took part in the study had high skills in working in MS word, downloading information from the internet, and can send and access received e-mails. Three items had mean response between 2 and 3. This indicates moderate skills of the participants in that area of computer usage. Participants’ skills with working with the spreadsheet was found to be low since that item scored an average response less than 2. Considering the mean of means of the participants’ responses indicates that teachers’ competency in working or using the computer is moderate.

Research Question 3: *What is the extent of these teachers’ integration of technology in teaching mathematics?*

Research question three sought to access the teachers’ level of technology integration into teaching mathematics. Teachers’ responses to this item were analyzed using frequency and percentages and is presented in Table 3.

Table 3: Teachers level of Integrating Technology into Teaching Mathematics

	Never Freq (%)	Some Extent Freq (%)	High Extent Freq (%)
I use computers in preparing for lessons	85 (81)	20 (19)	0 0
I use computers in teaching mathematics	95 (90.5)	10 (9.5)	0 0
N = 105			

Results from Table 3 shows that only 20 of the participants of the study representing a percentage of 19% indicated that they use computer in preparing for lessons. 85 of the participants representing 90.5% said they do not use computer in preparing for lessons. Further question on whether they use computer in teaching indicated that 95 representing 90.5% of the respondents indicated they have never used computers in the classroom. Thus about 9.5% of the participants use computers in teaching mathematics.

7. Discussion

The results on the availability of technological tools in schools indicate that the most available tools in the various schools are computers. This result is not surprising because

since the use of computers was accepted and encouraged for use and as a mode of instruction by the Ghana Education Service, the Government of Ghana has shown its commitment by supplying quite a number to computer to many schools. The target supply of computers to schools was aimed at providing a computer for each child’s use popularly known as one child-one laptop. The aim of this supply was to ensure that computer literacy takes its roots in Ghanaian education at all levels (MOESS, 2010).

The results indicate that the computers in the laboratory were not enough and teachers found it difficult to access them for any other thing apart from having ICT lessons. However, according to Hill (cited in Odogwu, 2011), a teacher need not have a computer for each child before teaching with it. The author asserts that a determined and a competent teacher can use even one computer to transform his or her instructional strategies.

Following the results on teacher competency with the use of computer, the study found that teachers have moderate knowledge in technology use which the researcher finds it as a good knowledge possessed by the teachers. This indicates that teachers have the knowledge which can form as knowledgebase for teaching. Teachers who participated in the study had high knowledge in computer fundamentals such as working with MS word, downloading materials from the internet, sending and receiving e-mails. They also demonstrated a moderate knowledge in the rest of the items measuring this variable, with the exception of knowledge on spreadsheet which was low. Thus generally, teachers demonstrated basic knowledge to enable them use technology for teaching mathematics.

However, a result on teacher integration was not very encouraging as most of the teachers who participated in the study were found not to utilize computing into their teaching strategies. The study found that less than 10% of the study participants made use of computing in teaching mathematics. Teachers were found not to integrating technology into teaching even though some of them use computers in preparing lessons. It is quite surprising that upon teachers’ knowledge demonstrated in computer fundamentals, it is not utilized to enhance teaching and learning process. This finding support the work of Odogwu (2011) who found in a study that a handful of the study participants (less than 10%) used technology in mathematics teaching and learning.

8. Conclusion and Recommendation

In conclusion to this study, there are inadequate supply of computers in the schools in the Sunyani east and west municipality. This prevents mathematics teachers to access them to use in the classroom. Teachers who participated in the study have basic knowledge on technology which can serve as fundamental knowledge for teaching and change the mode of mathematics delivery in the classroom. Teachers were however found not to incorporate technology into teaching mathematics.

It is recommended that schools need to be adequately resourced in terms of supply of technology tools for use by

all teachers particularly, mathematics teachers to enable the technology related aims of mathematics education to be achieved. Teachers need to be trained and encouraged on how to incorporate their knowledge of computers into planning, teaching and evaluating their teaching of mathematics, since it has been found useful to teaching and learning.

It is further recommended that teacher preparation institutions such as the Faculties of Education in the Universities as well as the Colleges of Education need to include courses that focus on integration of technology into instruction in their curricula. Those who have such course in their curricula need to strengthen its teaching. These would equip teacher trainees on skills of incorporating technology into lesson planning and instructional processes.

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