Ghanaian Prospective Mathematics Teachers’ Perceived Self-Efficacy towards Web Pedagogical Content Knowledge

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Abstract  
In Ghana, teacher preparation geared towards pedagogical integration of emerging technologies is quite minimal. The study employed a Learning Technology by Design approach to investigate 172 Ghanaian mathematics prospective teachers’ perceived self-efficacy towards Web Pedagogical Content Knowledge (WPCK). The Web Pedagogical Content Knowledge Survey (WPCKS) served as the primary data source. The WPCKS comprised three sub-scales: Web Attitude (WA), Web Pedagogical Content Knowledge (WPCK), and Web Content Knowledge (WCK). The WPCKS was administered three times during the semester—at the beginning, at mid-semester, and at the end. The mean scores for WA, WCK, and WPCK at the start of the semester were 2.8, 1.3, and 2.7 respectively. While the data for the mean scores for WA showed a steady increase from the start to the end of the semester, that for WCPK increased at mid-semester but declined at the end of the semester. That for WCK decreased in the middle of the semester, but increased at the end of the semester. Project-based web resource interventions have the potential to improve prospective mathematics teachers’ self-efficacy.

Keywords: Web pedagogical content knowledge, prospective teachers, mathematics, technology, Ghana.
1.0 Introduction
The importance of pedagogical integration of existing technologies into the teaching and learning of mathematics is unquestionable. Research has shown that existing technologies have increasingly become important in mathematics education because of their positive effect on students’ acquisition of mathematical knowledge and skills needed for the twenty-first century. The integration of Information and Communication Technologies (ICTs) in school curriculum improves students’ learning outcomes and equips them with competencies and survival skills for the information society (Buabeng-Andoh, 2012).

The role of the teacher in the effective pedagogical integration of technologies in mathematics education cannot be overemphasized. John and Sutherland (2004) indicated that teachers’ knowledge base, skills and attitudes towards technology signify how much students can benefit from learning through new technologies. According to Boakye and Banini (2008), a mathematics teacher with pedagogical proficiency makes a difference in the learning process. They argued that if a mathematics teacher possesses limited knowledge of existing technologies, pedagogical integration will be seriously compromised. A mathematics teacher should therefore be equipped with the relevant pedagogical knowledge and skills to ensure effective technology integration.

In Ghana, the mathematics curriculum was reviewed to conform to the New Education Reforms of 2007 and Ghana ICT for Accelerated Development (ICT4AD, 2003) policy (Agrei & Voogt, 2011). It places emphasis on the use of ICTs in the teaching and learning of mathematics at all levels of education (MOESS, 2007). This is intended to facilitate scientific, industrial and technological advancements in the country. In view of this, the government of Ghana in collaboration with its educational institutions has made several efforts to promote the integration of ICT in mathematics education. ICT courses have currently been incorporated into teacher education curriculum to equip prospective teachers with prerequisite knowledge to teach with technology. At the Teacher Education Universities such as the University of Education, Winneba, ICT courses are integrated into the mathematics education program to prepare prospective graduate teachers on how to integrate emerging technologies such as multimedia tools and web technology in teaching mathematics (Department of Mathematics Education, 2010).

Boakye and Banini (2008) however noted that training geared towards pedagogical integration of ICT in Ghana is minimal. The Ministry of Education (MOE, 2009) reported that Ghanaian teachers’ practices have marginally reflected technology integration because they lack pedagogical skills of technology integration. The e-readiness of teachers for pedagogical integration of technology in second cycle institutions in Ghana is currently less than 10% (MOE, 2009). Buabeng-Andoh (2012) who recently explored teachers’ skills, perceptions, and practices about ICT in second cycle institutions in Ghana found that about 68% of the 231 teachers used some type of software in their lesson delivery. Even though a survey by Apeantin (2010) had suggested that prospective mathematics teachers have sound knowledge of some software for teaching mathematics, Agyei and Voogt (2011) identified lack of knowledge about ways to integrate ICT in lessons and lack of training opportunities for ICT integration knowledge acquisition as core barriers for technology integration in Ghana. These barriers call for the adoption of a framework for the creation of opportunities for prospective mathematics teachers to acquire pedagogical skills to teach with technology.

1.1 Web Pedagogical Content Knowledge
The Technology, Pedagogy and Content Knowledge (TPACK) framework has become the integral component of the modern mathematics teacher (Koehler & Mishra, 2006). Mathematics teachers with TPACK can successfully adopt the technologies of the day in teaching. In spite of the usefulness of TPACK, Lee, Tsai, and Chang (2008) observed that it is too broad to be developed for classroom instruction. They suggested that educators should focus on specific technology
when providing teachers with experiences on technology integration. Consequently, they proposed the Web Pedagogical Content Knowledge (WPCK) framework which is limited to the use of web resources and web technologies in instructions. The WPCK is a locus of functional knowledge within the framework of TPACK involving web technology (Lee et al., 2008). It involves how teachers can utilize web technology as a pedagogical tool and an added value in learning specific content. The present study examined how educators could facilitate the acquisition and growth of prospective mathematics teachers’ web pedagogical content knowledge.

1.2 Teacher Self-Efficacy
Bandura (1986) notes that self-efficacy is a major determinant of the choices individuals make, the effort they expend, the perseverance they exert in the face of difficulties and the thought patterns and emotional reactions they experience. Bandura’s self-efficacy theory states that people would be motivated to perform an action if they are confident that they would perform that action successfully. Educational researchers have emphasized the importance of teachers’ self-efficacy in teaching (Ahmad, Basha, Marzuki, Hisham, & Sahari, 2010; Chen, 2010). Teacher self-efficacy in this study describes teachers’ perceptions of their own competence and ability of teaching with web technology. Studies have identified teacher self-efficacy as a measurable component that influences teachers’ decisions to integrate technology into their lessons (Teo, 2009) in a number of ways. First, prospective teachers’ self-efficacy in the use of technology is correlated with their expertise (Chen, 2010; Maninger & Anderson, 2007). Second, self-efficacy has been found to be a good predictor for computer use among mathematics, science and English language teachers (Wong, Goh, Hanafi, & Osman, 2010). In fact, low levels of technology use in instruction may be attributed to teachers’ lack of self-efficacy in incorporating technology resources (Littrell, Zagumny & Zagumny, 2005). Thus, teachers who feel incompetent towards an instructional task would less likely attempt the task. Teacher self-efficacy is therefore a useful indicator of levels of technology integration and can be used to measure teacher preparedness to teaching with technology (Wong, Teo, & Russo, 2012). The increase in prospective teachers’ self-efficacy has the potential to enhance their confidence to make pedagogical changes towards using technology for instructions (Robertson & Al-Zahrani, 2012).

1.3 Research Problem
Previous studies (Khorrami-Arani, 2001; Teo, & Russo, 2012; Robertson & Al-Zahrani, 2012) have identified self-efficacy as a good predictor of teachers’ knowledge base, decisions, goals, confidence and effort in their instructions. However, attempts to identify and explain how prospective teachers construct web technology self-efficacy have been limited in mathematics education. To date, there is no published research on Ghanaian mathematics teachers’ self-efficacy towards web pedagogical content knowledge for mathematics instruction. The lack of empirical evidence seriously limits educators’ efforts towards preparing prospective mathematics teachers to integrate web technology in mathematics education.

1.4 Purpose of the Study
The primary purpose of the study was to investigate prospective mathematics teachers’ self-efficacy levels towards WPCK. The secondary purpose was to determine the impact of a web technology methods course on their perceived self-efficacy.

1.5 Significance of the Study
Findings from the study could help in predicting prospective mathematics teachers’ capabilities, attitudes and readiness to integrate existing, new, and emerging web resources and technologies in their future
teaching. Findings would also inform curriculum decisions on technology integration for policy decisions and implementation.

1.6 Research questions
The following questions guided the study:
1. What are the levels of Ghanaian prospective mathematics teachers’ perceived self-efficacy towards web technology integration?
2. What is the impact of a web technology methods course on Ghanaian prospective mathematics teachers’ perceived self-efficacy towards Web Pedagogical Content Knowledge?

2.0 Methods
The present study sought to gain a contextual understanding of how Ghanaian prospective mathematics teachers developed their self-efficacies for web technology integration. The study adopted a survey design. Survey design was deemed appropriate because it provided opportunity for participants to use a questionnaire to self-assess their efficacy levels (Fraenkel & Wallem, 2000) to integrate web technology, pedagogy and mathematical content that could add value to students’ learning.

2.1 Participants and Context
The participants included a third year intact class of 172 (162 males and 15 females) prospective mathematics teachers pursuing a 4-year Bachelor of Science degree in mathematics education at the University of Education, Winneba (UEW) in Ghana. The participants were enrolled in a 12-week semester course dubbed, “Web technologies for mathematics Teacher”. The intact class was purposively selected because the researchers were interested in the levels of these prospective teachers’ self-efficacy before and after undertaking the web technology methods course. The authors’ expectation was that their self-efficacy levels may indicate their readiness to deploy web resources to teach mathematics during their internship programme and after graduation.

2.2 The Web Technologies Methods Course
The methods course was a new cognate course for prospective mathematics teachers. The course was designed to provide participants the opportunity to learn to identify and locate web-based resources and evaluate their suitability for mathematics instruction. It was also intended for the prospective teachers to appreciate web technologies such as Hypertext Markup Language (HTML), CSS, and JavaScript, and their usefulness in the design of virtual learning environments. In addition, participants were required to design developmentally appropriate web portals for teaching and learning mathematics (Department of Mathematics Education, 2010).

The participants examined various web-based resources for mathematics instruction, characteristics of good websites and types of web layout, and learnt how to create web contents with the aid of HTML, Cascading Style Sheets (CSS), WYSIWYG Web Builder 8.0 and Dreamweaver in Photoshop.

The course was developed and taught by the first researcher on Moodle platform. The delivery was done in hybrid mode involving face-to-face demonstrations and online interactions. Sample demonstrations and practical activities—including the use of HTML and CSS— took place in the institution’s Math Laboratory. With the aid of the Resources and Activity tools in Moodleplatform, all online reading materials, quizzes, assignments, forums, and tasks relating to the design steps were presented developmentally to cover 12 weeks. In the final project, each group of four to five students was requested to: (i) Identify a mathematics topic that could be adequately taught using web resources and (ii) Develop web content for a targeted class.
in the Ghanaian senior high school curriculum. They were first required to design a project layout to show the web resources they would be creating for their target learners. At the end of the semester, each group (36 in all) was guided to host their final piece of project-based web resources onto free webhosting site.

2.3 Data Collection and Analysis

2.3.1 Questionnaire. The study adapted the Web Pedagogical Content Knowledge Survey (WPCKS) questionnaire designed by Lee et al. (2008) to examine teachers’ self-efficacy towards web pedagogical content knowledge. There were 18 items measuring the prospective teachers’ self-efficacies and attitudes towards web technology. The constructs adapted included web content (5 items), web pedagogical content (7 items) and web attitude (6 items). Sample items include: “I feel web technology can be actually used on math teaching practice” (web attitude); I know how to select proper math content from web resources” (web content); and “I will be able to use web technology to support teaching for the content of a particular math unit” (web pedagogical content). To determine the impact of the methods course on prospective teachers’ web technology efficacy levels, the original scale was reduced to a five-point (1-5) Likert scale from strongly disagree to strongly agree.

The questionnaire was pre-tested with 49 fourth year pre-service mathematics teachers (not part of the current study) for purposes of establishing reliability. The data were processed using SPSS version 16.0. Cronbach’s Alpha was established for each of the three constructs. The reliability statistics for the web content (r = .580), web pedagogical content (r = .670), and web attitude (r = .800) were all found to be acceptable, in line with Kline’s criteria (Kline, 2005). The overall reliability coefficient for the entire questionnaire was .769.

To determine growth in pre-service teachers’ self-efficacy, the WPCKS questionnaire was administered in three phases; at the beginning, at mid semester and at the end of the semester. During the first week of the semester, the first and second authors met and discussed the purpose of the research with all students enrolled in the course and sought their consent to conduct the research. All the students volunteered to participate in the research and the questionnaire was then distributed to them during class session. In order to ensure individual responses were independent, the students were allowed ample time to stay in the classroom, respond to the questionnaire and return them to the researchers as soon as they were satisfied with their responses. This process enhanced the return rate of the completed questionnaires. Similar processes were adopted in distributing and collecting the questionnaires during the second and third phases of the questionnaire administration. The return rate in each phase was 100%. The authors received approval for the study from the first author’s institution. Furthermore, all participants provided written consent prior to data collection.

The responses to the questionnaire items were grouped into web content, web pedagogical content and web attitudes for the first, second and third phases of the surveys. Composite means were computed in SPSS for each of the three constructs at each of the phases. The composite means were exported to Microsoft Office Excel 2007 to create the area chart (see Figure 1). For the purpose of analysis, participants’ scores were categorized as low self-efficacy (.0-2.4), moderate self-efficacy(2.5-3.4) and high self-efficacy (3.5-5.0) relative to web content knowledge (WCK), web pedagogical content knowledge (WPCK) and attitude towards web instructions (WA).

3.0 Results

The purposes of the study were to determine prospective teachers’ perceived self-efficacy levels, and the impact of a methods course on their web pedagogical content knowledge. Web pedagogical content
knowledge was conceptualized as the integral knowledge of prospective teachers’ web content knowledge and web pedagogical knowledge including predisposition or attitude towards web instruction.

3.1 Prospective Teachers’ Efficacy Levels
The first research question investigated the prospective mathematics teachers’ perceived self-efficacy towards web technology integration at the beginning of the semester. On entry into the methods course, the composite means (see Figure 1) indicated that prospective mathematics teachers’ self-efficacy level for Web Content Knowledge (WCK= 2.7) was moderate while their self-efficacy level for Web Pedagogical Content Knowledge (WPCK= 1.3) was low. The composite mean for their attitude towards web instructions (WA=2.8) was also at the moderate level. Comparatively, the prospective mathematics teachers rated their self-efficacy in WCK and WA relatively higher than their WPCK. The results suggest that the prospective mathematics teachers were moderately confident about their knowledge and positive attitude towards web-based resources but less confident in their ability to integrate web technology in mathematics instructions.

3.2 Changes in Prospective Teachers’ Self-Efficacy
The second research question examined the impact of a web technology methods course on prospective mathematics teachers’ perceived self-efficacy towards Web Pedagogical Content Knowledge. Data showing changes in prospective teachers’ self-efficacy levels are presented in Figure 1. The mean scores for WPCK (3.4) and WA (4.0) increased from entry of the methods course to mid-semester. However, the mean score for WCK (2.6) was lower than that at entry (2.7) of the methods course. That is, most prospective mathematics teachers judged themselves as moderately competent in the three constructs during the semester.

Data in Figure 1 indicated increases in the mean scores for WA (4.7) and WCK (3.0) from mid-semester to completion of the methods course. This suggests the methods course impacted prospective teachers’ attitude towards the use of web resources for mathematics instructions. In contrast, the mean score for WPCK decreased from mid-semester (3.4) to completion (3.2) of the course.

In summary, the mean score for WA showed a steady increase from beginning to the end of the semester, while that of WPCK increased from start of the semester to mid-semester, and then decreased at the end of the semester. The mean score for WCK showed a decrease at mid-semester, and then an increase at the end of the semester.

Interestingly, there was a continuous positive growth in prospective mathematics teachers’ web attitude (WA= 2.8 to 4.7) at the end of the methods course. The high composite mean level of 4.7 out of 5.0 showed that participants were positive in their ability to use web technology in mathematics to enhance teaching skills, enrich the mathematics course content, and to enhance students’ learning.

4.0 Discussion
Mathematics teacher practices are yet to reflect technology integration partly because of their integration knowledge gap. How a teacher preparation program helps bridge this knowledge gap to facilitate reforms towards technology integration in mathematics teaching was the essence of the study. Evidence has shown that developing teachers’ pedagogical integration knowledge is not possible in a one shot class on technology workshop, but a process learned through creating or developing a project or product(Koehler, Mishra & Yahya, 2007). Learning technology by design has been suggested in the literature as one effective way of providing opportunity for developing teachers’ pedagogical integration knowledge. The intent for adopting learning technology by design for this study was to trace prospective mathematics teachers’ knowledge growth, capabilities and effort to integrate web technology and resources in the teaching of
mathematics. The study explored the self-efficacy levels of 172 prospective mathematics teachers use of web technology and web resources and the impact of web technology methods course on their self-efficacy towards WPCK.

The results showed appreciably moderate to high self-efficacy levels among prospective mathematics teachers in integrating web resources. Specifically, prospective mathematics teachers’ web content knowledge and web pedagogical content knowledge improved from the beginning, through mid-semester to the end of the semester. This corroborates findings by Hu and Fyfe (2010); Lee et al. (2008); and Koehler et al. (2007) that learning technology by design promotes technology, pedagogy and content knowledge. The increase in WPCK mean score from the start of the semester to mid-semester may be attributed to the involvement of participants in design-based activities such as identifying, locating, analyzing and evaluating suitable web-based resources for mathematics instruction as well as the self-authoring of simple virtual learning environments. Surprisingly, while participants’ web attitudes were incessantly growing, their web pedagogical content knowledge unexpectedly declined towards the end of the semester. Perhaps, participants were rating themselves in line with the final web piece they created and other professional web resources examined and not what they presumed they could create at the initial survey. A second reason for the decline could be that the participants shifted their attention from understanding web content to learning the pedagogies involved. They might have realized that there was more web pedagogical content knowledge to be learnt than what they have learnt.

The result implies that the methods course was effective in providing the adequate experiences that could facilitate prospective mathematics teachers’ acquisition and development of the integral knowledge of web technology, pedagogy and mathematics content needed for teaching mathematics. This integral knowledge is a key predictor of teachers’ decisions and readiness to integrate technology in teaching (Koehler & Mishra, 2006; Khorrami-Arani, 2001). It is anticipated that findings from this line of research would elaborate on the link between teacher WPCK acquisition processes and their teaching practices. Although the composite mean level of prospective mathematics teachers’ self-efficacy in WCK increased from 2.6 to 3.0 at the end of the course, it remained within the moderate level (WCK=3.0). This moderate level suggests that participants judged themselves as having sufficient amount of knowledge about how to search and select proper materials on the web that can enrich mathematics course content.

5.0 Conclusion

This study exemplifies how teacher education programs could enhance the knowledge and self-efficacy of prospective mathematics teachers towards integration of web technology in mathematics instruction. The study shows that web technology method course could provide positive experiences for prospective mathematics teachers to develop their self-efficacies for web technology integration in mathematics instructions. However, the data suggests that the methods course had varying impact on the three constructs. The main conclusion is that incorporating a methods course on web technologies into mathematics teacher education program has the potential of building prospective teachers’ self-efficacy to integrate ICT in mathematics education.

The authors recommend that future research use qualitative techniques, such as interviews, to gain insight into why the methods course had varying impact on the three constructs. The present study examined the prospective mathematics teachers’ self-efficacy over one semester. A study that would track the development of their self-efficacy over a longer period is also warranted.
References


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**Figure 1**: Area chart of prospective mathematics teachers’ self-efficacy growth/levels in web technology integration in math instruction before, during, and after a methods course.