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Research Article

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Utilization of Information and Communication Technology in Teaching and Learning of Chemistry at Senior High Schools in Ghana

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ABSTRACT

The study investigated the potential of information and communication technology (ICT) in the teaching of chemistry at Senior High Schools (SHSs) in Ghana. The study uses a cross-sectional survey design while employing purposive and simple random sampling techniques to select the SHSs and science teachers, respectively. A total of three chemistry teachers were sampled from 10 SHSs purposely selected making a total of 30 teachers. The study investigates the competence and ICT tools usage by science teachers and how the usage of these tools can be sustained and improved for the teaching of chemistry in Ghana. Furthermore, the study identifies the possible factors that impede science teachers' use of ICT tools in teaching chemistry at the SHSs in Ghana. The study has found that science teachers are competent in using ICT tools in performing teaching and learning activities. However, the utilization of ICT has not been most effectively utilized in secondary schools in teaching and learning chemistry since the general usage of ICT by teachers was low. Besides, the study found that the utilization of ICT tools in teaching chemistry is bedeviled by myriads of factors and these factors greatly influence the science teachers' and students' capabilities of using ICT for the teaching-learning process. These factors were found to be teacher-level factors, cost-related factors, technological-related factors, management and leadership-related factors, and environmental-related factors. Based on the findings of the study, it is recommended that the Ministry of Education should ensure that adequate ICT resources and facilities needed for proper utilization of ICT tools for teaching and learning chemistry in SHSs in Ghana are provided in the right numbers.

Keywords: education, factors, ICT tools, science, teaching

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INTRODUCTION

In the 21st century, rapid advancements in information and communication technology (ICTs) have brought great transformations and influenced the expectations of modern society. ICT has transformed many elements of our daily lives as well as every facet of human endeavor (Ngbongha et al., 2020). ICT has become a fundamental aspect of teaching and learning in schools, and its incorporation into the classroom will enhance the teaching environment tremendously (Dei, 2019).

The conventional face-to-face teaching methodology is increasingly being replaced by the use of ICT in teaching and learning. Internet communication is replacing face-to-face classroom interaction, typically white or blackboards are being substituted by online interactive whiteboards, and books or printed resources are being replaced by e-books or internet resources and libraries (Suryani, 2010).

This has driven schools and families all over the world to invest significant sums of money in ICT tools, resources as well as other educational technologies to stay current with their mission and vision (Bulman et al., 2015). Without a doubt, the Internet, and some other ICT technologies, in general, provide a crucial medium for knowledge distribution as well as prospects for global development and growth (Lima, 2006).

Also, according to Sarfo (2011), the efficiency with which computers are used in education could be a key factor in deciding which nations would flourish in the future. In the field of education, the use of contemporary informational resources and technology is critical for perfecting classroom instruction, executing learning and teaching on a scientific-methodological level, and upholding worldwide standards of education (Geladze, 2015).

Recognizing the impacts of technology at work and in everyday life, particularly in the lives of today's schools and universities, there is a pressing need to reorganize the curriculums and classroom climate to close the digital gap between urban and rural countries in teaching and learning (Mikre, 2011). Teachers and students will gain knowledge of certain topic areas that have resulted from this restructuring, which will encourage relevant learning and enhance professional efficiency (Haji et al., 2017). Through digital tools and equipment, all topics, particularly science, arithmetic, linguistics, arts and humanities as well as other significant fields, may be taught and studied more effectively (Ghavifekr & Rosdy, 2015). Furthermore, ICT offers aid and supplementary assistance for both instructors and students in the areas of efficient teaching and learning using computers and other devices as learning aids (Jorge et al., 2003).

Ghana's government has recently implemented education reform aiming at boosting educational standards and integrating ICT in teaching and learning at all levels of school (Lawrence & Tar, 2018a). To support this goal, ICT facilities have been constructed in SHSs and other locations, and free computers and internet access have been made available to expand access and improve the relevancy of education (Bayuo et al., 2018).

The use of ICTs in senior high schools (SHSs) is critical because learning and teaching can take place not just in the classroom but also when students and teachers are physically separated (Ghavifekr & Rosdy, 2015). For instance, as a consequence of the temporary lockdown due to the COVID-19 pandemic, all educational establishments in the world, especially Ghana, have established broad educational programs of direct class instruction via the internet or television for students at homes around the world.

Although there is a lot of information on how ICTs are spread and are used in high schools in advanced countries, there is still not much information about just how ICT tools are being used by students and teachers in Ghanaian SHSs and how they could be used to maintain and enhance science learning and teaching.

Problem Statement

According to available reports, schools and universities which do not utilize digital technologies in learning and teaching will be left behind in the educational market (Afolabi, 2001; Olelewe & Amaka, 2011; Stewart, 1999). Additionally, in the worlds of education, business, and governance, knowledge about the use of ICT tools in the classroom is growing to the point, where using words alone just to express ideas, skills, and attitudes to educate students is fruitless (Dei, 2019; Oje, 2005). The growing complexity of instructional methods, as well as the need for innovative, varied, and expected responses to national and school-based problems, necessitate a new, more comprehensive approach to science education (Michael et al., 2016).

Most SHSs in Ghana have ICT laboratories where students and teachers can learn basic computer skills (Parthemore, 2003; Yidana & Asiedu-Addo, 2001). Several of these institutions have internet access, allowing students and teachers to strengthen their contacts with the outside world. The concern is what impact would it have on science instruction if teachers at SHSs use ICT tools in the classroom?

It has been shown that Ghanaian educational leaders are interested in how instructors and students utilize ICT tools in teaching and learning and how such use enhances learning (Boakye & Banini, 2008). It is because they realized that Ghanaian professionals and graduates cannot vie for positions on the world market due to a lack of competencies, particularly in the field of ICT (Nyarko, 2007).

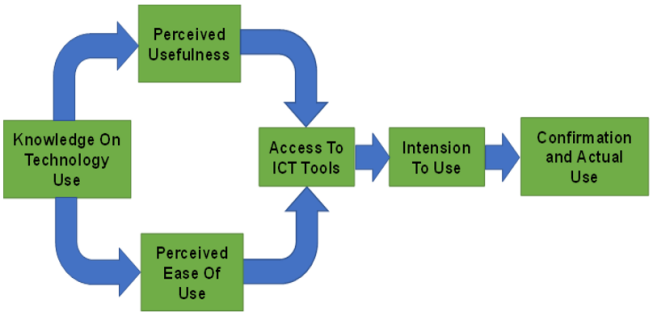

Figure 1. Conceptual framework of the study (Davis, 2003)

Owing to lack of data, it is essential to conduct a frequent study to explore the impact of ICT tools and their efficient use in science education as well as the possible factors that hinder science teachers' use of ICT tools in teaching chemistry at the SHSs.

Research Questions

The study sought to answer the following research questions:

1. What skills do science teachers possess and their level of ICT tools usage in teaching chemistry at SHSs in Ghana?
2. What factors prevent science teachers' from using ICT tools in teaching chemistry at the SHSs Ghana?

Purpose of the Study

The purpose of the study is to revive curriculum designers' awareness of the need for and opportunities for employing ICT in science teaching and learning at the SHS level in Ghana. The findings of the study will be valuable to teachers, administrators, and policymakers in evaluating and reforming policies related to the successful use of ICT tools in science teaching. Furthermore, investigating the use of computers and other technology as additional educational materials in the classroom and learning environment may help educators and students become effective technology users in the future. Further research into the impacts of computer software and hardware, as well as their potential use as instructive and educational tools in all academic subjects, would be encouraged by the findings of this study.

CONCEPTUAL FRAMEWORK

The conceptual framework for this study was based on a modified technology acceptance model (TAM) (Davis, 2003), as shown in **Figure 1**. The model connects perceived utility and ease of use to attitudes toward and actual use of ICT (system use). TAM theory was created to quantify the effectiveness or success of technology in assisting in the understanding of a system's worth and efficacy. It is regarded as one of the most prominent theories in information systems research today. However, the notion has expanded through time to include more precise criteria that explain how a user can accept technology (Ghavifekr & Rosdy, 2015).

The proposed framework covers several criteria directly related to the present study's main goal, which explains how skills and knowledge influence the perceived usefulness and ease of use of ICT tools as complementary instructional materials. The components in the

conceptual model have been methodically linked so that their connection allows teachers and students to assess their effectiveness in using ICT technologies in teaching and learning. Teachers' and students' intentions to utilize ICT tools are also driven by their opinions of their utility, perceived ease of use, and actual use of ICT technologies. This study used this proposed framework to look at ICT tools as sources of extra instructional content for science teachers in the class.

METHODOLOGY

Research Design

The study used a cross-sectional survey research design using a mix of quantitative and qualitative methodologies. A cross-sectional survey design, according to Ngbongha et al. (2020), provides an accurate assessment of the characteristics of the entire population of people at a specific point in time. It is also more realistic than the experimental because it looks at occurrences in their natural environment. A standard set of questions is used in cross-sectional survey research to provide a general picture of a group's beliefs, attitudes, self-reported behaviors, and demographic and background information (Agyemang & Mereku, 2015). A cross-sectional survey research design is a cost-effective and efficient way to collect a huge amount of data from a big number of people, and it can be used to discover key beliefs, characterize the relationship among variables, or compare groups at a certain point in time. A cross-sectional survey can be conducted on the entire population or, more typically, on a representative sample of the population.

Population and Sample

The targeted population of the study comprised all science teachers in the Wa and Kasena-Nankana East Municipals of the Upper West and Upper East Regions. Both Municipals have about 10 Senior High/Technical Schools each. However, the accessible population comprised science teachers in 10 SHSs, who were purposively sampled. The purposive sampling technique was used to select the SHSs that are specifically offering general science or elective chemistry.

Furthermore, a simple random sampling technique was employed to select the science teachers in these 10 SHSs since it allows all the units in the population to have an equal chance of being selected. Specifically, a total of three chemistry teachers were selected from each school making a total of 30 teachers. The sample size of 30 science teachers was determined using the Raosoft Inc. online sample size calculator taking into consideration a 5% margin of error at a 95% confidence level.

Research Instruments

The research instruments adapted in this study to collect the data from the chemistry teachers to answer the research questions were questionnaires. The items of these research instruments were based on the ICT requirements in the SHS science curriculum.

Questionnaire

The questionnaire was chosen since it takes less time to complete and assures that respondents remain anonymous (Ali, 2018). A questionnaire is also a self-reporting instrument that may be used to collect data from a large number of people in a cost-effective and timely manner (Hoque et al., 2012).

To collect data from the chemistry teachers sampled, two separate sets of questionnaires were adapted from Deebom and Zite (2016), Dei (2019), Lawrence and Tar (2018b), Nja and Idiege (2019), and Ochu (2017). There were both closed and open-ended questions on the surveys. Closed-ended items provide the participant with a limited number of options, such as yes, no, or multiple-choice pre-set options. This has the advantage that coding is quick and can be done by a computer. The responses can be compared, and numerical values can even be allocated for statistical analysis. The responses, on the other hand, do not always reflect the respondents' genuine experiences (Burns et al., 2019).

The open-ended items provide participants the freedom to react in whatever way they choose, using phrases made up of any words they want. This can be effective for generating additional concerns not covered by the survey or allowing the participant to react in their language, based on their own cultural and social experiences rather than the researcher's (Burns et al., 2019). However, analyzing and coding open-ended objects can take longer than analyzing closed-ended items. Furthermore, the open-ended questions delve deeper into the experiences of science teachers in using ICT tools as instructional materials in science teaching at the SHS level.

The questionnaire items were developed in line with the research questions, with some of them using a 5-point Likert scale with SA (strongly agree) (5 points), A (agree) (4 points), SD (strongly disagree) (3 points), D (disagree) (2 points), and UD (undecided) (1 point). Others were categorized as VHU-very highly utilized (4 points), HU-highly utilized (3 points), RU-rarely utilized (2 points), and NU-not utilized on a 4-point Likert scale (1 point).

The questionnaire items were also categorized into sections; (A) demographic information about the respondent, (B) science teachers' use of ICT tools in teaching, and (C) factors impeding science teachers' use of ICT tools in teaching.

Validity of the Research Instruments

The items in the questionnaire were face validated by experts in the field of measurement and evaluation from the School of Science, Mathematics, and Technology Education, Department of Science and Mathematics Education, C. K. Tedam University of Technology and Applied Sciences, Navrongo, to ensure the questionnaire's validity. Before the questionnaire was sent to the respondents, the experts' observations and corrections on the items were taken into account. This guarantees that the questionnaire items are clear.

Reliability of the Research Instruments

A pilot test was done in three SHSs outside the targeted population to ensure the questionnaire's reliability. The pilot test included 10 chemistry teachers. The suggested sample size for pilot tests, according to Johanson and Brooks (2010), is 10-20% of the overall sample size.

The pilot test feedback aids in improving the study's quality in terms of content coverage and dependability. The Cronbach's coefficient alpha (α), which is commonly used to assess the reliability of measuring scales with multi-point items, was also utilized to analyze the study's reliability. This method is commonly used to determine the relationship between the scores of individual test items and the total score for all test items. Items having a high correlation with the test index score have a high level of reliability, whereas those with a poor correlation with the test index score have a low level of reliability and have been removed from the test (Ali, 2018).

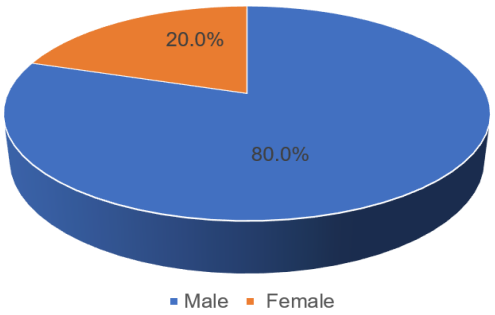

Figure 2. Fequency distribution of science teachers' gender

Method of Data Analysis

There were two key steps to the data analysis. The initial step was data preparation, which included taking notes, sorting, and organizing the information. The analysis itself was the second component. Statistical tools such as descriptive statistics and the statistical package for social sciences (SPSS) software, version 21.0, were used to code and analyze the responses from the questionnaire items. The frequency and proportion of the general population in the demographic background were determined using descriptive statistics. In addition, it was utilized to calculate the average, standard deviation, frequency, and percentage.

The SPSS software was used to analyze the data since it is user-friendly and can handle most quantitative data analyses.

The scale's mean is 3.0 and 2.50, respectively, based on the 5-point and 4-point Likert rating scales. As a result, mean ratings between 3.0 and 2.50 were seen as indicating greater influence and usage, while mean ratings below 3.0 and 2.50 were interpreted as indicating less influence and usage, respectively.

RESULTS AND DISCUSSION

Frequency Distribution of Science Teachers

The study used 30 science teachers in Upper West and East Regions to obtain the data to answer the research objectives. Out of the 30 science teachers, 24 of them were males representing 80% and six were females representing 20.0% as presented in **Figure 2**.

The small number of female respondents in the present study is because the majority of females do not pursue science at the secondary, pre-service, and tertiary levels.

Frequency Distribution of Science Teachers' Age

The age distribution of the science teachers is presented in **Figure 3** showed that the majority of the science teachers representing 50.0% (N=15) were within the age range of 31-40 years followed by the age of 24-30 years representing 30.0% (N=9). Furthermore, six science teachers were above 40 years representing 13.6%.

Knowing the age distribution of the teachers is crucial in determining which group of science teachers might have been trained at the pre-service and tertiary levels in the 21st century using ICT tools. Out of 30 science teachers, 80.0% (N=24) of them are within the age range 24-40 years and would have probably been exposed to computers and other ICT tools during their pre-university education or university education. However, the other 20.0% (N=6) of the science teachers who were above their 40s, probably did not have exposure to ICTs and might have perceived them to be unrealistic.

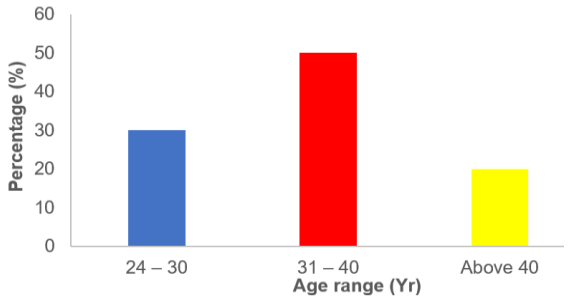

Figure 3. Frequency distribution of science teachers' age

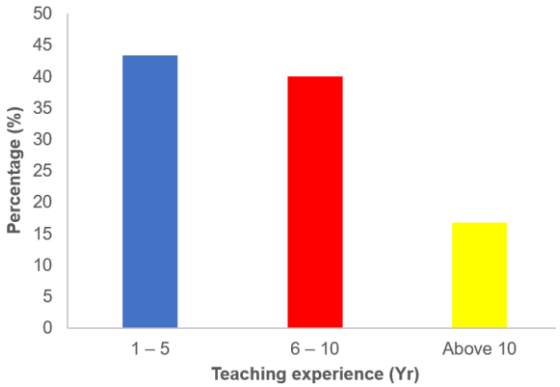

Figure 4. Frequency distribution of science teachers' teaching experience

Frequency Distribution of Science Teachers' Teaching Experience

The results presented in **Figure 4** showed that 43.3% (N=13) of the science teachers had teaching experience ranging from 1-5 years and 40.0% (N=12) also ranging from 6-10 years. The rest of the five science teachers representing 16.7% have teaching experience above 10 years.

The frequency distribution of the teaching experience of the science teachers shows that the majority of them were newly posted teachers. It is expected that these new teachers would be using ICT tools in the teaching and learning process since they were exposed to ICT as a subject matter during their pre-university education or university education.

Frequency Distribution of Science Teachers' Literacy in Computers

The results presented in **Figure 5** showed the science teachers' literacy in computers. Out of the 30 science teachers used for the study, 27 teachers representing 90.0% were computer literates. The rest of the three teachers representing 10.0% were computer illiterates.

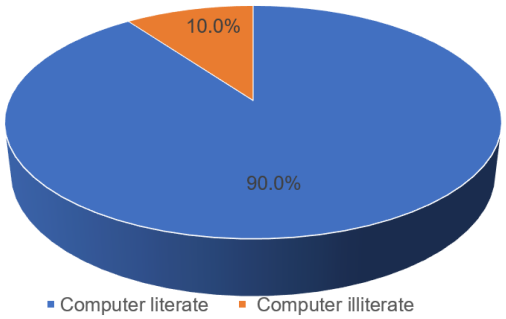

Figure 5. Frequency distribution of science teachers' literacy in computers

Figure 5 suggests that once the majority of the science teachers and students are computer literates, their use of ICT tools in the teaching and learning process would be effective.

Science Teachers' Skills in Using ICT Tools in Teaching SHS Chemistry

To determine the teachers' skills in using ICT tools in teaching SHS chemistry, they were asked to indicate whether they have ever or can use ICT tools in carrying out some activities as summarized in **Table 1**. The results in **Table 1** showed that most of the science teachers have demonstrated a considerable level of skills in using ICT tools to carry out several activities.

Out of the 30 teachers, 27 of them representing 90.0% use social media tools as a shared means of sharing information with students and colleagues as well as using Microsoft word in generating examination questions. Furthermore, 25 out of the 30 teachers can create a document in Microsoft Word representing 83.3%.

In addition, 24 teachers out of 30 use the spreadsheet in data analysis and computing results of students, which represents 80.0%. While 76.7% (N=23) of the 30 teachers who indicated that they use

Table 1. Science teachers' competency and ICT tools usage for teaching SHS chemistry (frequency: n & percentage: %)

Do you use ICT tools to do the following activities?	Yes	No	If yes, how often?				Mean	SD
			VHU	HU	RU	NU		
Storing, retrieving, and sharing information with students	$N=23$ 76.7%	$N=7$ 23.3%	$N=6$ 26.1%	$N=13$ 56.5%	$N=4$ 17.4%	$N=0$ 0.0%	3.09	2.62
Organizing computer files in folders and subfolders	$N=22$ 73.3%	$N=8$ 26.7%	$N=12$ 54.5%	$N=3$ 13.6%	$N=5$ 22.7%	$N=2$ 9.1%	3.14	2.80
Creating a document in Microsoft Word	$N=25$ 83.3%	$N=5$ 16.7%	$N=6$ 24.0%	$N=17$ 68.0%	$N=2$ 8.0%	$N=0$ 0.0%	3.16	2.67
Using Microsoft Word in generating examination questions	$N=27$ 90.0%	$N=3$ 10.0%	$N=19$ 70.4%	$N=6$ 22.2%	$N=2$ 7.4%	$N=0$ 0.0%	3.63	3.15
Preparing exercises, assignments, homework, quizzes, and tasks for students using Microsoft Word	$N=19$ 63.3%	$N=11$ 36.6%	$N=1$ 5.3%	$N=3$ 15.8%	$N=5$ 26.3%	$N=10$ 52.6%	1.74	1.45
Printing a document in Microsoft Word	$N=21$ 70.0%	$N=9$ 30.0%	$N=4$ 19.0%	$N=11$ 52.4%	$N=5$ 23.8%	$N=1$ 4.8%	2.86	2.43
Using a formula in a spreadsheet	$N=16$ 53.3%	$N=14$ 46.7%	$N=2$ 12.5%	$N=9$ 56.3%	$N=3$ 18.8%	$N=2$ 12.5%	2.69	2.29
Using the spreadsheet in data analysis and computing of students results	$N=24$ 80.0%	$N=6$ 20.0%	$N=8$ 33.3%	$N=13$ 54.2%	$N=3$ 12.5%	$N=0$ 0.0%	3.21	2.74
Using a spreadsheet to plot a graph	$N=21$ 70.0%	$N=9$ 30.0%	$N=3$ 14.3%	$N=12$ 57.1%	$N=5$ 23.8%	$N=1$ 4.8%	2.81	2.37
Creating a presentation using PowerPoint with animation functions	$N=20$ 66.7%	$N=10$ 33.3%	$N=6$ 30.0%	$N=11$ 55.0%	$N=1$ 5.0%	$N=2$ 10.0%	3.05	2.65
Using multimedia projectors in science lessons presentation	$N=17$ 56.7%	$N=13$ 43.3%	$N=2$ 11.8%	$N=9$ 52.9%	$N=5$ 29.4%	$N=1$ 5.9%	2.71	2.28
Creating a presentation with video or audio clips	$N=0$ 0.0%	$N=0$ 0.0%	$N=0$ 0.0%	$N=0$ 0.0%	$N=0$ 0.0%	$N=0$ 0.0%	0.00	0.00
Database applications	$N=12$ 40.0%	$N=18$ 60.0%	$N=0$ 0.0%	$N=1$ 8.3%	$N=7$ 58.3%	$N=4$ 33.3%	1.75	1.29
Desktop publishing	$N=8$ 26.7%	$N=22$ 73.3%	$N=0$ 0.0%	$N=0$ 25.0%	$N=2$ 37.5%	$N=6$ 75.0%	1.25	0.71
Using animation in lesson delivery	$N=13$ 43.3%	$N=17$ 56.7%	$N=1$ 7.7%	$N=1$ 7.8%	$N=2$ 25.0%	$N=9$ 69.2%	1.54	1.30
Finding the meaning of scientific words in e-dictionary	$N=15$ 50.0%	$N=15$ 50.0%	$N=1$ 6.7%	$N=3$ 20.0%	$N=8$ 53.3%	$N=2$ 13.3%	2.21	1.81
Using graphics software to create pictures	$N=6$ 20.0%	$N=24$ 80.0%	$N=0$ 0.0%	$N=1$ 16.7%	$N=3$ 50.0%	$N=2$ 33.3%	1.83	1.41
Using scanners to capture graphics, photos and/or text	$N=3$ 10.0%	$N=27$ 90.0%	$N=0$ 0.0%	$N=0$ 0.0%	$N=2$ 6.7%	$N=1$ 33.3%	1.67	1.15
Importing clipart into text	$N=2$ 6.7%	$N=28$ 93.3%	$N=0$ 0.0%	$N=0$ 0.0%	$N=0$ 0.0%	$N=2$ 100.0%	1.00	0.00
Creating and maintaining blogs or websites	$N=1$ 3.3%	$N=29$ 96.7%	$N=0$ 0.0%	$N=0$ 0.0%	$N=1$ 100.0%	$N=0$ 0.0%	2.00	1.41
Creating digital learning materials for students	$N=5$ 16.7%	$N=25$ 83.3%	$N=0$ 0.0%	$N=1$ 20.0%	$N=3$ 60.0%	$N=1$ 20.0%	2.00	1.55
Using chemistry tutorial packages on CD-ROMs/downloads to deliver lessons	$N=16$ 53.3%	$N=14$ 46.7%	$N=3$ 18.8%	$N=10$ 62.5%	$N=2$ 12.5%	$N=1$ 6.3%	2.94	2.50
Surfing the internet to collect information to prepare chemistry lessons notes	$N=23$ 76.7%	$N=11$ 36.7%	$N=18$ 78.3%	$N=3$ 13.0%	$N=2$ 8.7%	$N=0$ 0.0%	3.70	3.22
Browsing the internet to collect learning materials or resources to be used by students during lessons	$N=19$ 63.3%	$N=11$ 36.7%	$N=3$ 15.8%	$N=13$ 68.4%	$N=2$ 10.5%	$N=1$ 5.3%	2.95	2.49
Searching for teaching and learning materials from the Internet	$N=21$ 70.0%	$N=9$ 30.0%	$N=11$ 52.4%	$N=7$ 33.3%	$N=3$ 14.3%	$N=0$ 0.0%	3.38	2.93
Using the internet to post information and give feedback to students	$N=20$ 66.7%	$N=10$ 33.3%	$N=3$ 15.0%	$N=12$ 60.0%	$N=2$ 10.0%	$N=3$ 15.0%	2.75	2.37

Table 1 (Continued). Science teachers' competency and ICT tools usage for teaching SHS chemistry (frequency: n & percentage: %)

Do you use ICT tools to do the following activities?	Yes	No	If yes, how often?				Mean	SD
			VHU	HU	RU	NU		
Editing text online containing the Internet links and images	$N = 14$ 46.7%	$N = 19$ 63.3%	$N = 0$ 0.0%	$N = 4$ 28.6%	$N = 9$ 64.3%	$N = 1$ 7.1%	2.21	1.73
Using the Internet search engines (Google, Yahoo, Bing, etc.) to achieve self-directed learning	$N = 22$ 73.3%	$N = 8$ 26.7%	$N = 16$ 72.7%	$N = 4$ 18.2%	$N = 2$ 9.1%	$N = 0$ 0.0%	3.64	3.16
Accessing and downloading documents for individualized learning	$N = 18$ 60.0%	$N = 12$ 40.0%	$N = 3$ 16.7%	$N = 13$ 72.2%	$N = 2$ 11.1%	$N = 0$ 0.0%	3.06	2.56
Using emails and web addresses in giving and assessing the students' assignments and examination	$N = 19$ 63.3%	$N = 11$ 36.7%	$N = 4$ 21.1%	$N = 10$ 52.6%	$N = 4$ 21.1%	$N = 1$ 5.3%	2.89	2.47
Using the internet to teach on an e-learning platform	$N = 7$ 23.3%	$N = 23$ 76.7%	$N = 0$ 0.0%	$N = 2$ 28.6%	$N = 4$ 57.1%	$N = 1$ 14.3%	2.14	1.69
Using the zoom to teach	$N = 2$ 6.7%	$N = 28$ 93.3%	$N = 0$ 0.0%	$N = 0$ 0.0%	$N = 1$ 50.0%	$N = 1$ 50.0%	2.00	1.41
Using google meet to teach	$N = 5$ 16.7%	$N = 25$ 83.3%	$N = 0$ 0.0%	$N = 0$ 0.0%	$N = 3$ 60.0%	$N = 2$ 40.0%	1.60	1.10
Using google classroom to upload chemistry notes, and assignments, assessing and providing feedback to students	$N = 8$ 26.7%	$N = 22$ 73.3%	$N = 1$ 12.5%	$N = 2$ 25.0%	$N = 4$ 50.0%	$N = 1$ 12.5%	2.38	2.00
Using google forms to prepare and mark students' assignments	$N = 2$ 6.7%	$N = 28$ 93.3%	$N = 0$ 0.0%	$N = 0$ 0.0%	$N = 1$ 50.0%	$N = 1$ 50.0%	1.50	1.00
Using interactive whiteboard to teach	$N = 0$ 0.0%	$N = 0$ 0.0%	$N = 0$ 0.0%	$N = 0$ 0.0%	$N = 0$ 0.0%	$N = 0$ 0.0%	0.00	0.00
Using virtual chemistry Lab to teach chemistry practical	$N = 11$ 36.7%	$N = 19$ 63.3%	$N = 0$ 0.0%	$N = 3$ 27.3%	$N = 7$ 63.6%	$N = 1$ 9.1%	2.18	1.71
Downloading or uploading curriculum resources from/to website or learning platforms for students to use	$N = 17$ 56.7%	$N = 13$ 43.3%	$N = 1$ 5.9%	$N = 3$ 17.6%	$N = 4$ 23.5%	$N = 9$ 52.9%	1.76	1.50
Using ChemSketch to draw structures of molecules	$N = 12$ 40.0%	$N = 18$ 60.0%	$N = 1$ 8.3%	$N = 6$ 50.0%	$N = 2$ 16.7%	$N = 3$ 25.0%	2.42	2.08
Using Phet to teach simulations in chemistry	$N = 0$ 0.0%	$N = 0$ 0.0%	$N = 0$ 0.0%	$N = 0$ 0.0%	$N = 0$ 0.0%	$N = 0$ 0.0%	0.00	0.00
Searching for educational games on the Internet	$N = 7$ 16.7%	$N = 23$ 76.7%	$N = 0$ 0.0%	$N = 0$ 0.0%	$N = 3$ 42.9%	$N = 4$ 57.1%	1.43	0.93
Downloading and installing educational software on computer	$N = 5$ 16.7%	$N = 25$ 83.3%	$N = 0$ 0.0%	$N = 0$ 0.0%	$N = 2$ 40.0%	$N = 3$ 60.0%	1.40	0.89
Using educational Television (TV) for practical illustration of some concepts during the teaching and learning process	$N = 3$ 10.0%	$N = 27$ 90.0%	$N = 0$ 0.0%	$N = 0$ 0.0%	$N = 2$ 66.7%	$N = 1$ 33.3%	1.67	1.15
Using social media tools (MSN, Yahoo Messenger, Skype, WhatsApp) as a shared means of sharing information with students and colleagues	$N = 27$ 90.0%	$N = 3$ 10.0%	$N = 23$ 85.2%	$N = 3$ 11.1%	$N = 1$ 3.7%	$N = 0$ 0.0%	3.81	3.31
Overall mean and standard deviation							2.25	1.82
Cronbach's alpha=0.82								

Note. SD: Standard deviation

computers in storing, retrieving, and sharing information with students, 22 out of the 30 teachers specified that they could organize computer files in folders and subfolders and also use the internet search engines (Google, Yahoo, Bing, etc.) to achieve self-directed learning representing 73.3%, respectively. Besides, 70.0% (N=21) of the 30 teachers showed that they can print a document in Microsoft word, use a spreadsheet to plot a graph, and search for teaching and learning materials on the internet.

Some other activities specified by the chemistry teachers where they are competent of using ICT tools to carry out include the following creating a presentation using PowerPoint with animation functions and using the internet to post information and give feedback to students, which represents 66.7% (N=20), respectively; preparing exercises, assignment, homework, quizzes and tasks for students using Microsoft Word, browsing the internet to collect learning materials or resources for students to use during lessons, using emails and web address in giving and assessing the students' assignment and examination (63.3%, N=19); accessing and downloading documents for individualized learning (60.0%, N=18); using multimedia projectors in science lessons presentation and downloading or uploading curriculum resources from/to website or learning platforms for students to use (56.7%, N=17); using a formula in a spreadsheet and, using chemistry tutorial packages on CD-ROMs/downloads to deliver lessons (53.3%, N=16); and finding the meaning of scientific words in e-dictionary (50.0%, N=15).

However, the activities where the majority of the chemistry teachers were less competent in using ICT tools to perform include using zoom to teach and creating and maintaining blogs or web sites (96.7%, N=29); importing clipart into text and using google forms to prepare and mark students' assignments (93.3%, N=28); using educational television (TV) for practical illustration of some concepts during the teaching and learning process and using scanners to capture graphics, photos and/or text (90.0%, N=27); using google meet to teach as well as downloading and installing educational software on the computer (83.3%, N=25), using graphics software to create pictures (80.0%, N=24); using the internet to teach on an e-learning platform, creating digital learning materials for students and searching for educational games on the internet (76.7%, N=23); desktop publishing and using google classroom to upload chemistry notes, assignments, assessing and providing feedback to students (73.3%, N=22); using

virtual chemistry lab to teach chemistry practical and editing text online containing internet links and images (63.3%, N=19); using ChemSketch to draw structures of molecules (60.0%, N=18); and using animation in lesson delivery (56.7%, N=17).

More so, the activities where ICT tools were not utilized at all as stated by the chemistry teachers are creating a presentation with video or audio clips, using an interactive whiteboard and Phet to teach simulations in chemistry representing 0.0% (N=0), respectively.

From the results of this study, the level of skills exhibited by the chemistry teachers in the utilization of ICT may be because the majority of them are computer literates representing 90.0% (N=27) while very few of them were computer illiterates representing 10.0% (N=3).

Kennah (2017) conducted a study on the use of ICT in the teaching and learning process in secondary schools and indicated that teachers' self-confidence and competence increase remarkably as they can use ICT in their classroom with little or no problems. Bukaliya and Mubika (2011), on the other hand, surveyed 320 secondary school teachers to assess their knowledge of ICT tools. Only 7.5% of the teachers were aware and experienced in computer-assisted training, according to their findings. In addition, 43% of the teachers utilized a spreadsheet, 37.5% used the internet, and 46% used email, according to their findings.

Several studies have found that teachers' ICT skill, as well as their attitudes toward technology, impacts both their first usage of technology and their future behavior (Chou et al., 2019; Lawrence & Tar, 2018). Sipilä (2014) looked at teachers' opinions of ICT integration, their degree of ICT competency, and the issues that may prevent them from using ICT in the classroom. According to the findings, teachers who are proficient in the use of ICT frequently use technology in their lessons. Tambunan (2014), on the other hand, claims that teachers' interpersonal interactions, usage of information technology, and self-improvement all influence their ICT competency. Furthermore, the report claims that for teachers to achieve the best results in terms of student learning, they must be skilled in the use and management of ICT technologies. The competence of teachers in the field of information technology is a critical need to improve learning outcomes. From the comfort of one's own home, one can establish a relationship between technology, human resource development information, and the preparedness of persons to work (Msila, 2015). Teachers are expected to keep up with technological advancements to improve their information technology skills and maintain their position as leaders in the use of ICT tools in the teaching and learning process in schools.

Science Teachers' ICT Tools Usage in Teaching SHS Chemistry

To determine the degree of science teachers' ICT tools usage in teaching SHS chemistry, a 4-Likert scale of VHU, HU, RU, and NU were used to determine how often they use ICT in performing the activities they capable of doing. The Cronbach's alpha coefficient determined on the 44 items was 0.82 signifying the constructs showed very good reliability.

The number of chemistry teachers who exhibited a certain level of competence in using ICT tools and how often they use ICT in performing the activities are presented in **Table 1**. The responses on the use of ICT tools for teaching by chemistry teachers had means above the cut-off point of 2.50 suggesting that teachers highly utilized ICT tools for teaching chemistry.

Considering the first level of the 4-Likert scale, the activities where ICT tools were VHU by the chemistry teachers include the following; 27 out of the 30 teachers who specified they use social media tools (Facebook, WhatsApp, Messenger, Instagram, etc.) as a shared means of sharing information with students and colleagues, the majority of them (N=23) indicated that social media tools are very highly utilized by them, which represents 85.2%. This finding is consistent with the finding of the study carried out by Burns et al. (2019). The study found that some teachers, who either have a passion for ICT in education or have obtained formal training at their own expense, are quite active in the use of ICTs and social media (such as Facebook and WhatsApp groups) for enhanced communication with students via mobile phones. Besides, out of the 23 teachers who indicated that they surf the internet to collect information to prepare chemistry lessons notes, most of them (N=18) representing 78.3% showed that the internet is very highly utilized to aid in the preparation of chemistry notes.

In addition, of 22 teachers who stated that they use internet search engines (Google, Yahoo, Bing, etc.) to achieve self-directed learning, 16 of them representative of 72.7% showed that the Internet search engines are very highly utilized by them. Similarly, Koo (2008) concluded in his study that teachers frequently use the internet both in the classroom and outside the school setting. Also, 25 teachers disclosed that they can use Microsoft Word in generating examination questions but 19 of them representing 70.4% showed that Microsoft word is very highly utilized in typing examination questions, which supports the findings of a study conducted by Mereku et al. (2009). More so, 22 teachers indicated that they could organize computer files in folders and subfolders. However, 12 out of the 22 teachers representing 54.5% indicated that computers are very highly utilized in organizing files into folders and subfolders. For searching for teaching and learning materials from the internet, 21 teachers are capable of doing that but then 15 of them representing 52.1% stated that the internet is very highly utilized in searching for teaching and learning materials to deliver lessons.

For the second level of the 4-Likert scale, the activities specified by the chemistry teachers where ICT tools are highly utilized are also summarized in **Table 1**. Out of the 18 teachers who indicated that they could access and download documents from the internet for individualized learning, 13 of them representative of 72.2% disclosed that they highly utilized the internet to access and download documents. Besides, 68.0% (N=17) of the 25 teachers specified that they could create a document in Microsoft word and that the Microsoft Word application is highly utilized and this affirmed the findings of Yildirim (2007). Waite (2004) indicated that even though teachers showed great interest and motivation to learn about the potential of ICT, in practice, the use was relatively low, and it was focused on a narrow range of applications, with word processing being the predominant use. Furthermore, out of the 19 teachers who stated that they browse the internet to collect learning materials or resources to be used by students during lessons, 13 of them representing 68.4% highly utilized the internet to gather students' learning materials or resources. This finding is in concurrence with the views of Ali (2018) as all the teachers either agreed or strongly agreed that ICT helped teachers to improve teaching with more updated materials.

In addition, out of the 20 teachers who are capable of using the internet to post information and give feedback to students, 12 of them indicated that they highly utilized the internet to post information and

give feedback to students representing 60.0%. More so, for the 16 teachers who disclosed using chemistry tutorial packages on CD-ROMs/downloads, 10 of them indicated that it is highly utilized in the chemistry class representing 62.5%. Also, out of the 21 teachers who stated they can use the spreadsheet to plot graphs, 12 of them indicated that they highly utilized the spreadsheet in graphing representing 57.1%.

Other activities disclosed by the science teachers where ICT tools are HU include using a formula in a spreadsheet (56.3%, N=9); PowerPoint to create a presentation with animation functions (55.0%, N=11); multimedia projectors in science lessons presentation (52.9%, N=9); emails and web address in giving and assessing the students' assignment and examination (52.6%, N=10); spreadsheet in data analysis and computing of students results (52.4%, N=13); printing a document in Microsoft Word (52.4%, N=11); and ChemSketch to draw structures of molecules (50.0%, N=6). A study conducted by Frank et al. (2011) indicates that teachers use computers to write lesson plans, prepare materials for teaching, record and calculate students' grades, and communicate with other teachers. As such, computers have become a routine tool for helping teachers accomplish their professional work.

Undoubtedly, the third and fourth levels of the 4-Likert scale depict the activities indicated by the chemistry teachers where ICT tools are RU and NU as presented in **Table 1**. This is found to be due to the fact that the majority of the chemistry teachers indicated that they were less competent in using ICT tools to perform those activities.

The activities where ICT tools are RU by the science teachers include using educational television (TV) for practical illustration of some concepts during the teaching and learning process; using the internet to teach on an e-learning platform such as using zoom to teach, using google meet to teach, using google classroom to upload chemistry notes, assignments, assessing and providing feedback to students, using google forms to prepare and mark students' assignments. Others include editing text online containing internet links and images; using a virtual chemistry lab to teach chemistry practicals; creating digital learning materials, using database applications, finding the meaning of scientific words in e-dictionary; creating pictures with graphics software; and creating and maintaining blogs or web sites.

Besides, the activities where ICT tools are Not Utilized by the science teachers include the following desktop publishing; using animation in lesson delivery; downloading and installing educational software on the computer; searching for educational games on the internet; downloading or uploading curriculum resources from/to website or learning platforms for students to use; preparing exercises, assignment, homework, quizzes, and tasks for students using Microsoft word; and importing clipart into text.

Considering all the 44 items that were designed to measure teachers' use of ICT in teaching chemistry as summarized in **Table 1**. The results show that teachers' use of ICT in teaching chemistry is low with an average mean (m) of 2.25 and a standard deviation (SD) of 1.82. This shows that ICT integration in Ghanaian secondary schools is low. However, teachers are change agents in schools, according to Buabeng-Andoh (2019). They are the driving forces behind the implementation of ICT in education. When teachers' ICT integration is low, it has an impact on how they use technology in the classroom. Teachers will have complete control over the impact of ICT on students' learning. They make decisions about how to best affect knowledge. Both educators and learners will benefit from the inclusion of ICT since it will provide fresh, interesting, and rewarding learning experiences. As a result, instructors must be trained to have the essential knowledge and abilities to properly support their students' use of ICT in the classroom. In other words, successful ICT integration in schools and classrooms is determined by training and competency.

Factors Hindering Science Teachers' from Using ICT Tools in Teaching Chemistry at the SHSs

The factors affecting science teachers' from using ICT tools in teaching chemistry at the SHS level were determined using a 5-Likert scale of SA-strongly agree (5), A-agree (4), SD-strongly disagree (3), D-disagree (2), and UD-undecided (1) as summarized in **Table 2**.

Table 2. Factors hindering science teachers' use of ICT tools in teaching SHS chemistry

What factors hinder your use of ICT tools in teaching chemistry?	SA	A	SD	D	UD	Mean	SD
Teacher-level factors							
Lack of knowledge and appreciation for the use of the ICT tools	$N = 11$ 36.7%	$N = 15$ 50.0%	$N = 3$ 10.0%	$N = 1$ 3.3%	$N = 0$ 0.0%	4.20	3.74
Lack of teacher confidence in the use of ICT tools	$N = 18$ 60.0%	$N = 5$ 16.7%	$N = 2$ 6.7%	$N = 3$ 10.0%	$N = 2$ 6.7%	4.10	3.82
Lack of skills and competencies to handle the computers and their peripheral devices	$N = 21$ 70.0%	$N = 7$ 16.7%	$N = 0$ 23.3%	$N = 2$ 6.7%	$N = 0$ 0.0%	4.60	4.12
Fear to use ICT tools in teaching due to limited knowledge	$N = 6$ 20.0%	$N = 19$ 63.3%	$N = 4$ 13.3%	$N = 1$ 3.3%	$N = 0$ 0.0%	4.0	3.53
Lack of training and skills development on the use and adoption of ICT tools for teaching and learning at the schools	$N = 20$ 67.7%	$N = 6$ 20.0%	$N = 2$ 6.7%	$N = 1$ 3.3%	$N = 1$ 3.3%	4.4	4.02
Lack of interest by teachers	$N = 2$ 6.7%	$N = 4$ 13.3%	$N = 18$ 60.0%	$N = 6$ 20.0%	$N = 0$ 0.0%	3.1	2.63
Most teachers not in favor of using ICT tools in school	$N = 1$ 3.3%	$N = 3$ 10.0%	$N = 21$ 70.0%	$N = 5$ 16.7%	$N = 0$ 0.0%	3.0	2.53
Teacher resistance to change and negative attitudes	$N = 1$ 3.3%	$N = 3$ 10.0%	$N = 8$ 26.7%	$N = 16$ 53.3%	$N = 2$ 6.7%	2.50	2.13
Lack of pedagogical models on how to use ICT tools for teaching	$N = 19$ 63.3%	$N = 9$ 30.0%	$N = 1$ 3.3%	$N = 1$ 3.3%	$N = 0$ 0.0%	4.50	4.07
Shortage of qualified teachers with capacity in ICT applications	$N = 11$ 36.7%	$N = 16$ 53.3%	$N = 1$ 3.3%	$N = 2$ 6.7%	$N = 0$ 0.0%	4.20	3.75
No or unclear benefit to using ICT tools for teaching science	$N = 9$ 30.0%	$N = 18$ 60.0%	$N = 1$ 3.3%	$N = 2$ 6.7%	$N = 0$ 0.0%	4.10	3.68

Table 2 (Continued). Factors hindering science teachers' use of ICT tools in teaching SHS chemistry

What factors hinder your use of ICT tools in teaching chemistry?	SA	A	SD	D	UD	Mean	SD
Lack of time	$N = 0$ 0.0%	$N = 1$ 3.3%	$N = 17$ 56.7%	$N = 11$ 36.7%	$N = 1$ 3.3%	2.60	2.13
The complexity of integrating ICT tools in teaching science	$N = 22$ 73.3%	$N = 7$ 23.3%	$N = 0$ 0.0%	$N = 1$ 3.3%	$N = 0$ 0.0%	4.70	4.19
Lack of computers	$N = 3$ 10.0%	$N = 5$ 16.7%	$N = 16$ 53.3%	$N = 4$ 13.3%	$N = 2$ 6.7%	3.10	2.73
Lack of Android phones	$N = 2$ 6.7%	$N = 3$ 10.0%	$N = 19$ 63.3%	$N = 6$ 20.0%	$N = 0$ 0.0%	3.00	2.59
Lack of Ipad	$N = 7$ 23.3%	$N = 15$ 50.0%	$N = 3$ 10.0%	$N = 2$ 6.7%	$N = 3$ 10.0%	3.70	3.38
Lack of the Internet data	$N = 17$ 56.7%	$N = 8$ 26.7%	$N = 2$ 6.7%	$N = 3$ 10.0%	$N = 0$ 0.0%	4.30	3.89
Cost-related factors							
The cost of acquiring the computers and their peripheral devices, installation, and maintenance	$N = 7$ 23.3%	$N = 21$ 70.0%	$N = 0$ 0.0%	$N = 2$ 6.7%	$N = 0$ 0.0%	4.10	3.63
The cost of acquiring ICT materials and textbooks for use in teaching and instruction purposes	$N = 19$ 63.3%	$N = 9$ 30.0%	$N = 1$ 3.3%	$N = 1$ 3.3%	$N = 0$ 0.0%	4.50	4.07
The high cost of the hardware and software applications leads to low integration of ICT in teaching	$N = 9$ 30.0%	$N = 17$ 56.7%	$N = 0$ 0.0%	$N = 3$ 10.0%	$N = 1$ 3.3%	4.00	3.61
The cost of an internet bundle and access to the Internet	$N = 25$ 83.3%	$N = 5$ 16.7%	$N = 0$ 0.0%	$N = 0$ 0.0%	$N = 0$ 0.0%	4.80	4.32
The cost of training and acquiring skills and knowledge in the use of computers and applications	$N = 27$ 90.0%	$N = 2$ 6.7%	$N = 0$ 0.0%	$N = 1$ 3.3%	$N = 0$ 0.0%	4.80	4.34
Technological-related factors							
Inadequate and lack of computers to aid the teaching of science in school	$N = 6$ 20.0%	$N = 21$ 70.0%	$N = 1$ 3.3%	$N = 1$ 3.3%	$N = 1$ 3.3%	4.00	3.56
School computers out of data and/or needing repair	$N = 22$ 73.3%	$N = 8$ 26.7%	$N = 0$ 0.0%	$N = 0$ 0.0%	$N = 0$ 0.0%	4.70	4.23
No computer laboratories for teaching, demonstration, and learning	$N = 0$ 0.0%	$N = 1$ 3.3%	$N = 23$ 76.7%	$N = 6$ 20.0%	$N = 0$ 0.0%	2.80	2.32
Few and limited computers available are outmoded and obsolete	$N = 27$ 90.0%	$N = 2$ 6.7%	$N = 0$ 0.0%	$N = 1$ 3.3%	$N = 0$ 0.0%	4.80	4.34
There is no internet connectivity in the computer laboratories	$N = 20$ 66.7%	$N = 6$ 20.0%	$N = 1$ 3.3%	$N = 3$ 10.0%	$N = 0$ 0.0%	4.40	4.02
Limited or poor internet connectivity in the schools with internet connectivity	$N = 6$ 20.0%	$N = 19$ 63.3%	$N = 1$ 3.3%	$N = 4$ 13.3%	$N = 0$ 0.0%	3.90	3.47
Lack of supporting devices such as projectors, interactive whiteboards, scanners, printers, and photocopiers among others to aid the teaching and actual use/demonstration	$N = 0$ 0.0%	$N = 1$ 3.3%	$N = 25$ 83.3%	$N = 4$ 13.3%	$N = 0$ 0.0%	2.90	2.38
Lack of periodical maintenance of the computers and their peripheral devices at the computer laboratories and classrooms	$N = 27$ 90.0%	$N = 1$ 3.3%	$N = 1$ 3.3%	$N = 1$ 3.3%	$N = 0$ 0.0%	4.80	4.32
Management and leadership-related factors							
The high cost of acquisition of ICT facilities	$N = 7$ 23.3%	$N = 18$ 60.0%	$N = 1$ 3.3%	$N = 3$ 10.0%	$N = 1$ 3.3%	3.90	3.50
Lack of access to ICT tools	$N = 21$ 70.0%	$N = 7$ 23.3%	$N = 0$ 0.0%	$N = 2$ 6.7%	$N = 0$ 0.0%	4.60	4.12
Lack of strong government policies on ICT instructional delivery	$N = 4$ 13.3%	$N = 23$ 76.7%	$N = 2$ 6.7%	$N = 1$ 3.3%	$N = 0$ 0.0%	4.00	3.51
Using ICT tools in teaching and learning not being a goal in our school	$N = 0$ 0.0%	$N = 1$ 3.3%	$N = 22$ 73.3%	$N = 6$ 20.0%	$N = 1$ 3.3%	2.80	2.28
Inadequate support from the government, ministry of education, and other agencies on the acquisition and implementation of ICT tools in the secondary schools	$N = 24$ 80.0%	$N = 4$ 13.3%	$N = 0$ 0.0%	$N = 1$ 3.3%	$N = 1$ 3.3%	4.60	4.20
Lack of adequate content/material for teaching	$N = 7$ 23.3%	$N = 19$ 63.3%	$N = 2$ 6.7%	$N = 2$ 6.7%	$N = 0$ 0.0%	4.00	3.58
Inadequate funding of programs and ICT related activities	$N = 25$ 83.3%	$N = 3$ 10.0%	$N = 1$ 3.3%	$N = 1$ 3.3%	$N = 0$ 0.0%	4.70	4.26
The heads (headmasters/headmistresses) do not appreciate the role and impact on the deployment and adoption of the use of ICT in teaching and learning at the schools	$N = 0$ 0.0%	$N = 2$ 6.7%	$N = 20$ 66.7%	$N = 8$ 26.7%	$N = 0$ 0.0%	2.80	2.31
Too difficult to use ICT tools in science subjects' curricula	$N = 1$ 3.3%	$N = 1$ 3.3%	$N = 21$ 70.0%	$N = 6$ 20.0%	$N = 1$ 3.3%	2.80	2.38
Very few teachers use ICT tools due to a lack of motivation	$N = 2$ 6.7%	$N = 3$ 10.0%	$N = 19$ 63.3%	$N = 4$ 13.3%	$N = 2$ 6.7%	3.00	2.57
Insufficient pedagogical support for teachers in a time of need	$N = 8$ 26.7%	$N = 18$ 60.0%	$N = 1$ 3.3%	$N = 3$ 10.0%	$N = 0$ 0.0%	4.00	3.60
Limitation of infrastructure	$N = 9$ 30.0%	$N = 17$ 56.7%	$N = 0$ 0.0%	$N = 3$ 10.0%	$N = 1$ 3.3%	4.00	3.61

Table 2 (Continued). Factors hindering science teachers' use of ICT tools in teaching SHS chemistry

What factors hinder your use of ICT tools in teaching chemistry?	SA	A	SD	D	UD	Mean	SD
School time organization (fixed lesson time, etc.)	$N = 7$ 23.3%	$N = 19$ 63.3%	$N = 1$ 3.3%	$N = 3$ 10.0%	$N = 0$ 0.0%	4.00	3.56
The pressure to prepare students for examination and tests	$N = 1$ 3.3%	$N = 4$ 13.3%	$N = 8$ 26.7%	$N = 17$ 56.7%	$N = 0$ 0.0%	2.60	2.24
Most parents not in favor of using ICT in school	$N = 2$ 6.7%	$N = 1$ 3.3%	$N = 21$ 70.0%	$N = 6$ 10.0%	$N = 0$ 0.0%	3.00	2.52
Incessant power failure	$N = 9$ 30.0%	$N = 16$ 53.3%	$N = 4$ 13.3%	$N = 1$ 3.3%	$N = 0$ 0.0%	4.10	3.64
Environmental-related factors							
School space organization (classroom size and furniture etc.)	$N = 8$ 26.7%	$N = 19$ 63.3%	$N = 1$ 3.3%	$N = 1$ 3.3%	$N = 1$ 3.3%	4.10	3.63
Lack of space in the computer laboratories	$N = 26$ 86.7%	$N = 4$ 13.3%	$N = 0$ 0.0%	$N = 0$ 0.0%	$N = 0$ 0.0%	4.90	4.35
Poor ventilation in the computer laboratories	$N = 8$ 26.7%	$N = 21$ 70.0%	$N = 0$ 0.0%	$N = 0$ 0.0%	$N = 1$ 3.3%	4.20	3.71
Due to the absence of air conditions in the computer laboratories, dust easily and often enters the computer laboratory	$N = 7$ 23.3%	$N = 20$ 66.7%	$N = 1$ 3.3%	$N = 2$ 6.7%	$N = 0$ 0.0%	4.10	3.61
Overall mean and standard deviation						3.90	3.45
Cronbach's alpha=0.75							

The factors were categorized into five main groups namely teacher-level factors, cost-related factors, technological-related factors, management and leadership-related factors, and environmental-related factors. The Cronbach's alpha coefficient determined on the 50 items was 0.75 signifying the constructs showed good reliability.

The data in **Table 2** showed that some factors hinder science teachers' potential of using ICT tools in teaching chemistry since these factors have benchmark mean values greater than 3.0 while others score below the cut-up point of 3.0 indicating that these factors do not hinder the use of ICT in teaching chemistry by the science teachers.

The overall mean of all the factors impeding chemistry teachers' use of ICT for teaching is 3.90 with a standard deviation of 3.45. This suggests that these factors greatly influence the science teachers' capability of using ICT for teaching and that the data points are widely dispersed away from the mean as indicated by the higher standard deviation.

Teacher-level factors affecting their ICT use in teaching SHS chemistry

From the **Table 2**, the teacher-level factors the chemistry teachers strongly agree to as factors hindering their ICT use in teaching SHS chemistry include the complexity of integrating ICT tools in teaching science (73.3%, N=22), lack of skills and competencies to handle the computers and their peripheral devices (70.0%, N=21), lack of training and skills development on the use and adoption of ICT tools for teaching and learning at the schools (67.7%, N=20), lack of pedagogical models on how to use ICT tools for teaching (63.3%, N=19), lack of teacher confidence in the use of ICT tools (60.0%, N=18), and lack of internet data (56.7%, N=17).

Furthermore, the teachers agree that fear of using ICT tools in teaching is due to limited knowledge (63.3%, N=19), no or unclear benefits to using ICT tools for teaching science (60.0%, N=18), shortage of qualified teachers with capacity in ICT applications (53.3%, N=16), lack of knowledge and appreciation for the use of the ICT tools (50.0%, N=15), and lack of iPad (50.0%, N=15) as teacher-level factors.

Besides, most teachers are not in favor of using ICT tools in school (70.0%, N=21), lack of android phones (63.3%, N=19), lack of interest by teachers (60.0%, N=18), lack of time (56.7%, N=17) and lack of computers (53.3%, N=16) were strongly disagreed by the teachers as factors affecting their ability to use ICT tools in teaching chemistry. However, 16 teachers representing 53.3% disagree that resistance to change and negative attitudes affect their ability to use ICT in teaching chemistry.

Technical challenges in most schools have evolved into a serious issue, a source of aggravation for teachers, and a source of disruption in the teaching and learning process. Teachers are unable to utilize the computer for instruction if there is a shortage of technical assistance and no repair available (Jamieson-Proctor et al., 2013). As a result of not receiving any advice on the subject, teachers will be discouraged from utilizing computers for fear of equipment failure. According to a study by Turel and Johnson (2012), technological issues become a key hurdle for teachers, and these issues include low connectivity, malware attacks, and printer malfunction. However, developed countries such as the Netherlands, the United Kingdom, and Malta have acknowledged the necessity of technical assistance to help teachers use ICT in the classroom (Yang & Wang, 2012).

Teachers' attitudes toward ICT can influence the adoption and integration of ICT in schools, according to studies conducted by Hew and Brush (2007) and Huang and Liaw (2005). If teachers have negative attitudes toward technology, providing them with excellent ICT facilities may not influence them to use it in their teaching. If, on the other hand, teachers have a positive attitude toward the use of technology, they may readily provide important insight into the adoption and integration of ICT in the classroom teaching and learning process.

Cost-related factors affecting chemistry teachers' ICT use in teaching SHS chemistry

The cost-related factors the chemistry teachers strongly agree with as factors impeding their ICT use in teaching SHS chemistry as summarized in **Table 2** include the cost of training and acquiring skills and knowledge in the use of computers and applications (90.0%, N=27), the cost of an internet bundle, and access to the internet (83.3%, N=25), and the cost of acquiring ICT materials and textbooks for use in teaching and instruction purposes (63.3%, N=19).

Also, the chemistry teachers agreed that the cost of acquiring computers and their peripheral devices, installation, and maintenance

(70.0%, N=21), and the high cost of hardware and software applications lead to low integration of ICT in teaching (56.7%, N=17).

The cost element relates to ICT training materials and ICT infrastructure deployment and implementation. Dei (2019) confirms this fact, stating that the higher the cost of computers and their accessories, the fewer computers one can purchase with restricted funds. As a result, to enhance access to ICT tools, academic institutions need accurate information on computer costs so that alternative sources of low-cost peripherals can be sought. According to Huang and Liaw (2005), the cost of ICT tools would not be a concern if African economies were not impoverished and consequently lacked resources.

Technological-related factors affecting chemistry teachers' ICT use in teaching SHS chemistry

The technological-related factors the chemistry teachers strongly agree with hindering their ICT use in teaching SHS chemistry as summarized in **Table 2** include the following; few and limited computers available in their schools are outmoded and obsolete (90%, N=27), lack of periodical maintenance of the computers and their peripheral devices at the computer laboratories and classrooms (90%, N=27), school computers out of data and/or needing repair (73.3%, N=22) and no internet connectivity in the computer laboratories (66.7%, N=20).

Furthermore, the teachers agreed that inadequate and lack of computers to aid the teaching of science in school (70.0%, N=21) and limited or poor internet connectivity in the schools (63.3%, N=19) affect their ability to use ICT tools in instruction. However, the teachers strongly disagreed with the lack of supporting devices such as projectors, interactive whiteboards, scanners, printers, and photocopiers among others to aid the teaching and actual use/demonstration (83.3%, N=25), and no computer laboratories for teaching, demonstration, and learning (76.7%, N=23) as technological-related factors affecting their ability to use ICT tools in teaching chemistry

Management and leadership-related factors affecting chemistry teachers' ICT use in teaching SHS chemistry

From the **Table 2**, the management and leadership-related factors the teachers strongly agree on as factors influencing their ability to use ICT tools in teaching chemistry are inadequate funding of programs and ICT related activities (83.3%, N=25), inadequate support from the government, ministry of education, and other agencies on the acquisition and implementation of ICT tools in the secondary schools (80.0%, N=24) and lack of access to ICT tools (70.0%, N=21).

Furthermore, the factors agreed by the chemistry teachers as factors hindering their ICT use in teaching are lack of strong government policies on ICT instructional delivery (76.7%, N=23), lack of adequate content/material for teaching (63.3%, N=19), school time organization (fixed lesson time, etc.) (63.3%, N=19), insufficient pedagogical support for teachers in the time of need (60.0%, N=18), high cost of acquisition of ICT facilities (60.0%, N=18), limitation of infrastructure (56.7%, N=17), and incessant power failure (53.3%, N=16).

Besides, the chemistry teachers strongly disagree that using ICT tools in teaching and learning is not a goal of their schools (73.3%, N=22), difficulty in using ICT tools in science subjects curricula (70.0%, N=21), most parents not in favor of using ICT in schools (70.0%, N=21), heads (headmasters/headmistresses) not appreciating the role and impact on the deployment and adoption of the use of ICT in teaching and learning at the schools (66.7%, N=20), and very few teachers making good use of ICT tools due to a lack of motivation (63.3%, N=19) as management and leadership-related factors hindering their ICT use in teaching. However, 17 teachers representing 56.7% disagreed that the pressure to prepare students for examination and tests affect their ability to use ICT in teaching chemistry.

Numerous studies have found that leadership and management support is a stronger determinant of teachers' integration of ICT into teaching (Boulton, 2017; Lawrence & Tar, 2018; Shin, 2015). According to Schiller (2003), "the educational potential of information and communication technology may not be achieved without leadership support." As a result, according to Dei (2019), educators who received constructive support from administrators were more likely to use technology in their teaching, whereas those who received poor support or encouragement from higher authorities in school were less enthusiastic about using the computer or did not use it at all.

Environmental-related -related factors affecting chemistry teachers' ICT use in teaching SHS chemistry

The only environmental-related factor the chemistry teachers strongly agreed with as a hindrance to their ICT use in teaching SHS chemistry is the lack of space in the computer laboratories (86.7%, N=26). Also, they agreed on poor ventilation in the computer laboratories (70.0%, N=21), dust due to the absence of air conditions in the computer laboratories (66.7%, N=20), and school space organization (classroom size and furniture, etc.) (63.3%, N=19) as factors impeding their ICT use in schools.

All of the participants agreed that "if training can be offered for all teachers, problems in adopting computers in education will be curbed" during the semi-structured interview. "Computer competency is highly tied to training, and competence cannot be expected in the absence of sufficient training," they all agreed. The participants also agreed that "it would be beneficial if school principals could also lead computers in education." Unfortunately, some of the school leaders are similarly lacking in digital technology and computer knowledge," they noted. The ten teachers who took part in the interview also agreed that change initiatives should begin with the school administration because "when they buy the initiatives, it's easy to sell them to the rest of the staff." Another emphasized that "if computers in education are to be successful, especially when there is strong resistance, the principle of instructional leadership must be sustained." For example, one of the school teachers "highlighted the necessity to emphasize the relevance of computers at all times because teachers may not be aware of this critical part of teaching today."

According to Ali (2018), effective ICT integration is determined by school leaders' perspectives and vision rather than teachers' ICT skills. Teachers' actions, views, and attitudes are influenced by the actions, beliefs, and attitudes of school leaders (Fu, 2013). As a result, for successful ICT integration, school leaders must be supportive and develop an ICT-friendly learning environment.

CONCLUSIONS AND RECOMMENDATIONS

The present study investigates the potential use of ICT tools by science teachers in teaching chemistry as well as the possible factors that hinder their use of ICT tools in teaching chemistry at the SHS in Ghana.

The study found that science teachers are competent in using ICT tools in performing teaching activities. However, the utilization of ICT has not been most effectively utilized in secondary schools in teaching and learning chemistry since the general usage of ICT by teachers is low with an overall mean and standard deviation of 2.25 and 1.82, respectively.

Besides, the study found that the utilization of ICT tools in teaching chemistry is bedeviled with myriads of factors and these factors greatly influence the science teachers' capabilities of using ICT for the teaching-learning process with overall mean and standard deviation of 3.90 and 3.45, respectively. These factors were found to be teacher-level factors, cost-related factors, technological-related factors, management and leadership-related factors, and environmental-related factors.

Based on the findings of this study, the following recommendations were made:

1. The Ministry of Education should ensure that adequate ICT resources and facilities needed for proper utilization of ICT as a tool for teaching and learning science in SHSs in Ghana are provided in the right numbers.
2. Headteachers of SHSs should also encourage teachers to use ICT in teaching science and lead by example.
3. More and essential ICT training for science instructors should be provided so that they become familiar with modern methodology for imparting knowledge and skills, and maybe become part of the curriculum structure for their professional development.

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