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Exploring the Use of Technology in Teaching Physics at Senior High Schools in the Cape Coast Metropolis of Ghana

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Abstract:

Technology has profound and lasting influence in classroom as being a powerful tool that can change the way lessons are taught by facilitating both teachers' instruction practices and students' learning processes. The purpose of this study was to explore the use of technology in teaching physics within the Cape Coast Metropolis in the Central Region of Ghana. The study employed descriptive cross-sectional survey. The population for the study was Senior High School (SHS) physics teachers and students of the Cape Coast Metropolis in Ghana. The sample size for the study was made up of 20 teachers and 100 final year students. The main instrument used for the study was a questionnaire for both the teachers and the students. Data were analyzed using means, standard deviations and frequencies. It was found that the physics teachers hardly use modern and digital forms of technology in teaching physics.

Keywords: Technology, physics, teaching, senior high school

1. Introduction

The use of technology has influenced our way of life in this 21st century. Technology dictates the pace in commerce, communication, finance, education and even sports (soccer with the introduction of video assisted referee and goal line technology). In education, technology has the potential to change the way teaching and learning is done. The rapid change requires a corresponding response from educators to use technology in order to develop the proficiency and skills for students, and to bring innovation in teaching and learning, which can lead to a robust educational system (State Educational Directors Association, 2007). There is therefore a growing interest on how teachers use technology in the classroom (Albion, Jamieson-Proctor & Finger, 2010). The challenges for education in this ever changing 21st century are how to find out and use technological tools that add efficiency and value to both teaching and learning. Technology has profound and lasting influence in classroom as being a powerful tool that can change the way lessons are taught by facilitating both teachers' instructional practices and students' learning processes. Effective learning and teaching requires that both teachers and students are able to use new technologies to access, organize and evaluate information to solve problems and innovate practical ideas in real-world settings (Jimoyiannis, 2010).

Technology can enhance the teaching and learning of science if it is use in line with researched based effective teaching practices (Bryan, 2006). In science education in general and physics in particular, there is a wide range of efficient technological tools and applications available for teaching and learning. Rios and Madhavan (2000) classified technologies that are appropriate for physics instruction into four categories. These categorizations are (1) computer interfacing equipment to collect and process data, (2) experimental or theoretical modelling, (3) computer simulations requiring graphics, and (4) research/reference/presentation programs for gathering, reporting, and/or displaying information.

The use of technology in science education is advocated for because technology provides opportunities for active learning, enable students to perform at higher cognitive levels, supports constructive learning, promotes scientific inquiry and conceptual change and promotes active and participatory learning as well (Jimoyiannis, 2010). Technology enhances both investigative and practical aspect of science teaching; expedites and enhances production of school work; improves motivation and engagement; supports exploration and experimentation as well as fosters self-regulated and collaborative learning (Osborn & Hennessy, 2003).

According to Flick and Bell (2000) the following standards have been developed by national science organizations for integrating technology into science classroom.

- Technology should be introduced in the context of science content.
- Technology should address worthwhile science with appropriate pedagogy.
- Technology instruction in science should take advantage of the unique features of technology.
- Technology should make scientific views more accessible.
- Technology instruction should develop understanding of the relationship between technology and science. (p. 40)

The application of technology in teaching is complicated considering the challenges newer technologies pose to teachers. The word technology applies equally to analog and digital, as well as new and old technologies. As a matter of practical significance, however, most of the technologies under consideration in current literature are newer and digital and have some inherent properties that make applying them in straightforward ways difficult (Koehler & Mishra, 2009). Many scholars describe technology in terms of digital and analog technologies, but Koehler & Mishra (2009) argue that, "on an academic level, a pencil and a software simulation are both technologies. But the latter, is qualitatively different in that its functioning is more opaque to teachers and offers fundamentally less stability than more traditional technologies" (p. 61). But with this distinction, there is still a much "struggling with whether technology refers only to calculators and computers or to a much wider range of potential instructional aids" (Lederman & Niess, 2000, p. 345). According to Koehler & Mishra, by their nature, newer digital technologies, which are protean, unstable, and opaque, present new challenges to teachers who are struggling to incorporate more technology in their teaching pedagogies. This is because new technology will continuously change our way of teaching and learning (Burch & Mohammed, 2019).

Different techniques in the form of teaching methods can be employed by teachers to achieve their lesson objectives (Borich, 2007). Thus, teachers of all disciplines including physics use various teaching methods to achieve lesson objectives which are the key concept, and skills to be presented to the student using the available technology. There is now a call for teachers to use interactive and learner centered approaches rather than the traditional teacher centered approaches in teaching. The use of these learner centered approaches in teaching requires the use of technology which enables students to engage in a flexible learning that allows dynamism of learning in terms of location, time, materials, content and teaching approaches (Collis & Moonen, 2001).

Koehler and Mishra (2009) posit that at the heart of every good teaching with technology are three core components: content, pedagogy, and technology, plus the relationships among and between them. Teachers need to have a focus on the relationship that exists between the educational task, the scientific concepts and technological tools that students can use in responding to the task in order to improve learning in science and mathematics (Jahreie, 2010).

Although the integration of technological, pedagogical and content, is now gaining attention, there is little evidence to suggest that teachers are actually integrating these components in their teaching especially in this part of our world. According to Collin and Moonen (2008), many developing countries are concentrating on procuring hardware with more attention paid to installing these hardware in schools rather than how those hardware are used in schools. This idea is corroborated by Mishra and Koehler (2009) who argue that just bringing technology to the educational institutions is not enough to ensure its success. What is important is the extent to which teachers will utilize the technology in their teaching (Kafyulilo, 2010).

For the integration of technology into pedagogy and content to occur, teachers need to have knowledge about the science content they teach and how that subject matter can be transformed by the application of technology (Koehler & Mishra, 2009). Thus, teachers should have the knowledge of various technologies as they are used in teaching and learning settings, and conversely, knowing how science and mathematics teaching might change as a result of using a particular technology (Richardson, 2009).

UNESCO (2008) outlines specific ICT competencies that teachers should possess to be able to integrate technology in teaching in the most appropriate way. Such competencies include the ability to: manage information; structure problem tasks; integrate open-ended software tools; integrate subject-specific applications with student-centered teaching methods as well as collaborative projects in support of students' deep understanding of key concepts and their application to solve complex real-world problems.

One of the approaches through which teachers can develop their skills to effectively integrate technology in the classroom is by working through different stages of professional development to blend technology, content and pedagogy (Niess, 2005). Harris and Hoffer (2011) asserted that for teachers to adequately integrate technology across different subject areas in the school curriculum, with emphasis in physics, they need to demonstrate a firm mastery of TPACK, which is an amalgamation of teachers' knowledge of curriculum content, general pedagogies, technologies, and contextual factors that influence learning (Koehler & Mishra, 2009).

Many researchers (Niess, 2005; Tilya, 2008) accept the fact that technology is important in physics teaching. However, some studies report that the level of integration of technology, pedagogy and content is minimal in most schools (Wieman & Perkin, 2005).

Ghana does not want to be left in the way technology can be maximized to bring about improvement and development. It has therefore developed the "Ghana's vision of the National Science, Technology and Innovation Policy". The policy has its basic objectives among others as:

- "to seek to master scientific and technological capabilities by a critical mass of the products of all institutions;
- ensure that Science, Technology and Innovation (STI) support Ghana's trade and export drive for greater competitiveness; and
- to promote science and technology culture (Ministry of Environment, Science, and Technology, 2010)"

Ghana's education policy makers over the years have attempted to encourage the use of Information and Communication Technology (ICT) in the classroom through educational reforms and other policies. It is against this background that this research seeks to explore the use of technology in teaching physics within the Cape Coast Metropolis in the Central Region of Ghana.

2. Statement of the Problem

Poor performance in physics by students over the years has made educational researchers to look for the underlying causes with researchers identifying factors inside and outside the classroom as the possible causes (Buabeng, Ossei-Antoh & Ampiah., 2014). The main factors that account for students' lack of interest and poor performance in physics have been attributed to teachers (Camarao & Nava, 2017; Ekici, 2016). Heras (2017) asserts that physics teachers "follow traditional teaching approaches based heavily on solving standard problems and learning by rote, with no hint of free inquiry or discussion" (p.10). A study by Buabeng and Ntow (2010) identified a wide range of reasons which accounted for students' negative response to physics in Ghana. Key among these factors was the teacher factor. The study revealed that there is a reduced interest in the subject at the Senior High School (SHS) level because the subject was poorly presented to them. Physics teachers who took part in the study also admitted that poor tuition is one of the many reasons accounting for the low interest level among students.

It is not clear the kind of pedagogical approaches the physics teachers use and whether they incorporate technology in their teaching and if they do what kind of technology is it. These are the issues that served as a central focus for this research.

3. Research Questions

The research was guided by the following question.

- What are students' and teachers' perception about the use of technology in physics classroom?
- What kind of technology is available for teaching physics?
- What type of pedagogical approaches do physics teachers use?

4. Methods

The study employed descriptive cross-sectional survey. The population for the study was Senior High School (SHS) physics teachers and students of the Cape Coast Metropolis in Ghana. The sample size for the teachers was made up of 20 teachers which comprised 18 males and 2 females who were selected by the census approach. Seventeen of the teachers had first degree with the remaining three having master's degree. The sample size of the students consisted of 100 final year students selected by stratified sampling of which 70 were males and 30 were females.

The main instrument used for the study was a questionnaire for both the teachers and the students. The questionnaire was multi-dimensional with a biographic section. One section had ten items relating to the use of technology in the classroom in which respondents were to indicate their level of agreement or disagreement with the statements. The items were scaled using 5 point Likert scale which started with "Strongly Disagree to Strongly Agree". Under another sub-dimension of the questionnaire, respondents were given list of technologies and teaching methods to choose as many as are applicable in their school. Teachers and students' response were coded and analysed using descriptive statistics like means, standard deviations and frequencies.

5. Results

The purpose of the research was to explore the use of technology in the teaching of physics in Senior High schools.

5.1. Research Question One

What Are Students' and Teachers' Perception about the Use of Technology in Physics Classroom? This question sought to find and compare the perception that physics students and teachers in the Cape Coast Metropolis have about the use of technology in teaching physics. This question was answered by using means and standard deviations with a cut-off point values as (1-2.9 = disagree, 3.0-3.5 = neutral or undecided, above 3.6 = agree).

From Table 1, it can be seen that overall mean of 3.12 of the teachers' perception is within the cut-off values of 3.0- 3.5 indicating that teachers are neutral or undecided about the use of technology in teaching physics. Teachers reported in agreement (M=3.65, SD=1.22) on the statement "I use technological hardware and software within the educational context." However, they reported in disagreement (M=2.30, SD= 9.9) on the item "I use modern/advanced technologies such as computer, internet, digital video and overhead projectors during the instructional period." On the use technology during the instructional period to stimulate students' interest, the teachers had a mean of 3.30 and a standard deviation of 1.34. Comparing this with the cut-off values, it means teachers were neutral about their use of technology to stimulate student interest.

Item	Mean	Std. Dev
I access the Internet quite frequently during instructional period to search for information	3.50	1.43

I use technology -related activities in classroom that will improve my students' understanding.	3.20	1.00
I use technology(s) activities that promote increased problem-solving and critical thinking during the instructional period.	3.30	1.21
I have access to different forms of technology at any time during the instructional day	3.20	1.05
I use technological hardware and software within the educational context	3.65	1.22
I use modern/advanced technologies such as computer, internet, digital video and overhead projectors during the instructional period.	2.30	.99
I use technology during the instructional period to stimulate my students' interest.	3.30	1.34
I alter instructional period to incorporate technology during teaching.	3.15	1.30
I have enough time to use the classroom technology(s) during my instructional period.	2.60	1.23
I use technological tools to assess students during the instructional period.	2.95	1.27
Mean of means	3.12	1.20

Table 1: Means and Standard Deviations for Teachers about Use of Technology

The perception of students on the use of technology is presented in Table 2. From Table 2, the overall mean scores of the students' perception which is 2.49 with a standard deviation of 1.22 indicates that the students are in disagreement on the use of technology in teaching physics. As shown in Table 2, the students did not agree with any of the items. The students were undecided or neutral about two items, that is "my teacher uses technology -related activities in classroom that will improve my understanding (M=3.14, SD=1.47) and "my teacher alters instructional period to incorporate technology during teaching' (M=3.25, SD=1.10). On teachers use of modern/advanced technologies such as computer, internet, digital video and overhead projectors during the instructional period, the students reported in disagreement with a mean score of 2.64 and a standard deviation of 1.40.

Item	Mean	Std. Dev
My teacher allow me to access the internet quite frequently during instructional period to search for information	2.16	1.25
My teacher uses technology-related activities in classroom that will improve my understanding.	3.14	1.47
My teacher uses technology(s) activities that promote increased problem-solving and critical thinking during the instructional period.	2.67	1.35
I have access to different forms of technology at any time during the instructional day	1.87	0.99
I use technological hardware and software within the educational context	2.33	1.28
My teacher uses modern/advanced technologies such as computer, internet, digital video and overhead projectors during the instructional period.	2.64	1.40
My teacher uses technology during the instructional period to stimulate my interest.	2.77	1.32
My teacher alters instructional period to incorporate technology during teaching.	3.25	1.10
I have enough time to use the classroom technology(s) during my instructional period.	2.05	1.07
My teacher uses technological tools to assess me during the instructional period.	2.01	0.96
Mean of means	2.49	1.22

Table 2: Means and Standard Deviations of Students about Use of Technology

5.2. Research Question two

What Kind of Technology Is Available for Teaching Physics? Under this sub-dimension of the questionnaire, respondents were given list of technologies to choose as many as are applicable in their school. The results are shown in Figures 1 and 2.

Figure 1: Results of Students on Technologies Available for Teaching

From Figure, it can be seen that 98 and 96 out of hundred students chose books and chalk/white board respectively while 94 students out the hundred choose lab equipment as the technologies commonly used in teaching physics in their schools. Twenty-five and ten students chose videos and simulations respectively with only one student selecting interactive white board.

From Figure 2, it can be seen that all the 20 teachers chose books and chalk/white board followed by chart/picture and lab equipment which were selected by 17 and 16 teachers respectively. Six and four teachers selected simulation and videos respectively while none of the teachers chose interactive white board.

Figure 2: Results of Teachers on Technologies Available for Teaching

5.3. Research Question three

What Type of Pedagogical Approaches do Physics Teachers Use? Under this subscale, a list of common methods of teaching was presented and respondents were asked to select as many as apply in their schools. The results of both students and teachers are shown in Figures 3 and 4 respectively. From Figure 3, it can be observed that the method which was chosen by almost all the students was question and answer. This was followed by demonstration and lecture methods which were chosen by 77 and 75 students respectively.

Figure 3: Results of Students on Methodologies Use for Teaching

From figure 4, it be seen that all the twenty teachers chose question and answer and demonstration methods while 15 and 14 teachers chose group discussion and brainstorming respectively. Lecture was selected by only seven teachers.

Figure 4: Results of Teachers on Teaching Methodologies Use

6. Discussions

From Table 1, it can be seen that the mean score for teachers on the use of technology is 3.12 with a standard deviation of 1.20. This means that the teachers were neutral or undecided about their use of technology in teaching physics. It can also be seen from Table 2 that the mean score for students on the use of technology was 2.4 with a standard deviation of 0.83 indicating that students disagree with the statement that technology is used in teaching physics in the classroom. Therefore, if physics teachers are unsure about the use of technology in teaching physics and students disagree that technology is used in teaching physics then students view will be accepted as reflecting the reality since they are at the receiving end. It therefore means that the physics teachers hardly use modern form of technology in teaching physics. This is result in support of a study conducted by Buabeng (2018) in New Zealand where it was found that physics teachers barely use ICT tools in teaching physics.

According to Mottmann (1999), two of the most important reasons for introducing technology and other instructional innovations into physics education are "1) to improve students' physics ability, and 2) to improve students' negative reactions toward physics" (p.75). Since physics teachers in the Cape Coast Municipality do not use technology in teaching physics, the implication is that classroom teaching will not bring improvement in students' physics ability and their development of positive reaction towards the subject.

From Figures 1 and 2, it can be seen that both students and teachers agree that the most common technologies available for teaching physics in the schools are books, chalk/ white board, charts, lab equipment and to some extent computer hard and software. These common technologies available for teaching science such as laboratory equipment are analogue and traditional in nature which are appropriate for doing science not for teaching science (McCrory 2008). From Figures 1 and 2, it be seen that computer hard and software were somehow common technologies for teaching physics in the school. However, simulations and videos which go with computers were among the least technologies used in teaching physics as reported by both teachers and students. It is therefore possible that some of the teachers may be using presentation software for teaching physics in the classrooms but not videos and simulations. This implies that the students

cannot develop conceptual understanding of physics using problem solving approaches since such approaches require digital technologies like simulations, models, animations and videos for teaching physics (Buabeng, 2015; McCrory, 2008).

From Figures 3 and 4, it can be seen that more than half of both teachers and students chose questions and answer, group discussion, demonstration and brainstorming with the most common methods chosen being question and answer and demonstration and the least being brainstorming. This means that both students and teachers are in agreement with each other on the use of these methods in teaching physics.

However, on lecture method, students and teachers' responses varied widely as 75% of the students chose lecture method while only 33% of teachers chose it. This means that both teachers and students disagree with each other on the use of lecture method in teaching physics. While majority of the students chosen lecture method, minority of the teachers chose it. This difference could be attributed to each group understanding of the concept but since the students are at the receiving end, their views should supersede that of the teachers. It can therefore be said that dominant methods of teaching physics are the questions and answer and demonstration methods. These methods may be consistent with traditional kind of technologies like books and laboratory equipment which are the common technologies in schools. Because the schools in study area are first class schools, they may have well equipped laboratories with scientific equipment but may not be enough for every student to handle, so teachers will have to use question and answer and demonstration methods combined with these scientific instruments to demonstrate concepts and principles in physics class. These teacher-centred approaches to teaching will not make physics interesting to a lot of the students. Similar findings were reported by Masika (2011) and Vosniadou (2007), where physics classroom teaching was dominated by teacher-centred approaches and chalk and talk instruction. Many researchers have noted that, physics would be more interesting to learn if student-centred approaches which incorporate modeling, animations and simulations for problem solving are used (Pedersen, 2011; Tversky, Morrison, & Betancourt, 2002). The finding however contradicts a study by Buabeng, et al. (2014) on an investigation into physics teaching in Senior High Schools in which they observed that dominant methods for teaching physics were discussion and lecture methods.

7. Conclusion and Recommendations

It is evident from the study that the common technologies which teachers use in teaching physics are the traditional types like charts and laboratory equipment which do not stimulate students' interest in the subject. The physics teachers rarely incorporate modern/digital form of technologies in teaching physics. The methods used for teaching physics in the cape coast metropolis are teacher -centered approaches like demonstration and question and answer.

It is therefore recommended that teachers should use student-centered approaches in their lesson delivery for students to grasp the concepts or skills delivered to them well. Physics teachers should avoid the use of lecture method in delivering their lessons as was indicated in this study. It is further recommended that physics teachers should also integrate modern and digital technologies such as videos and simulations which are known to stimulate students interest.

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