PRE-SERVICE SCIENCE TEACHERS' COMPETENCE, SELF-EFFICACY BELIEFS AND READINESS LEVELS IN ICT INTEGRATION IN TEACHING SCIENCE

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ABSTRACT

The purpose of this study was to examine the levels of pre-service teachers' self-efficacy beliefs, competence and readiness toward ICT integration in science teaching. Data was collected in two phases. The first phase consisted of a structured questionnaire, which was given to 172 pre-service science teachers at Wesley and Akrokerri Colleges of Education in Ashanti Region of Ghana to gather their opinions. The second phase involved structured face-to-face interview with purposive sample of 24 pre-service science teachers, who had already responded to the questionnaire to validate major issues, which emerged from the questionnaire data. The quantitative results of the study showed that the pre-service basic science teachers had high levels of competence (M = 3.71, SD =1.07), self-efficacy beliefs (with a subscale M = 3.72, SD = 1.08) and readiness (with subscale M = 3.73, SD = 1.34) in ICT integration in science teaching. However, the qualitative data obtained from the study did not wholly reflect the outcome of the quantitative aspect of the study. In spite of the disparity between the quantitative and the qualitative findings, the results in general raised significant issues related to the quality of ICT integration regarding pre-service basic science teachers' competence, self-efficacy beliefs and readiness, which need to be given a serious consideration.

Keywords: ICT integration, self-efficacy beliefs, readiness, competence, pre-service science teachers.

INTRODUCTION

Information and Communication Technology (ICT) is bringing about new opportunities for educators, because it can provide powerful support for educational innovations in teaching and learning. The Government of Ghana shares this view, and considers ICT literacy as an engine for accelerated development (Ghana ICT4AD Policy document, 2003). The ICT policy provides the framework for preparation of teachers' orientation package on integration of ICT in the teaching / learning process. This is manifested in the introduction of ICT as subject and tool for teaching in the school curriculum in September 2007 following the recommendations made in the ICT4AD document (2003).

Yusuf and Balogun (2011) asserted that the use of information and communication technology as a tool for enhancing students' learning and teachers' instruction is a catalyst for improving access to quality education in formal settings. In the same vein Pitler, Hubbell and Kuhn (2012) observed that technology is now an expected part of the classroom experience, and, when used effectively, it can enrich students' learning. However, the success of integrating ICT into teaching and learning depends strongly upon the engagement of teachers. There is the need to prepare teachers for integration of the ICT into curriculum and to ensure

that the pre-service teachers are capable of integrating ICT into their future classroom instruction.

However, some key factors have to be satisfied for successful integration of ICT into teaching. These factors include teachers' self-efficacy beliefs, competence and readiness in technology integration. Reasonably, for pre-service teachers they should be well equipped in order to integrate technology in education. Pre-service teachers need to understand how their technology knowledge and skills work together with their pedagogy and content knowledge (Mishra & Koehler, 2006). So it is important to consider pre-service teachers' self-efficacy in technology integration for the reason that teacher' self-efficacy beliefs has been found to be a vital construct in the development of education in parts of the world (Berman, MacLaughlin, Bass, Paully & Zellman, cited in Cheung, 2008).

On the part of teacher educators there is a need to understand the dimensions that influence teachers' competence, self-efficacy beliefs and readiness towards technology integration. To date, however, neither pre-service nor in-service basic science teachers' level of competence self-efficacy beliefs and readiness in technology integration has been investigated together in Ghana. Mereku, Yidana, Hodzi, Tete-Mensah, Tete-Mensah, and Williams (2009) asserted that for Ghana, and Africa as a whole, to be able to fully integrate ICT into teaching and learning there is the need for frequent collection and analysis of data on ICT usage. This study therefore aims to bridge this gap. The study may reveal the pre-service science teachers' levels of competence, self-efficacy beliefs and readiness toward technology integration. This will provide a clue to the science educators in the colleges involved the needed areas to address in the programme for ICT integration in teaching and learning. The following research questions guided the study:

1. What is pre-service science teachers' competence level of integrating ICT for science teaching and learning process?
2. What are pre-service science teachers' self-efficacy beliefs toward ICT integration for science teaching and learning?
3. What is pre-service science teachers' readiness level of integrating ICT for science teaching and learning?

LITERATURE REVIEW

Technology integration is an organization of the goals of curriculum and technology into a coordinated and harmonious manner for purpose of classroom instruction. Morton (1996) argued that technology integration is not simply seeing the computer as a tool instead technology is integrated when it is used in a seamless manner to support and extend curriculum objectives and to engage students in meaningful learning. Mullen (2001) suggested that technology infusion should be implemented throughout the teacher education curriculum to allow student teachers develop a sound pedagogical rationale of how to teach with technology. Kumar, Rose and D'Silva (2008) argued that educational technology requires teachers who can integrate technology into curriculum and use it to improve student learning. This calls into question the teachers' readiness, competence and self-efficacy beliefs towards integration of technology with science teaching. These factors are discussed in the following sections.

Pre-service teachers' Competence in ICT Integration

Agyei (2012) defines competence as having the ability to perform a specific task. Smarkola cited in Agyei (2012) contended that in order to ensure effective integration of technology the teacher must move beyond being "computer literate" to "technology competence". It is obvious that teachers' technology use and knowledge are closely related to their confidence level (Atkins & Vasu, 2000; Lam, 2000). In order to integrate technology into the classroom successfully, teachers need to have technical competence to use various computer applications for educational purposes (Rilling, Dahlman, Dodson, Boyles & Pazvant, 2005; Cunningham, 2000). It therefore means that teachers should initially be trained to build their competency in ICT material utilization.

As highlighted by Kirschner and Woperies (cited in Yusuf & Balogun, 2011), the major ICT competencies required by teachers can be categorized into the following: competency in making personal use of ICT, mastery of a range of educational paradigms that make use of ICT, competency in using ICT as tool for teaching and competency in mastering a range of assessment paradigms which involves use of ICT. The teacher should understand the policy dimensions of the use of ICT for teaching and learning. This study is intended to investigate pre-service competence in using ICT as a tool for teaching because it has a direct bearing on their ability to integrate technology into teaching and learning.

Pre-service teachers' Self-efficacy beliefs towards ICT Integration

According to Bandura (1997), self-efficacy refers to one's belief of the one's capability to perform a specific task. Similarly, Wong, Teo and Russo (2012) define Computer teaching efficacy of teachers as an evaluation of their capability to teach with computers and their personal belief in using computers as effective teaching tool to improve students' performance in learning. Self-efficacy beliefs toward technology integration have been theorized to be a determining factor in how well a teacher is able to effectively use technology to improve teaching and learning (Albion, 2001). Some studies found self-efficacy to be a significant determinant of intentions and use (Anderson & Maninger, 2007; Chen, 2010; Teo, 2009). Anderson and Maninger (2007) explored factors that best predicted pre-service teachers' intentions to use a variety of software and found value beliefs and self-efficacy to be significant predictors. As such, it is important to understand the factors that drive teachers' use of technology for instructional purposes. Broadly, these factors arise from the external environments where the teachers work (Ertmer, 2005) or teachers' attitude towards computer use (Teo, 2008). Ertmer (2005) argued that although the environmental conditions affect technology use, such as infrastructure to enable technology integration, how personal factors such as teachers' beliefs affect technology use in teaching are yet to be resolved.

Zhao and Cziko (2001) in their study identified that teachers' perceived ability to use technology (computer self-efficacy) affected their technology use. This finding is consistent with that of Ahmad, Madarsha, Zainuddin, Ismail and Nordin (2011) who found that computer self-efficacy was an important determinant in affecting faculty members' use of computer technology.

A study conducted by Compeau and Higgins (as cited in Teo & Koh, 2010) revealed that an individual's use of technology was affected by their self-efficacy and participants with higher self-efficacy beliefs used computers more often and experienced less computer-related anxiety. Yusuf's (2005) study conducted on teachers' self-efficacy in implementing computer

education in Nigerian secondary schools revealed that teachers lacked the needed experience and competence in the use of computers either for educational or industrial purposes.

Pre-service teachers' Readiness towards ICT Integration

Readiness or preparedness has to do with awareness, knowledge of use, attitude to use as well as getting skilled in the use of information technology (Ayotola & Morenikeji, 2011). Inan and Lowther (2009) defined teachers' readiness as teachers' perceptions of their capabilities and skills required to integrate technology into their classroom instruction. Carl (2005) stated that the readiness with regard to teaching with technology refers to the teachers' ability to demonstrate an understanding of what tools and skills are necessary to integrate technology into teaching.

Goktas, Yildirim and Yildirim (2009) stated that the necessary skills and the level of future teachers' readiness are key factors in integrating ICT with instruction. That is why teacher training institutions should play a crucial role in preparing future teachers to become proficient in the integration of technology into the curriculum.

Boakye and Banini's (2008) study which investigated teachers' ICT readiness in Ghana reported that about ten percent of the 221 teachers used in the study indicated they always use ICT for instructional purposes which implied that the level of readiness regarding technology integration by teachers was very low at that time. Though their sample cannot be said to be representative of Ghanaian teachers, this study intended to find out if this situation is the same today or has changed with time in Ghana.

METHODOLOGY

Research Design

A descriptive survey research design was employed in the study using questionnaire as the main instrument. A survey research design was chosen because the study was conducted to investigate the levels of pre-service science teachers' self-efficacy beliefs, competence and readiness. Surveys are used to learn about people's beliefs, values, demographics, opinions and other types of information (Creswell, 2012; McMillan & Schumacher, 2004).

Sample

Purposive sampling was used to select 172 level 200 pre-service science teachers two science and mathematics colleges of education namely, Akrokerri College of Education and Wesley College of Education for the study. This category of students was used because ICT is offered only at level 200. Sixty-seven (16 females and 51 males) pre-service teachers were selected from Akrokerri College of Education and 105 pre-service teachers (20 females and 85 males) from Wesley College of Education.

A subgroup consisting of 24 pre-service science teachers (10 from Akrokerri College of Education and 14 from Wesley College of Education) was selected for the qualitative phase of the study. Twelve respondents were picked from those who obtained highest mean scores while the other 12 from those with low mean scores.

Instruments

The study used a questionnaire and semi-structured interviews to collect quantitative and qualitative data respectively to answer the research questions. The use of more than one tool enabled the researchers to triangulate the data to obtain more reliable findings.

Questionnaire

Researchers' designed scale, Science Teachers Competence, Self-efficacy beliefs and Readiness in ICT integration Instrument (STCSRICTI) was employed. A draft scale was developed after an extensive review of literature and similar scales (Koc & Bakir, 2010). The draft scale was subjected experts' comments and a pilot test to determine its face and content validity. Feedback from the experts' comment the pilot study led to deletion of 17 items. Factor analysis was conducted on the remaining 17 items which yielded three subscales: Science Teachers' Competence in ICT Integration (STCICTI) and Science teachers' self-efficacy beliefs towards Technology Integration (STSICTI) with seven items respectively and Science Teachers Readiness in Technology Integration (STRICTI) with three items. The calculated Cronbach alpha coefficient of the scale and the subscales were: STCSRICTI, .90; STCICTI, .90; STSICTI, .89 and STRICTI, .59.

The final instrument was made up of two sections, A and B. Items in section A were used to collect demographic information such as gender, age and name of college. Section B consisted of the Science Teachers Competence, Self-efficacy beliefs and Readiness in ICT integration. Each item of the questionnaire consisted of a statement followed by five weighted options namely strongly agree(SA)=5, agree(A)=4, neutral(N)=3, disagree(D)=2 and strongly disagree(SD)=1. Examples:

1. I can comfortably and confidently use computer for instructional purposes.
2. I believe I can choose technologies that enhance teaching approaches that suit the basic level of education.

Semi-structured interview

A semi-structured interview was employed to seek clarifications from interviewees' responses to some of the questionnaire items. The semi-structured interview was pilot tested to determine its validity and reliability. This led to some changes in the wording of instrument. The final interview protocol included:

1. Name examples of ICT tools that can be used for effective teaching and learning in the classroom at the basic level of education.
2. How will you use a particular ICT tool apart from computer to teach a specific concept?
3. How will you use computer to enhance teaching and learning in the classroom?
4. How ready do you think you are to integrate ICT in your lessons?

Data Collection Procedure

The questionnaire was administered by the junior authors. The interviews were conducted after the analysis of the questionnaire data. This was to facilitate the selection of the subsample for the interviews

Data Analysis

Quantitative data analysis

Descriptive statistics were used to determine the mean scores, standard deviations, frequencies and percentages of the participants' responses. The mean score for the sub-scales were used to describe the pre-service science teachers' level of competence, self-efficacy beliefs and readiness in ICT integration. To facilitate the interpretation of the data, 'strongly disagree' and 'disagree' were categorized as 'disagree' while 'strongly agree' and 'agree' were categorized as 'agree'. The mean scores that fell within $1.0 \leq M \leq 2.4$ were considered

low level and those within $2.5 \leq M \leq 3.5$ were considered moderate level while those that fell within $3.6 \leq M \leq 5.0$ were considered high level (Koc & Bakir, 2010).

Qualitative data analysis

The audio-tape recorded interview of every pre-service teacher interviewee was transcribed verbatim. The transcripts, including preliminary interpretations and follow up questions were given to the pre-service teachers to obtain their comments and feedback to make sure that the transcriptions were true reflection of the recorded version. The transcriptions were read several times to identify concordance and disagreements between interview data and questionnaire data on the pre-service basic science teachers' levels of competence, self-efficacy beliefs and readiness in ICT integration.

RESULTS

Demographic Data of Respondents

A sample of 172 respondents was used. About 61.0% (105) of the respondents was selected from Wesley College of Education while 39.0% (67) respondents were chosen from Akrokerri College of Education for the study. The respondents were made up of 136 (79.07%) males and 36 (20.93%) females. The dominant age group ranges between 24 – 26 years (39%, n=39) and the less dominant age group was 31 and above (11%, n=11).

Research question 1: What is pre-service science teachers' competence level of integrating ICT for science teaching and learning process?

Table 1 presents the mean scores, standard deviations and percentage frequencies for each item of the subscale. The means of the respondents' scores on the subscale ranged from 3.02 (SD=1.31) to 4.15 (SD=1.07) with a sub-scale mean of 3.71 (SD=1.22) while the frequencies ranged from 10 (6%) to 141(93.0%). Apart from two items (1 and 16), the item mean scores and the subscale mean of 3.71 are above 3.60 which are in the high level bracket.

Table 1: Descriptive statistics for pre-service science teachers' competence levels in ICT integration

Item number	% frequency			MS	SD
	Agree	Neutral	Disagree		
1	57.6(99)*	12.2(21)	30.2(52)	3.44	1.35
3	82.0(141)	6.0()11	12.0(20)	4.13	1.06
12	67.0(115)	15.0()26	18.0(30)	3.74	1.12
13	69.0(118)	12.0(21)	19.0(32)	3.80	1.27
15	82.0(138)	6.0(10)	13.0(21)	4.15	1.07
16	44.0(74)	17.0(29)	39.0(67)	3.02	1.31
17	68.0(116)	8.0(14)	24.0(41)	3.71	1.28
Overall MS/SD				3.71	1.28

*frequencies in parentheses

The results showed that the respondents generally had high competence level for ICT integration into science instruction.

Over 60 % of respondents indicated high competence levels in five out of the seven items. For example, 82% of the respondents (141) claimed that they could use ICT to give effective presentation and explanation in their lessons (item 3) while 81.6% (138) respondents indicated they would be able to down load photos and display them on a computer (item 15).

This implies that a good number of the pre-service science teachers had acquired some basic skills to access useful information from the internet which they could use to present their lessons.

Research questions 2: What are pre-service science teachers' self-efficacy beliefs towards integrating ICT for science teaching and learning?

The frequencies, percentages, mean scores and standard deviations of the participants' responses on Science Teachers' Self-Efficacy Beliefs towards ICT Integration are presented in Table 2.

Table 2: Percentage frequencies, MS and SD of pre-service basic science teachers' responses for self-efficacy beliefs towards ICT integration

Item Number	% frequency			MS	SD
	Category				
	Agree	Neutral	Disagree		
2	63.0(107)*	14.0(24)	23.0(39)	3.52	1.15
4	71.0(123)	10.0(17)	19.0(32)	3.74	1.12
5	75.0(127)	8.0(14)	17.0(28)	3.83	1.14
6	70.0(119)	12.0(21)	18.0(30)	3.72	1.03
7	68.0(116)	17.0(28)	15.0(26)	3.77	1.08
11	69.0(118)	14.0(24)	17.0(29)	3.68	1.04
14	74.0(126)	12.0(21)	14.0(23)	3.80	1.04
	Overall MS/SD			3.72	1.08

*frequencies in parentheses

The mean scores ranged from 3.52(SD=1.15) to 3.83 (SD=1.14) with a sub-scale mean of 3.72 (SD=1.08) while the frequencies of respondents' scores ranged from 14 (8%) to 126 (74%). The results generally suggest that the pre-service science teachers have high level of self-efficacy beliefs towards technology integration for science teaching and learning. Over 70 % of the respondents expressed very high self-efficacy beliefs they could choose appropriate technologies to enhance instruction (item5), adapt the use of technologies in basic classrooms (item 6) and use technology as an instructional aid and integrate it into the curriculum (item 14).

Research questions 3: What is pre-service science teachers' readiness level of integrating technology for science teaching and learning?

Table 3 presents the mean scores, standard deviations and percentage frequencies of respondents' scores on the subscale, Science Teachers' Readiness in Technology integration.

Table 3: Percentage frequencies, MS and SD of Pre-service science teachers' responses on readiness subscale of ICT integration

Item Number	% frequency			MS	SD
	Category				
	Agree	Neutral	Disagree		
8	67.0(114)*	11.0(19)	22.0(38)	3.71	1.34
9	68.0(116)	8.0(14)	24.0(41)	3.87	1.37
10	64.0(110)	8.0(14)	28.0(47)	3.61	1.32

*frequencies in parentheses

The mean scores ranged from 3.61 (SD=1.32) to 3.87 (SD=1.37) with a sub-scale mean score of 3.73 (SD=1.34) while the frequencies of respondents' scores ranged from 14 (8%) to 116 (68%). The results indicate that the pre-service science teachers have high level of readiness towards technology integration in science teaching and learning.

DISCUSSION

Pre-service basic science teachers' competence level in ICT integration

The quantitative results of the study showed that the pre-service basic science teachers had high levels of competence in ICT integration in science teaching (see Tables 1). However, the qualitative data obtained from the study did not wholly reflect the outcome of the quantitative aspect of the study. The qualitative findings showed that the pre-service science teachers could not explain properly how they would apply what they have learned to enhance effective teaching and learning. For instance, though majority of the respondents (82 %) agreed that they could use ICT to give effective presentation and explanation in their lessons (item 3) a good number of the interviewees could not explain how they could use computer to ensure effective teaching. This is exemplified by the following excerpt:

> Assuming I am to teach a topic like metals and non-metals, I will make sure that I bring some types of metals and non-metals and group them according to the metals and non-metals and I will let them know the properties of each and how they are used (Interviewee, R2).

Another interviewee (R8) also made the following statement:

> Many pupils are having phones so I teach them how to go to the net to watch educational movie.

These responses clearly indicated their lack of knowledge about ICT integration into teaching and learning. Less than half of the pre-service basic science teachers agreed they had enough opportunities to (item 16) (see Table 1). The implication is that lack of enough opportunities for the pre-service science to practice with different technologies in the course of their training will adversely affect their knowledge and skills for integrating technology into their future science lessons.

Table 1 showed that two thirds of the respondents could install of educational software (item 13) as well as down load photos and show them on a computer (item 15). This implies that the pre-service science teachers have acquired some basic knowledge and skills as far as the general use of computer for other purposes other than teaching and learning is concerned. However, they must move beyond being "computer literate" to "technology competent" (Smarkola, cited in Agyei, 2012) to ensure effective integration of technology.

Pre-service basic science teachers' self-efficacy beliefs level in technology integration

The quantitative results showed that over 60 % of the pre-service science teachers had high self-efficacy beliefs towards technology integration (see Table 2). However, the responses of the interviewees did not support this assertion. For instance, Interviewee R10 was honest about his lack of knowledge about ICT integration. He categorically said 'I don't know' Interviewee R 24 on the other hand had this to say about ICT integration to enhance instruction:

> 'I can use the computer together with a projector to teach in the classroom. I will use the computer to down load from the internet some videos, photos or diagrams about what I am going to teach and show them on the projector for the learners to see'.

This is in contrast with Albion's (2001) assertion that high self-efficacy beliefs toward technology integration is a determining factor for how well a teacher effectively use technology to improve teaching and learning.

Pre-service basic science teachers' readiness level in ICT integration

The qualitative data corroborated quantitative results which showed that majority of the pre-service science teachers generally had high level of readiness in ICT integration (see Table 3). This is supported by the following excerpt from responses of one of the interviewee (R24) when asked to justify his readiness to integrate ICT into teaching had this to say:

> I will say yes, because I have my personal computer and also I have acquired some basic knowledge and skills in the use of computer. With these knowledge and skills I think I can search for materials from the internet as the internet contains a lot of different materials which are relevant for teaching and learning at the basic level of education.

However, this response does not necessarily justify his readiness in terms of their knowledge and skills regarding ICT integration. Boakye and Banini (2008) reported similar findings on Ghanaian teachers' ICT readiness where only ten percent of the teachers indicated they always used ICT for instructional purposes.

CONCLUSIONS

The main purpose of the study was to investigate the pre-service science teachers' levels of competence, self-efficacy beliefs and readiness in ICT integration. The quantitative findings indicated that the pre-service science teachers at both colleges of education had high levels of competence, self-efficacy and readiness in ICT integration. The qualitative findings did not wholly support the quantitative findings. It was however, evident from both quantitative and qualitative data that the pre-service science teachers were not provided with the sufficient opportunities to practice using ICT in teaching and learning. The implication is that the pre-service science teachers may avoid ICT integration or may not appropriately and effectively integrate ICT into their teaching.

RECOMMENDATIONS

Based on the findings it is recommended that:

1. Since the pre-service science teachers had insufficient learning experience in ICT integration, the colleges of education should focus on enhancement of their professional understanding and experience with the use of ICT in teaching and learning rather than to develop just technical ICT skills.
2. The colleges of education should provide the pre-service science teachers with multiple and real-world opportunities to learn and apply technology skills in micro or peer teaching sessions.

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