Towards ICT Integration in Mathematics Instruction: Prospective Teachers' Knowledge for Teaching with Technology

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Abstract

The integration of Information and communication Technology (ICT) in mathematics instruction has highly been emphasized by the Government of Ghana as a means of improving the quality of mathematics education. This has impose a great challenge to teacher educators on how to ensure that prospective teachers are equipped with the necessary technological pedagogical content knowledge that will enable them to effectively use technologies in the classroom. This study investigated the level of prospective mathematics teachers' technology related professional knowledge in ICT with regards to their readiness for ICT integration in classroom instruction. A survey of 126 third year undergraduate students from the Department of Mathematics Education in the University of Education, Winneba (UEW) was conducted using Teaching with Technology questionnaire. The questionnaire has an internal consistency reliability coefficient of 0.726. It was found in this study that, prospective mathematics teachers had a moderate level of Technological Pedagogical Content Knowledge (mean = 3.76, SD = 0.53). It was recommended that Teacher education institutions in Ghana should put in place a scheme that will address the technology related professional knowledge needs of prospective mathematics teachers.

Keywords: ICT Integration, Technology Pedagogical Content Knowledge, Prospective teachers

1. Introduction

Mathematics instruction involves several didactical processes which include the use of a carefully chosen tasks or activities to initiate mathematical thinking and keep the students engaged in the process of constructing new mathematical ideas and concept with the role of the teachers as a facilitator of knowledge construction through mathematical reasoning and communication (Hook, 2008). This means that, mathematics instruction should place more emphasis on mathematical processes such as mathematical thinking, reasoning, communication, connections and problem solving (NCTM, 2000). Research have indicated that the integration of Information and Communication Technologies (ICT) in the teaching and learning of mathematics allows students to conjecture and to validate their conjectures, to prove and convince others that their conjectures are true and to critique or disprove conjectures thereby improving the problems solving and critical thinking skills of students (Hook, 2008). BECTA (2003) summarized the key benefits of ICT in mathematics instruction: (i) ICT promotes greater collaboration among students and encourages communication and the sharing of knowledge. (ii) ICT gives rapid and accurate feedbacks to students and this contributes towards positive motivation. Consequently, ICT has become an essential tool for doing mathematics in today's world since it can be used in a variety of ways to improve the teaching and learning of mathematics (Nisse, 2006; Hook, 2008).

Emphasis has been place on ICT integration in mathematics instruction as a means of improving quality of teaching, expanding access to mathematics resources and making education responsive to the needs and requirement of the of the society (Republic of Ghana, 2003). Educational reforms in Ghana placed high emphasis on the integration of ICT tool in mathematics instruction. The syllabus for teaching mathematics at the senior high school level for example encourages teachers to integrate ICT tools like spreadsheet for teaching.

However, the degree to which meaningful ICT integration occurs in classroom instruction is greatly influenced by the pedagogical knowledge teachers have on how to use existing software to improve the teaching and learning process (Forgasz & Prince 2004; Keong, Horan, & Danie, 2005). Consequently, as part of the effort to integrate ICT in mathematics instruction, it is imperative for decision makers to know the level of prospective mathematics teachers' knowledge and skills in ICT integration.

1.1 Statement of the problem

The new educational reforms in Ghana have brought about changes in the pre-university curriculum and mathematics teachers are being challenged to strengthen their capacity in ICT integration in response to governments' policies and initiatives in the country. However, even though 87% of the second cycle institutions in Ghana are equipped with ICT facilities (Ministry

Of Education, 2009) statistics indicate that majority of mathematics teachers in Ghana are currently not integrating ICT in their classroom instruction (Ministry of Education, 2009; Mereku, Yidana, Hodzi, Tete-Mensah, Tete-Mensah & Williams, 2009). Even though there appears to be no single factor that determines why mathematics teachers are not using ICT in their teaching, there is widespread agreement that teachers' knowledge and skills in ICT plays a significant role (Forgasz & Prince 2004; Keong, Horan, & Danie, 2005; Koehler & Mishra, 2006).

Various studies (Shulman, 1986; Yelon, 1996; Ball, Lubienskis & Mewborn, 2001; Hughes, 2005) have indicated that teachers' knowledge and skills plays an important role in determining their actions and inactions in the classroom. Therefore, it may be correct to say that mathematics teachers can effectively integrate ICT in their instruction if only they have expertise in the pedagogical use of ICT tools. Yet, there have not been comprehensive research studies in Ghana on the knowledge and skill that prospective teachers have in the use of ICT tools for instruction (Ministry of Education, 2009). Research studies (e.g. Brand, 1997; Becker, 2000; Yidana, 2007; Mereku et al, 2009) in educational technology have mainly focused on teachers' attitude and beliefs, scheduling problems, lack of technical and administrative support, standardized testing, school environment, funding and learning styles with little emphasis on teachers' knowledge and skills in ICT integration.

1.2 Purpose

This study therefore investigated the level of prospective mathematics teachers' technology related professional knowledge and skills in ICT with regards to their readiness for ICT integration in classroom instruction.

2. Literature Review

2.1 Teachers Knowledge for Teaching with Technology

Teachers' knowledge has been found to play an important role in determining what goes on in the classroom as well as students success (Shulman, 1986; Hughes, 2005). However, the rapid advancement in information and communication technologies has created a profound effect on the way teachers teach and how learners learn which have lead to a changing process of teachers' knowledge (UNESCO, 2005; Fives & Buehl, 2008) and mathematics teacher are not an exception. Mathematics teachers in Ghana are currently required to ingrate ICT in their instruction. However, given the complexity and difficulties implied by the integration of technology into teaching and learning activities, educational technology needs of teachers should be grounded in theoretical models that allow teacher educators to reach a deep understanding of the multifactorial and multivariate process they face (Arroyo, Sanchez & Diaz, 2009).

Building on Shulman's (1986) idea of pedagogical content knowledge (PCK), Koehler and Mishra (2006; 2009), have added technology to PCK and designed a model that they call ‘technological pedagogical content knowledge’ (TPACK) to refer to the interrelationship of the three key components of teaching and learning: content, pedagogy, and technology. TPACK is a framework for understanding the specialised, multi-faceted forms of knowledge required by teachers to integrate technology in their teaching (Koehler & Mishra, 2006).

According to Koehler and Mishra (2006) the availability of a range of new, primarily digital technologies and requirements for learning how to apply them to teaching have changed the nature of the classroom or have the potential to do so. Consequently, “knowledge of technology has becomes an important aspect of overall teacher knowledge” (Koehler & Mishra, 2006, p.1024). TPACK emphasises that the knowledge and skills of the 21st century teacher intersect three fundamental areas: content knowledge, pedagogical knowledge and technological knowledge. Koehler and Mishra (2009) urge that rather than looking at each of these components (i.e. content knowledge, pedagogical knowledge and technological knowledge) in isolation, there is a need to look at them in pairs: pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and all three taken together as technological pedagogical content knowledge (TPACK) (Figure 1). To separate the three knowledge components constitutes a real bias regarding ICT integration in educational practice. Learning and teaching by means of technology takes place in a dynamic transaction of relationships among the three components of the TPACK framework and any change in any of the intervening factors needs be balanced through changes in the other two (Koehler & Mishra, 2006).

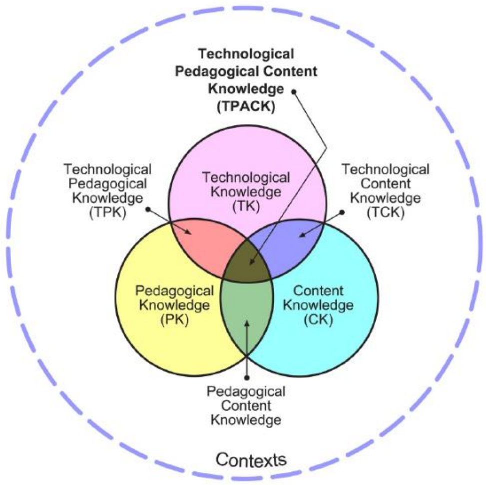

Figure 1: Technological Pedagogical Content Knowledge Framework

Source: Koehler and Mishra (2009)

TPACK was developed to assist with the integration of technology across the curriculum, the implication is that properly prepared teachers can take advantage of the unique features of technology to teach content in ways they otherwise could not.

2.1.1 Content Knowledge

Content knowledge (CK) in the TPACK framework is teachers' knowledge about the subject matter to be learned or taught (Koehler & Mishra, 2009). The content to be covered in Senior High School (SHS) mathematics is different from the content to be covered in an undergraduate course in mathematics. Clearly, mathematics teachers must know and understand the subjects that they teach, including knowledge of central facts, concepts, theories, and procedures within the field of mathematics; knowledge of explanatory frameworks that organize and connect ideas; and knowledge of the rules of evidence and proof (Shulman, 1986). The cost of not having a comprehensive base of content knowledge can be prohibitive; for instance, students can receive incorrect information and develop misconceptions about a content area in mathematics.

2.1.2 Pedagogical Knowledge

Pedagogical knowledge (PK) is teachers' deep knowledge about the processes and practices or methods of teaching and learning. They encompass, among other things, overall educational purposes, values, and aims (Shulman, 1986). PK also includes actions and strategies of teaching, organization of classroom experiences, providing for diverse learner needs, evaluation and implementation based on learner's prior notions, and transformation of ideas into understandable episodes (UNESCO, 2005). A mathematics teacher with deep PK understands how students construct knowledge and acquire skills and how they develop habits of mind and positive dispositions toward learning.

2.1.3 Pedagogical Content Knowledge

Pedagogical content knowledge includes an understanding of what makes the learning of specific topics easy or difficult; the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons Shulman (1986). PCK covers the core business of teaching, learning, curriculum, assessment and reporting, such as the conditions that promote learning and the links among curriculum, assessment, and pedagogy (Koehler & Mishra, 2009). The key to distinguishing the knowledge base of teaching lies at the intersection of content and pedagogy which includes understanding why some learners experience difficulties when learning a particular concept, while others find it easy to assimilate knowledge about useful ways to conceptualize and represent a chosen concept (UNESCO, 2005).

2.1.4 Technological Knowledge

Technological Knowledge (TK) goes beyond traditional notions of computer literacy to require that persons understand information technology broadly enough to apply it productively at work and in their everyday lives, to recognize when information technology can assist or impede the achievement of a goal, and to continually adapt to changes in information technology (Koehler & Mishra, 2009). TK therefore, requires a deeper, more essential understanding and mastery of information technology for information processing, communication, and problem solving than does the traditional definition of computer literacy. Most standard professional development workshops in educational technology and teacher training technology courses tend to focus on the acquisition of such skills (UNESCO, 2005; Koehler & Mishra, 2006; Vacirca, 2008). However, the development of relevant TK requires the ability to learn and adapt to new technologies since technology is frequently changing (Gill & Dalgarno 2008).

2.1.5 Technological Content Knowledge

Technological content knowledge (TCK) is an understanding of the manner in which technology and content influence and constrains one another. Understanding the impact of technology on the practices and knowledge of a given discipline is critical to developing appropriate technological tools for educational purposes. According to Koehler & Mishra (2009) the choice of technologies affords and constrains the types of content ideas that can be taught, likewise, certain content decisions can limit the types of technologies that can be used. Consequently, mathematics teachers need to master more than the subject matter they teach; they must also have a deep understanding of the manner in which the subject matter can be changed by the application of particular technologies (Forgasz & Prince, 2004).

2.1.6 Technological Pedagogical Knowledge

Technological pedagogical knowledge (TPK) is knowledge of the existence, components, and capabilities of various technologies as they are used in teaching and learning settings, and conversely, knowing how teaching might change as the result of using particular technologies in a particular way (Koehler & Mishra, 2006). TPK becomes particularly important because most popular software programs (example, Word, PowerPoint, Excel etc.) are not designed for educational purposes but are usually designed for the business environments. Most software tools are rarely created as solutions to pedagogical problems, as a result converting these general tools for classroom teaching is neither trivial nor obvious; it requires the teacher to engage with the affordances and constraints of particular technologies in order to creatively repurpose these technologies to meet specific pedagogical goals of specific content areas (Zhao, 2003).

2.1.7 Technological Pedagogical Content Knowledge

Technological Pedagogical Content Knowledge (TPACK) is the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones (Koehler & Mishra, 2006; 2009). TPACK represents a class of knowledge that is central to the mathematics teachers' work with technology. Other researchers (Keating & Evans, 2001; Zhao, 2003; Neiss, 2005; Hughes, 2005) have argued that knowledge about technology cannot be treated as context-free and that good teaching requires an understanding of how technology relates to the pedagogy and content. Thus, mathematics teachers need to develop fluency and cognitive flexibility not just in each of the key domains (TK, PK, and CK) of the TPACK framework, but also in the manner in which these domains and contextual parameters interrelate, so that they can construct effective solutions to students mathematical problems (Vacirca, 2008; Shin, Koehler, Mishrah, Schmidt, Bara & Thompson, 2009; Koehler and Mishra, 2009).

3. Methodology

The study used cross-sectional survey research design. Purposive sampling technique was used to sample one hundred and twenty six (126) third year undergraduate students from the Department of Mathematics Education in the University of Education, Winneba (UEW) which is the largest public university, mandated to train teachers in Ghana. The Department of Mathematics Education previously required students to take cognate courses in second subject area. This policy required students to take courses from other departments such as Physical Education, Science Education and Home Economics which they never ever use after graduation since the courses were not related in any way to mathematics teaching and learning. As a result, in 2003 the Department of Mathematics Education added the cognate ICT courses to the mathematics curriculum in order to equip students with ICT tools for teaching and learning mathematics. The Department has set up departmental computer laboratory which is equipped with 50 computers and a digital projector for the purpose of training students in ICT. The choice of the third year students as the sample for the study was based on the fact that the third year prospective mathematics teachers would have studied enough content in both mathematics and ICT courses as at the time of administering the instrument. Furthermore, Mathematics Education undergraduate students in the UEW are required to go on an out segment program to teach mathematics in various non-tertiary intuitions in their final year (fourth year) and it is imperative to investigate their knowledge in integrating ICT in mathematics instruction.

3.1 Instrument

Teaching with Technology questionnaire which was adapted and modified from Lambert (2004) was used to provide data on the teachers' knowledge and understanding in the use of technology in the classroom related to basic computer competencies recommended by the International Society for Technology in Education (ISTE). The questionnaire consisted of twenty six (26) items based on the Association for Mathematics Teacher Educators (AMTE) standards and indicators for TPACK. The AMTE standards and indicators for TPACK consists of four (4) standards that are used to measure prospective teachers knowledge and experiences that is needed to incorporate technology in the context of teaching and learning mathematics (Association for Mathematics Teacher Educators, 2006). These Standards are;

I. Designing and developing digital-age learning environments and experiences
II. Teaching, learning and the mathematics curriculum
III. Assessment and evaluation
IV. Productivity and professional practice

A Likert scale with five options (Strongly Agree (SA = 5), Agree (A = 4), Neutral (N = 3), Disagree (D = 2), Strongly Disagree (SD = 1)) was used to score the questionnaire. The questionnaire has an internal consistency reliability coefficient of 0.726.

4. Results

To investigate the prospective mathematics teachers' knowledge for teaching with technology, the following questions were posed in the study:

1. How do prospective mathematics teachers rate their knowledge and skills in the use of computer software for instruction?
2. What is the level of development of prospective mathematics teachers in the Association for Mathematics Teacher Educators (AMTE) TPACK standards?

The findings of the study are presented according to the research questions.

4.1 How do prospective mathematics teachers rate their knowledge and skills in the use of computer software for instruction?

Participants were asked to rate their knowledge and skills in the use of the following ICT common applications in the instructional process.

- Word processing
- Spreadsheet

- Presentation Packages
- Mathematical software
- Internet
- Email

The purpose was to determine how prospective mathematics teachers are convinced about their ability to use computer software in the teaching and learning process.

Word processing

Table 1 shows prospective mathematics teachers' ratings on their ability to integrate word processing software packages into the teaching and learning process.

Table 1: Prospective mathematics teachers' ratings on their ability to integrate word processing

I Can design a lesson in mathematics that requires the use of a word processor :	SD n (%)	D n (%)	N n (%)	A n (%)	SA n (%)	Total
to create documents and diagrams to engage in correspondence with students.	2(1.6)	2(1.6)	10(8.0)	73(58.4)	38(30.4)	125*
	3.2%			88.8%		
to create a classroom newsletter, and student assignment in a mathematical topic.	6(4.9)	7(5.7)	19(15.4)	59(48.0)	32(26.0)	123*
	10.6%			74%		

* the total is less than 126 because of missing responses

Result in Table 1 shows that there are more prospective mathematics teachers who strongly agree (SA) or agree (A) than those who strongly disagree (SD) or disagree (D) to the word processing items which indicate that the prospective teachers highly rate their knowledge in the use of word processing for instruction. Cumulatively, 88.8% (n=111) out of 125 participants (i.e. A or SA) indicated that they can design a lesson that involved the use of a word processor to create document and engage in correspondence with students. Additionally, 74% (n=91) out of 123 participants agreed that they can use word processor in their lesson to create a classroom news letter and students assignment in a mathematics topic. This finding indicates that in general, prospective mathematics teachers are competent in integration of word processing software.

4.1.1 Spreadsheet

Table 2 shows prospective mathematics teachers' ratings on their ability to integrate spreadsheet into the teaching and learning process. The result in Table 2 indicates that 35.2% (n= 44) and 32% (n= 40) strongly agreed or agreed that they can design a lesson that requires students to use a spreadsheet program to perform calculations. This shows that 67.2% (n= 84) of the participants have knowledge in the use spreadsheet and can help their student to perform calculations using the software.

Table 2: Prospective mathematics teachers' ratings on their ability to integrate spreadsheet

I Can design a lesson that requires students to use a spreadsheet program (e.g. MS. Excel):	SD	D	N	A	SA	Total
	n (%)	n (%)	n (%)	n (%)	n (%)	
to perform calculations with an existing spreadsheet.	21(16.8)	14(11.2)	6(4.8)	44(35.2)	40(32.0)	125*
	28%			67.2%		
to enter data or information into an existing spreadsheet.	24(19.4)	12(9.7)	6(4.8)	51(41.1)	31(25.0)	124*
	29.1%			66.1%		
to analyze and interpret data in a spreadsheet.	25(20.0)	9(7.2)	13(10.4)	41(32.8)	37(29.6)	125*
	27.2%			62.4%		
to create a new spreadsheet.	16(12.9)	18(14.5)	9(7.3)	54(43.5)	27(21.8)	124*
	27.4%			65.3%		
to create graphs or charts.	17(13.9)	20(16.4)	10(8.2)	52(42.6)	23(18.9)	112*
	30.3%			61.5%		

* The total is less than 126 because of missing responses

Additionally, 66.1% (n = 82) out of 124 participants agreed or strongly agreed that they can design a lesson that requires students to enter data into an existing spreadsheet. This indicates that more than half of the prospective mathematics teachers can guide their students to use spreadsheet software. Also, 62.4% (n = 78) of the participants agreed or strongly agreed that they can guide students to analyze and interpret data using spreadsheet. Furthermore, 61.5% (n = 75) of the participants agreed that they can use spreadsheet in their lessons to help student create graphs or charts.

4.1.2 Presentation packages

Table 3: Prospective mathematics teachers' ratings on their ability to integrate presentation packages

I Can design a lesson that requires students to use electronic presentation software (e.g. PowerPoint):	SD n(%)	D n(%)	N n(%)	A n(%)	SA n(%)	Total
to make electronic presentations to in class.	9(7.2)	14(11.2)	16(12.8)	48(38.4)	38(30.4)	125*
	18.4%			68.8%		
as part of a mathematics project.	9(7.1)	13(10.3)	22(17.5)	53(42.1)	29(23.0)	126
	17.4%			65.1%		

* The total is less than 126 because of missing responses

From Table 3, 68.8% (n= 86) out of 125 participants agreed or strongly agreed that they can design a lesson that requires students to make electronic presentation in class. Additionally, 65.1% (n=82) of the participants agreed or strongly agreed that they can integrate presentation software in the teaching and learning process such that students will use the software as part of a mathematics project.

4.1.3 Mathematics software

Table 4 indicates prospective mathematics teachers' rating on their ability to integrate mathematics software packages. The result shows that significant number (88.9%, n=112) of the participants agreed or strongly agreed that, they can guide students in their lessons to enter data into a mathematics software. Also 89.6% (n=112) out of 125 participants agreed or strongly agreed that, they can guide students in their lessons to use mathematics software to solve mathematical problems.

Table 4: Prospective mathematics teachers' ratings on their ability to integrate mathematics software

I Can design a lesson that requires students to use mathematical software (e.g. SPSS, Derive, Encarta):	SD n(%)	D n(%)	N n(%)	A n(%)	SA n(%)	Total
to enter information or data.	4(3.2)	3(2.4)	7(5.6)	48(38.1)	64(50.8)	126
	5.6%			88. 9%		
to enter and solve mathematical problems.	2(1.6)	3(2.4)	8(6.4)	44(35.2)	68(54.4)	125*
	4%			89.6%		
to analyze and interpret statistical data.	2(1.6)	7(5.6)	10(7.9)	51(40.5)	55(43.7)	125*
	7.2%			84.2%		
to create and design graph of functions.	2(1.7)	6(5.1)	12(10.2)	45(38.1)	53(44.9)	118*
	6.8%			82%		

* the total is less than 126 because of missing responses

A further 84.2% (n=106) out of 125 participants agreed or strongly agreed that they can design a lesson that requires students to analyze and interpret statistical data using mathematics software. However, 83% (n=98) out of 118 participants agreed or strongly agreed that they can integrate mathematics software in their lessons to guide students create and design graphs. These findings indicate that, significantly high number of the participants can use mathematics software in the teaching and learning process

4.1.4 Internet

The result in Table 4.6 indicates participants' ratings on their ability to integrate the Internet in the teaching and learning process. Out of 126 participants, 69.8% (n=88) agreed or strongly agreed that they can design a lesson that requires students to search for information on the internet, with 48.8% (n= 61) agreeing or strongly agreeing that they can guide students to create a class webpage. However, 66.4% (n=83) out of 125 participants agreed or strongly agreed that they can guide students to download electronic mathematics books form the internet.

Table 5: Prospective mathematics teachers' ratings on their ability to integrate the internet

I can design a lesson that requires students to use the internet:	SD n(%)	D n(%)	N n(%)	A n(%)	SA n(%)	Total
to search for and locate information for a mathematics project.	7(5.6)	12(9.5)	19(15.1)	57(45.2)	31(24.6)	126
	15.1%			69.8%		
to create or maintain a class webpage.	11(8.8)	17(13.6)	36(28.8)	43(34.4)	18(14.4)	125*
	22.4%			48.8%		
to download electronic mathematics books.	7(5.6)	13(10.4)	22(17.6)	52(41.6)	31(24.8)	125*
	16%			66.4%		

* the total is less than 126 because of missing responses

4.1.5 Email

Table 6 shows participants ratings on their ability to integrate email in the teaching and learning process. Out of 125 participants who responded ot item 7, 59.2% (n =74)) agreed or strongly agreed that they can design a lesson that requires students to use the e-mail to communicate with others.

Table 6: Prospective mathematics teachers' ratings on their ability to integrate email

I Can design a lesson that requires students to use e-mail:	SD n (%)	D n (%)	N n (%)	A n(%)	SA n (%)	Total
to communicate with others.	16(12.8)	17(13.6)	18(14.4)	37(29.6)	37(29.6)	125*
	26.4%			59.2%		
as part of an on-line project (e.g. e-mail a mathematical problem to an expert).	26(21.1)	21(17.1)	18(14.6)	26(21.1)	32(26.0)	123*
	38.2%			47.1%		

* the total is less than 126 because of missing responses

Also, 47.1% (n=58) agreed or strongly agreed that they can design lessons that requires student to use the internet as part of an online project.

Figure 2 below shows the mean scores of prospective mathematics teachers' ratings of their ability to integrate various software packages. Since a five- point (1-5) likert scale of five (5) was used in the questionnaire, the mean score ranged from 1(minimum) to 5(maximum). A mean value below 3.0 gives a general picture low level of knowledge in the integration of particular software while a mean value above 3.0 indicates high level of knowledge. The four top ICT application rating starting with the one with the highest mean score are Mathematics software (mean = 4.28), Word processor (mean = 3.99), Presentation package (mean = 3.69) and Internet (mean = 3.59).

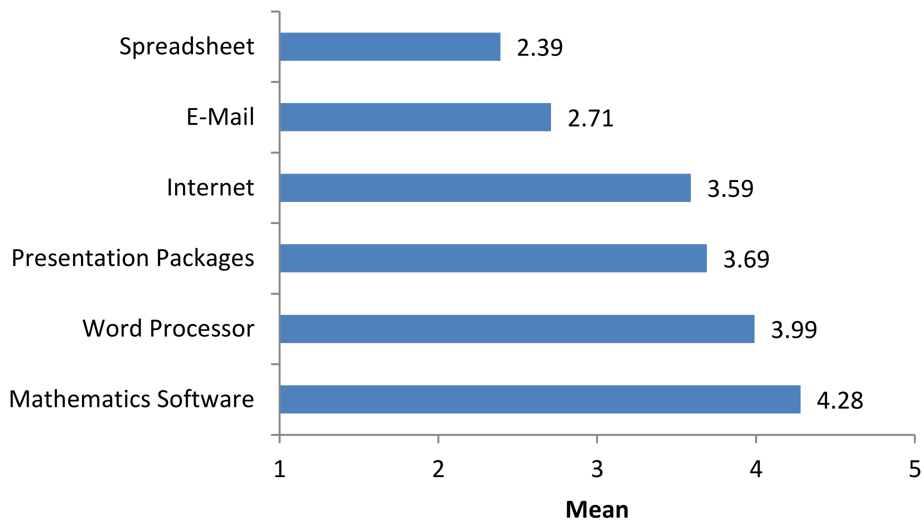

Figure 2: Mean scores of prospective teachers' ratings of their ability to integrate various software packages

However, both spreadsheet (mean = 2.39) and E-mail (mean = 2.70) had low mean score as compared to the other. The overall means score for the TPACK items was 3.76 (SD = 0.53) which indicate that participants of the study had a considerable Technological Pedagogical Content Knowledge (TPACK) score.

4.2 What is the level of development of prospective mathematics teachers in the Association for Mathematics Teacher Educators (AMTE) TPACK standards?

The participants' means scores of the AMTE TPACK standards questionnaire items have been illustrated in Figure 3. Participants mean scores in the AMTE TPACK standards ranged from

3.98 to 3.42. On the average, participants of this study had a high score (mean = 3.98) on the productivity and professional practice standard (IV). This signifies that on the participants of the study can evaluate and reflect on the effective use of existing and emerging technologies to enhance students' mathematical learning. This might be due to the fact that the participants of this study have been exposed to a wide range of software in the cognate ICT courses. Participants' mean score of 3.84 on the Teaching Learning and the Mathematics Curriculum standard (II) indicates that, on the average participant can use technology to support mathematics instruction. This can be as a result of the participants' exposure to mathematics related software in the cognate ICT courses.

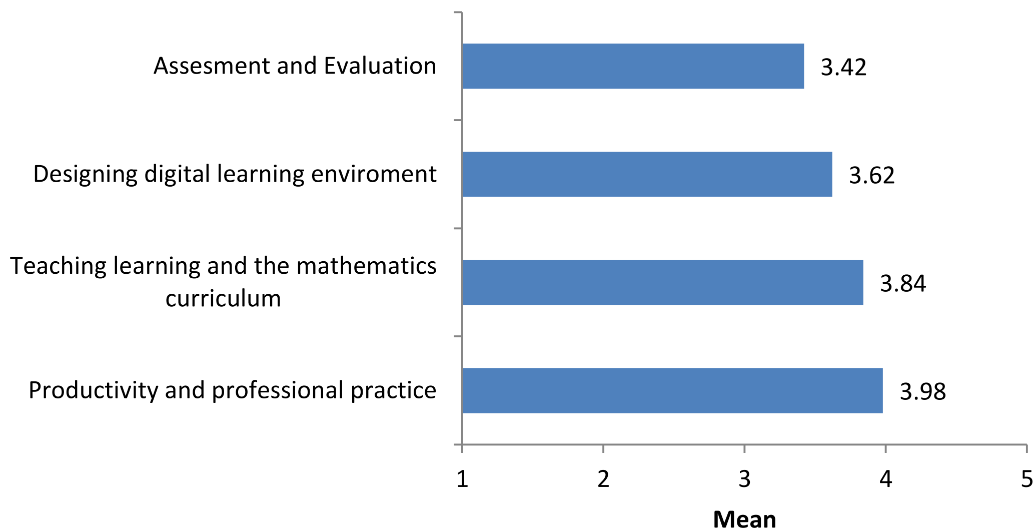

Figure 3: Mean scores for AMTE mathematics-related TPACK Standards

Designing digital learning environment standard (I) had a mean score of 3.62 which signifies, participants of this study have knowledge in designing digital learning environment for students using computer based technology. This might be as a result of the participants' exposure to instructional technologies in the multimedia course. However, among the four standards, Assessment and Evaluation standard (III) had the lowest mean score (mean =3.42) which indicates that participant have a fair knowledge in the use of computer technology in classroom assessment and evaluation.

5. Discussions and Implications

The study investigated pre-service mathematics teacher knowledge for teaching with technology. Research reveals that even though teachers' have positive perception about the use of ICT in the instructional process; computers are poorly integrated into teaching and learning processes in Ghana (Ministry Of Education, 2009). According to Cox, Abbott, Webb, Blakely, Beauchamp and Rhodes (2004), a gap exists between what teachers are taught in their courses and what they are expected to do with technology in a real classroom. In this respect, recent calls for effective technology integration stress the need to help teachers to bridge the gap between knowledge of good pedagogical practice, technical skills and content knowledge.

Koehler and Mishra (2006; 2009) introduced the concept Technological Pedagogical Content Knowledge (TPACK) to emphasise the comprehensive set of competencies teachers need to successfully integrate ICT in their educational practice. It was found in this study that, prospective teachers have ample TPACK (mean = 3.76, SD = 0.53). In general, the study revealed that prospective mathematics teachers' have ample knowledge in the pedagogical use of: (i) Word processing software (mean = 3.99), (ii) Presentation packages (mean = 3.69) (iii) Mathematics software (mean = 4.28) and the Internet (mean = 3.59).

Additionally, the study revealed that, participants' means scores of the AMTE TPACK standards question was considerably moderate with mean scores ranging from 3.42 to 3.98. This signifies that participants of the study can moderately;

- evaluate and reflect on the effective use of existing and emerging technologies in the classroom
- use technology to support mathematics instruction
- designing digital learning environment for students using computer based technology
- have a fair knowledge in the use of computer technology in classroom assessment and evaluation

Participants' moderate level in the AMTE TPACK standards might be due to the due to the cognate ICT courses. Koehler and Mishra (2006) argued that, most teacher training programmes in ICT have not highly trained prospective teachers effectively in the pedagogical use of technology due to the following reasons;

- *The rapid rate of technology change*

Training teachers to use specific software packages not only makes their knowledge too specific to be applied broadly, but it also becomes quickly outdated. Technology is changing so fast that any method that attempts to keep teachers up to date on the latest software, hardware, and terminology is doomed to create knowledge that is out of date every couple of years.

- *Inappropriate design of software*

  Most software tools are rarely created as solutions to pedagogical problems (Zhao, 2003). The software tools available today are designed for the world of business and work, not education. Usually, they are created as potential solutions to problems in the world of business as anticipated by programmers and other developers. Converting these general tools for classroom teaching is not easy. It requires the teacher to engage with the affordances and constraints of particular technologies in order to creatively repurpose these technologies to meet specific pedagogical goals of specific content areas. An emphasis on merely learning the technology may lead to an emphasis on students learning technology as the subject and content of learning rather than the subject matter that they are supposed to learn.

- *The situated nature of learning*

  The general approaches to technology courses at the teacher training institutions encourage nonspecific solutions to the problem of teaching. However, technology use in the classroom is context bound and is, or at least needs to be, dependent on subject matter, students' level, student background, and the kinds of computers and software programs available.

- *An emphasis on what, not how*

  Standard checklists of technological skills are very efficient means of listing what teachers need to know, but offer little suggestion on how teachers are to achieve these skills. This often leads to the development of technological learning situations that adhere to the letter of the standards but go against the spirit of true technology integration. Teachers have often been asked to learn to apply these skills in their own classrooms by themselves usually through trial and error.

However, Koehler and Mishra (2006) suggested that to solve these problems prospective teachers should be given the opportunity to experience real educational problems to be solved by technology during their training and also there should be continuous in-service training for teachers in technology integration. Developing an appropriate range of pedagogical skills in using ICT is a process of long-term experiential learning, rather than short-term conceptual learning and this requires teacher education programmes with built-in key technology elements, in-service teacher training and on-going support for professional self-development, with teachers taking greater responsibility in learning core competencies in technology-pedagogy integration (UNESCO, 2005).

6. Conclusion and Recommendations

From the summary of the major findings of this study, it is recommended that Teacher Education institutions in Ghana particularly the University of Education, Winneba, should put in place a scheme that will address the technology related professional needs of prospective mathematics teachers in ICT integration. Numerous studies (e.g. Can & Cagiltay, 2006; Lua & Sim, 2008) support the idea that effective technology training is the major factor that can help teachers develop positive attitudes toward technology integrating in curriculum. However, the technology training for prospective teachers should not simply focus on basic computing skills but it should be focused on the possible ways of helping prospective teachers to achieve deeper connections among content, pedagogical, and technological knowledge.

This might be accomplished by:

- Designing a series of ICT integrated modules in teacher education programmes which may include for example the use of technology in on-campus peer teaching programs by prospective teachers;
- Presenting various examples of content-specific technology integrated lessons in teaching Mathematics Methodology courses.

References

Arroyo, M. G., Sanchez, R. F., & Diaz, M. S. (2009). *Pedagogical innovation and ICT. Factors and conditions that favour good practices with ICT in Primary and Secondary schools*. Retrieved June 24, 2009, from http://www.formatex.org/micte2009/book/1389-1393.pdf

Ball, D., Lubienski, S., & Mewborn, D. (2001). Research on teaching mathematics. The unsolved problem of teachers' mathematical knowledge. In V. Richardson (Ed.), *Handbook of research on teaching* (4th ed.). New York: Macmillan

Becker, H. J. (2000). Findings from the teaching, learning, and computing survey: Is Larry Cuban right? *Education Policy Analysis Archives*, *8*(51). Retrieved May 31, 2009, from http://epaa.asu.edu/epaa/v8n51/

BECTA. (2003). *What the Research Says about Using ICT in Maths*. UK: Becta ICT Research.

Brand, G. (1997). What research says: Training teachers for using technology. *Journal of Staff Development*, *19*(1), 10–13.

Can, G., & Cagiltay, K. (2006). Turkish Prospective Teachers' Perceptions Regarding the Use of Computer Games with Educational Features. *Educational Technology & Society*, *9* (1), 308-321.

Cox, M., Abbott, C., Webb, M., Blakely, B., Beauchamp, T., & Rhodes, V. (2004). *ICT and Pedagogy – A review of the literature, ICT in Schools Research and Evaluation Series, 18.* London: BECTA

Fives, H., & Buehl, M. M. (2008). What do teachers believe? Developing a framework for examining beliefs about teachers' knowledge and ability. *Contemporary Educational Psychology, 33*, 134-176

Forgasz, H., & Prince, N. (2004). *Computers for secondary mathematics: Who uses them and how?* Retrieved March 2, 2009, from http://aare.edu.au/01pap/for01109.htm

Gill, L., & Dalgarno, B. (2008). *Influences on pre-service teachers' preparedness to use ICTs in the classroom*. Retrieved May 2, 2009, from http://www.aare.edu.au/03pap/war03165.pdf

Hook, C. H. (2008). *A Practical Framework for Technology Integration in Mathematics Education.* In Proceedings of the 2008 International Conference on Science and Mathemtics Education. Penang, Malaysia: SEAMEO RECSAM, 1 – 11

Hughes, J. (2005). The role of teacher knowledge and learning experience in forming technology integrated pedagogy. *Journal of Technology and Teacher Education*, *13*, 277-302.

Keating, T., & Evans, E. (2001). *Three computers in the back of the classroom: Pre-service teachers' conceptions of technology integration.* Paper presented at the annual meeting of the American Educational Research Association, Seattle, WA

Keong, C. C., Horan, I. S., & Danie, l. J. (2005).A study on the use of ICT in mathematics teaching. *Malaysian Online Journal of Instructional Technology (MOJIT) 2* (3), 43-51

Koehler, M. J. & Mishra, P. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, *108* (6), 1017–1054. Columbia: Columbia University.

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60-70.

Lambert, J. L. (2004). *Technology intergration expertise in meddle school social studies teachers: a study of multiplicity in thinking and practice*. Retrieved June 24, 2009, from http://www.lib.ncsu.edu/theses/available/etd3232004203313/unrestricted/etd.pdf

Lau, B. T & Sim, C. H. (2008). *Exploring the extent of ICT adoption among secondary school teachers in Malaysia*. Retreived 23 October, 2009 from http://www.ijcir.org/volume2 number2/article3%2019-36.pdf.

Mereku, D. K., Yidana, I., Hodzi, W., Tete-Mensah, I., Tete-Mensah, W., & Williams, J. B. (2009). *Pan-African research agenda on the pedagogical integration of ICT:Phase 1 Ghana report. University of Education, Winneba,*Canada: International Development Research Center(IDRC)

Ministry of Education, Science and Sports. (2007). *Teaching syllabus for mathematics (Senior High School).* Accra: Curriculum Research and Development Division (CRDD).

Ministry of Education. (2009). *Report on e-readiness assessment of second cycle institutions in Ghana.* Accra: ICT in Education Programmes Unit, Ministry of Education

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: NCTM

Neiss, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education*, *21*(5), 509–523.

Neiss, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education*, *21*(5), 509–523.

Republic of Ghana. (2003). *The Ghana ICT for accelerated development (ICT4AD) policy*. Accra, Ghana: Graphic Communications Group Limited.

Shin, T. S., Koehler, M. J., Mishra, P., Schmidt, D. A., Bara, E., & Thompson, A. D. (2009). *Changing Technological Pedagogical Content Knowledge (TPACK) through course experiences*. Retrieved June 24, 2009, from http://punya.educ.msu.edu/publications/Shin_et_al_SITE2009.pdf

Shulman, L. (1986). Those who understand: Knowledge growth in Teaching. *Education Research, 15(2),* 4-14.

UNESCO. (2005). *Regional guidelings on teacher development for pedagogical integration [Working draft]*. Bangkok, Thailand.

Vacirca, E. (2008). *How do teachers develop their technological pedagogical content knowledge in the context of system-wide pedagogical and curriculum reform?* Retrieved June 24, 2009, from AARE Conference Brisbane 2008: http://www.formatex.org/micte2009/book/13891393.pdf

Yelon, S. L. (1996). *Powerful principles of instruction.* London: Longman Publishers.

Yidana, I. (2007). *Faculty perceptions of technology integration in the teacher education curriculum: a survey of two Ghanaian universities.* [unpublished desertation] Ohio: College of Education of Ohio University

Zhao, Y. (Ed.). (2003). *What teachers should know about technology: Perspectives and practices*. Greenwich, CT: Information Age.