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The Potential of integrating ICT into the Teaching and Learning of Chemical Bonds in Senior High Schools in Ghana – A Case study

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ABSTRACT

This study was undertaken to investigate the potential of integrating Information and Communication Technology (ICT) into the teaching and learning of chemical bonding. Chemical bonding is a topic which is abstract in nature and requires the introduction of tangible elements to enable students build mental models for conceptual understanding. Nowadays, students spend more time with technological tools and prefer to use them in performing tasks and so this was tapped upon. Thirty students of Keta Senior High School in Keta, Ghana, who were randomly selected and three chemistry teachers purposely chosen, participated in the study. It employed both qualitative and quantitative methods for collection of data through pre- and post-tests, and the administration of an opinion questionnaire to assess improvement in performance after a chemistry software was used to teach the concept of chemical bonds. The integration of ICT into the teaching and learning of chemical bonds had the potential to reduce its abstraction while allowing students the premise to apply technologies that they were familiar with. Majority of the students (about 95%) had higher marks during the post test.
Keywords: Chemical Bonding, Conceptual understanding, ICT. Ghana

I. INTRODUCTION

Chemistry as a subject is one of the most feared due to the fact that some topics are abstract and require practical activities in laboratories in order for students to be able to form vivid mental imageries for comprehension of its three dimensional and abstract nature [1]. According to Yildrim, Kurt, and Ayas [2] learners must be able to first see images and then be able to arrange or imagine in a logical concrete manner, the changes that take place during chemical changes. They added that students must be able to develop images of chemical changes at the macro, micro and symbolic levels in order to form acceptable concepts and so images could help them to do this effectively. The chemistry laboratory is always recommended for practice as it is a unique learning environment that provides opportunities for varying modes of instruction, 'doing' things in order to form concrete images of them, and make learners practice as scientists. Yet, lack of space for laboratories, cost of equipment, as well as inherent dangers of some activities deny teachers and students alike of efficient study and practice [3]. Besides, traditional laboratories do not have provision for production of images of some complex events such as chemical bonding, to enhance conceptual understanding.

Chemistry deals with chemicals and their reactions, some of which are very dangerous to life if not handled with caution. Reactions of these chemicals are not easy to see nor understood by students as they cannot perceive the changes in real terms. As best, change in colour or temperature may suggest that a change has occurred, on the macroscopic level, but the microscopic changes cannot be perceived. Teachers usually explain these reactions through molecular diagrams or symbolic representations, which are also difficult to comprehend. Some chemistry educators have tried a few approaches such as enquiry, discussion, micro scale and green chemistry laboratories which all yielded some bit of positive results but other innovations could be tried in this technological era [4]. Since the main aim of chemistry education is to guide students to build mental models of chemical phenomena, then the integration of communications technology (ICT) and virtual laboratories, could be adopted for diversity of pedagogy and instructional technology to satisfy modern learners' obsessive engagement with computers. The use of technology and innovation has brought changes in the way knowledge taught and learned in institutions as there is a gradual but steady move from the traditional mode to hybrid or full online modes of digital learning. Computer Assisted Instruction has been of tremendous help in solving this problem in recent times; software is available where students could watch chemical reactions on computer as in real time [5] or perform activities in virtual laboratories. Thus, digital technology therefore plays an important role to support teaching, while highlighting learner autonomy and exposure to varied teaching styles which may suit individual learning styles.

Virtual laboratories require the use of information and communication technology. ICT is a general term that emphasises the integration of telecommunications, computers, software and audio-visual systems to enable users to create, access, store, transmit and manipulate information [6]. Modern communication technologies are an integral part of most students' lives, particularly in the case of secondary school students who are often more ICT cognisant than their teachers [7].

Computer integration in the classroom is the application of technology to assist, enhance, and extend students' knowledge. Using ICT in education means promotion of information literacy – the ability to access, use and evaluate information from different sources in order to enhance learning, solve problems, and generate new knowledge. According to Triona and Klahr [8] virtual activities provide portability, safety, cost-efficiency, minimisation error, flexibility, amplification or reduction of temporal and spatial dimensions, and rapid data analysis over traditional laboratories. As Internet is fast becoming the largest collection of information in the world, teachers can use it to enhance teaching, but it needs to be well structured and sequenced [9]. As ICTs provide both students and teachers with more opportunities in adapting teaching and learning to individual needs, schools have to aptly respond to this technical innovation. Tinio [10] states that the potentials of ICTs in increasing access and improving relevance and quality of education in developing countries can never be underestimated. Schools in the Western World have invested a lot in ICT infrastructures over the last 20 years, so that students use computers more often and for a much larger range of applications [11]and have reaped many benefits already. Several studies reveal that students using ICT facilities mostly show higher learning gains than those who do not and gain many learning skills [11, 12]. Interactive computer-based simulations could be used as conceptual change learning environments. The experience could lead to knowledge gain and reality, as students interact with the virtual environment.

Some topics in chemistry have been viewed to be abstract in nature. Thus, the use of applications that model real world situations would allow students to better understand the subject and develop skills to function effectively in this dynamic, information-rich, and changing environment. Studies indicate that students' skills in chemistry in particular and science in general are enhanced in ICT-based learning environments in education [13, 14] as students spend more time with technological tools. This goes to show that if ICT is integrated into the teaching and learning of chemistry the abstract nature of the course could be reduced. Volman [15] found that the use of ICTs in education contributes to a more constructivist learning, an increase in activity, and greater responsibility of students. This assertion has also been proven by Mikre [5]. Jegede [16], conducted studies on students' perceptions on the integration and benefits of ICT into school curricula and found that it had the possibility to promote interaction between students and teachers and improve access to quality education as well as connect learning to real life situations. This view was also perceived by students in studies undertaken by Lowther, Inan, Strahl and Ross [17] in western countries. Bhukuvhani, Kusure, Munodawafa, Sana and Gwizangwe [18] are also of the view that understanding and insight of principles are stimulated during the simulation of chemical principles. In line with this, Fu [19], suggests that to fully enhance the benefits of integrating ICT into education there should be orientation and training for all users, teachers inclusive, and the expansion of podcasting and online conferencing tools.

It is for these reasons that this study sought to find out the extent to which the integration of ICT into the teaching and learning process would influence the academic performance of students in Keta Senior High

Technical School in the Volta Region. It also implicitly sought to find out the potential of using pedagogical technology through devices that students are familiar with in making the understanding of chemical bonding more realistic to students. Secondary schools are a reasonable place to start integrating technology into education and to introduce new pedagogy through its integration as students are more conversant with ICT at this level and are at a cognitive development level where they need to build on abstraction of concepts.

The objectives of the study were to:

1. Find out how the use of ICT in the teaching and learning process could improve students' performance in chemical bonding.
2. Determine the perception of students regarding the integration of ICT into the teaching and learning of chemical bonding.

The following research questions guided the study.

1. What potential would the integration of ICT have in enhancing Keta Senior High and Technical School students' conceptions of chemical bonding?
2. What are the perceptions of students on the use of ICT in the teaching and learning of chemical bonding in chemistry?

II. RESEARCH DESIGN, SAMPLING AND INSTRUMENTATION

The study tried to find out the potential of integrating ICT into the teaching and learning of chemical bonding in a senior high school. The experimental design approach was used. The study involved thirty randomly selected students in one senior high school in the Volta region of Ghana. Three chemistry teachers in the school were purposively selected and trained to assist in the research work as facilitators, technology experts, and help to cultivate critical thinking. A pre-test was administered to the students to assess their knowledge base on chemical bonds, after which ICT lessons were carried out for six weeks, followed by a post-test to assess change in their academic performance. Pre-test, post-test and questionnaires were employed as the instruments for data collection because of the ease with which variables are compared and measured after treatment. The tests and their answers are shown as Appendices A and B. The same set of questions were mixed and administered as the post-test.

A questionnaire which contained both open and close ended items, was administered after the post-test to find out students' opinions about the use of ICT in teaching and learning concepts about chemical bonds. The data collected were analysed using quantitative and qualitative methods. The purpose of gathering different types of data was to obtain a deeper insight [20] into knowledge claims about the potential of technology use among Ghanaian SHS Chemistry teachers and students as well as for corroboration. Two forms of questionnaires were developed. One was for the students (Appendix C) and the other for teachers (Appendix D). They consisted of both close and open ended rating-scale type of questions on the familiarity and technology usage in the SHS curriculum.

Validity and reliability of instruments

In order to ensure the validity of the pre-test and post-test questions, a web-based standardised chemical bonding test downloaded from the website (http://www.glencoe.com) was vetted and approved by senior colleagues in the Department of Chemistry Education, University of Education, Winneba, before its adoption. Chemistry students from schools in the Keta Municipality who were not part of the sample were made to answer the test items twice within a week. It was realised that majority of the students (about 75%) reproduced the same answers. The reliability level of the test items was 0.74. Similarly, the questionnaires were given to non-sample chemistry teachers and students from different schools to see whether they would understand the items and produce similar results. About 90% of the respondents gave similar responses, which signified a high reliability of the questionnaire.

Data Collection Procedure

Individual students answered a 20-item pre-test a day before the introduction of the intervention in groups of 15 students per class. The question papers together with its instructions and time allocated for the test were given to students to answer in 25 minutes. Thus averagely one minute was used to answer one question, allowing for lapses. Each correct item was awarded one mark, summing up to 20 marks overall. This was followed by the intervention period.

The intervention lasted for six weeks with a session running for 90 minutes in the evenings for three times per week. Thus, in all, there were eighteen 90-minute sessions with the students. The sessions provided opportunities for students to learn about chemical bonding with the aid of computer software. After the intervention students wrote a post-test similar to the pre-test, which was also scored over a total of 20 marks.

The questionnaires were administered personally to the thirty students and collected as soon as they were completed to ensure a high response and return rate. Teachers' impressions about the integration of ICT were also collected.

Intervention

The interactive and user-friendly Chemxb software was installed on all the computers used by the students. After that, a laptop was connected to a projector, after which students were taken through steps on how to engage fruitfully with the installed software to ensure time on task was used for the intended purpose. This software employed the use of animations or graphics which showed vivid, intermediate, colourful imageries of the processes involved in bond formation. Animations have been found to be an effective mode of teaching chemistry through visualisation [21]. The software was divided into eight units which were:

Elements, compounds and mixtures	5.	Ionic bonding
Forming compounds	6.	Covalent bonding
Atomic structure	7.	Structure of materials
Chemical bonds	8.	Bond energies

However, the unit of interest in this study was 'chemical bonds'. The software had menus for easy access to the interactive simulations. The introductory interface is shown as Figure 1.

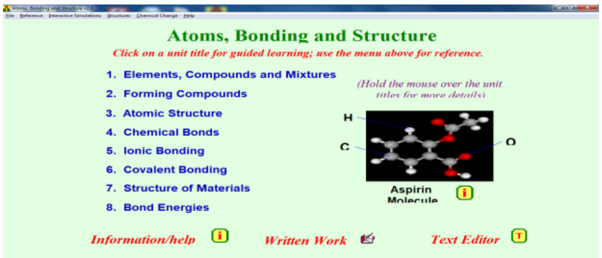

Figure 1: Interface of software

Figure 1 shows the introductory page for the electronic exercise (e-exercise). The students were asked to click on chemical bonds after which a window popped up to explain what chemical bonding was and the possible types of chemical bonds. The ease, and fun of use were interspersed with conceptual self-check e-exercises. The next interface (Figure 2) tested students' understanding of the tutorial provided at the end of the page.

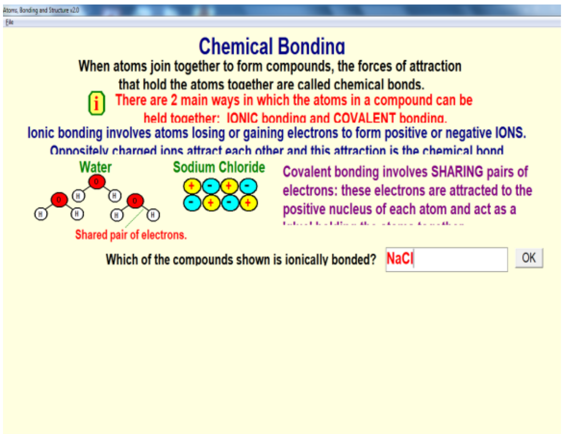

Figure 2 : Interface two of software

Figure 2 shows simple worded tutorial on chemical bonding after which a basic conceptual question is posed. Once the questions are answered correctly, more options are provided to explain the properties of each bond type more thoroughly. All questions on a page have to be answered correctly for subsequent pages to become active for further work as shown in Figure 3 with an arrow. In this case, concepts of principal bonds are sequenced.

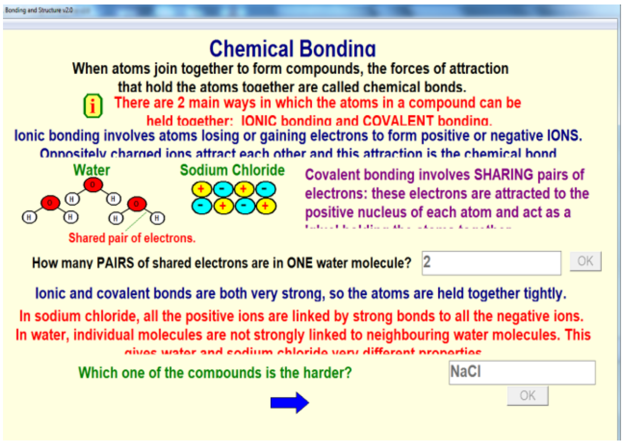

Figure 3. Interface three of software

Figure 3 shows that a participant can move on to another phase of their work, once the arrow sign appears. They also had the option to go back to verify results or concepts. Various aids were made available for users. For example, they could view the periodic table in order to see the categorisation of elements as well as the kind of bonds that could exist between elements from different parts of the table. Such categorisation and possible exercises that users could engage in is depicted in still form in Figure 4.

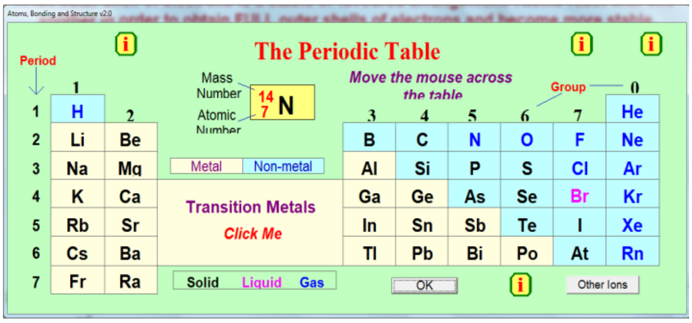

Figure 4 : The Periodic Table

Figure 4 showed the periodic chart which served as an interactive aid for users. An example of an activity which the periodic table could be used for is depicted as Figure 5.

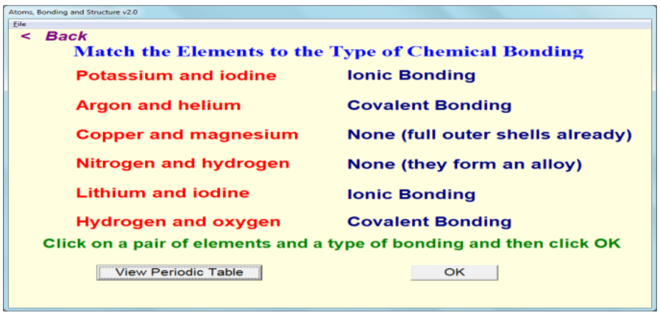

Figure 5: A periodic table activity

Figure 5 presents an e-activity which required the use of the periodic table in figure 4; an indication that the work was sequenced.

III. METHOD OF DATA ANALYSES

The data collected from students were analysed using descriptive and inferential statistics. Independent sample t-test was used to find out whether ICT integration could improve students' performance in chemical bonding. Statistical Package for Social Science (SPSS) software version 16.0 for Windows 7 was used to analyse the results obtained from the tests and questionnaires.

Differences in students' scores from the pre- and post-test were used to calculate their gain scores in order to assess their performance on a face value. However, independent sample t-test was used to determine whether there was significant difference in using ICT in teaching than in using the traditional lecture method, to ascertain the veracity of the outcome from gain or changed scores. The traditional lecture method was the conventional teaching approach of teachers in the Keta Senior High Technical School. It was therefore assumed that the pre-test score of the students was based on the traditional teaching approach. The use of ICT in the teaching of chemical bonding was assumed as an innovative teaching approach.

The responses from the students' close-ended questionnaire items were converted into percentages while the answers to the open-ended questions were put into themes to know their opinions about the use of ICT in the learning of chemical bonding. The results are presented in Tables and Figures to enhance discussion of findings.

IV. RESULTS AND DISCUSSION

Table 1 shows the pre- and post-tests results obtained by students.

Table 1: Students' pre- and post-test scores

Student No.	Pre-test sco	Post-test sco	Changed scores	Student No.	Pre-test sco	Post-test sco	Changed scores

	res	res			res	res	
1	8	12	*4*	16	7	14	*7*
2	14	18	*4*	17	12	16	*4*
3	11	15	*4*	18	10	15	*5*
4	9	14	*5*	19	13	19	*6*
5	12	18	*6*	20	10	14	*4*
6	15	19	*4*	21	9	13	*4*
7	10	10	*0*	22	12	16	*4*
8	7	17	*10*	23	10	18	*8*
9	9	19	*10*	24	16	15	*-1*
10	11	17	*6*	25	8	20	*12*
11	6	13	*7*	26	12	18	*6*
12	10	12	*2*	27	11	15	*4*
13	9	18	*9*	28	10	14	*4*
14	9	15	*6*	29	6	13	*7*
15	12	14	*2*	30	7	16	*9*

From Table 1, the post-test scores of students were higher than their pre-test scores. There were changed score values from -1 to 12, when the pre- and post-test scores of each student were compared. Only one student showed a deviation by scoring one mark less in the post-test as compared to the pre-test (serial number 24). To ascertain whether the gains were significant and if ICT contributed to the improvement of students' performance in the teaching and learning of chemical bonds, paired-sample t-test was used. The outcome is shown in Table 2.

Table 2: Paired sample t-test on students' pre- and post-test scores

	Pre-test scores	*Post-test scores*
Mean	10.1667	15.5667
Observations	30	30
df	29	
P(T<=t) one-tail	1.86E-11	

Paired-sample t-test was used to determine if there was a significant difference in performance of students with the integration of ICT. From Table 2, t-test analysis showed a p-value of 1.86×10^{-11}, which is less than 0.05, meaning that there is a significant difference between using software to learn and not. This further means that the use of the Chemxb software in the teaching and learning of chemical bonding had a positive impact on the students and there was therefore a significant difference between the use of innovative ICT and the traditional method of teaching and learning about chemical bonds.

The impressions of students and teachers about the integration of ICT in the teaching and learning of chemical bonding was analysed using data gathered from the questionnaires. This is presented as Table 3.

Table 3: Students' perceptions on integrating ICT to teach and learn (N=30)

No.	Perception	Positive responses	Negative responses
1.	I have engaged in chemistry lessons that use ICT before this	3	27
2.	ICT was useful in teaching and learning chemical bonding to enhance understanding	23	7
3.	Teacher was helpful in getting started with computer lessons	21	9
4.	The use of ICT in the lesson was like any ordinary lesson	11	19
5.	I have a phone **but** cannot use Microsoft office to type, make power point and do other applications on computer	20	10
6.	I have a phone and can do many useful things like excel, power point and type notes	12	18
7.	ICT must be employed in teaching other topics	25	5
8.	Animations and colourful images contributed to my understanding of	22	8

	chemical bonding		
9.	The ICT environment is new, safe, fun, and made me want to learn more	26	4
10.	Integrated ICT illustrates difficult concepts and promotes learning	27	3

Table 3 shows the responses of students and their opinions about their usage of computers and the integration of ICT in teaching chemical bonds. From items numbered 2, 3, 7, 8 and 9, only a small proportion of the sample had negative perceptions about the use of ICT in the teaching and learning process. They appeared not to be enthused about the innovation, probably because they did not own phones or had no personal computers for use and felt awkward through the ICT lesson. Majority of the sample were enthused about its integration.

Other items sought to find out if the students were conversant with the use of mobile phones, basic Microsoft office suite software such as Microsoft word, Microsoft excel and Microsoft PowerPoint, and if their fore knowledge influenced their engagement with the new software. The belief of the researchers was that users of software must have basic knowledge in ICT. The distribution of students who were familiar with computer usage is presented in Table 4.

Table 4: Frequency distribution of computer usage among students

Computer usage	Number of students	Percentage
Excellent	12	40.0
Good	11	36.7
Limited	7	23.3
Total	30	100.0

Table 4 shows that the number of students who used electronic devices was 23, out of which 12 representing 40% of the sample, were very conversant with the use of phones and computer applications. Those who were good in the usage of the phone only were 11, representing 36.7% of the students. Seven students were not conversant with the use of computers but had used the phone a few times; this represented 23.3% of the students. Figure 6 shows the percentages of computer usage of students.

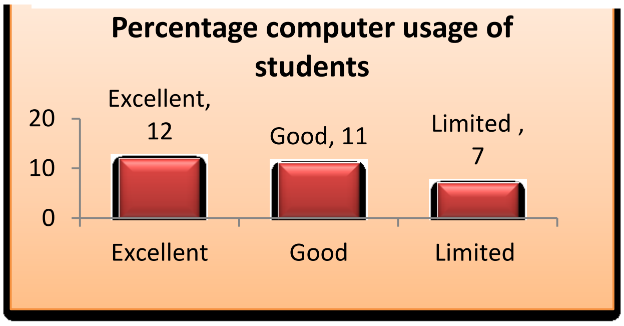

Figure 6: Percentage computer usage of students

From Figure 6, it is evident that only a small proportion of the sample were not very conversant with the use of modern technology or own any.

From the teachers' questionnaire, almost all of them attested to the usefulness of integrating ICT into their everyday lessons as it exciting, full of fun and had an inherent factor that encouraged students to investigate, explore, and work hard. They also saw it as an innovative instructional tool. They added that it promoted the teaching of difficult concepts as it illustrated them graphically and in interesting colourful ways. They were particularly excited about the colourful and yet simple illustrations of microscopic, macroscopic and symbolic processes of chemical bonding.

The key findings were:

- Majority of students were already conversant with the use of modern electronic technology and have used the computer for certain applications such as word applications software such as Microsoft word, Microsoft Excel and Microsoft Power point.
- About 7 students were not conversant with its use and did not think that it must be integrated in chemistry lessons or specifically be used to teach chemical bonding.
- There was a significant difference between the marks obtained by the students during the pre-test and the post-test.

- Majority of students perceived that ICT should be integrated into chemistry especially chemical bonding.
- Both teachers and students were excited about animations and simulations of microscopic, macroscopic and symbolic processes of chemical phenomena.
- They found the use of ICT fascinating, satisfying, innovative, more educative and fun
- Teachers found the integrated ICT to be a motivating and engaging tool which facilitated learning in a safe environment
- Teachers were of the view that it could help them to illustrate and alleviate students' misconceptions

V. DISCUSSIONS

The major intention and outcome of this study has been to introduce a promising way to motivate the teaching and understanding of chemical bonds in secondary schools and to find out its feasibility. Obtained results indicate students' experiences with the integrated ICT in the traditional lessons were mostly positive. Negative performance and comments were rare. Results also showed that there was a significant difference in the use of ICT in teaching a topic such as chemical bonding. This result correlates with that of Aksela and Karjalainen (2008) and Aksela and Lundell (2008), who studied the use of molecular modelling (using ICT) and chemistry teaching in general in Finland and found that different kinds of ICT visualisation effects promote the teaching and learning of difficult chemistry concepts. The results also agreed with a research review by Kozma (2005) who found that the use of ICT will not only make students have higher scores in subjects but teachers would learn new skills and these would result into increased innovativeness in schools. It was observed in this current study that the ICT integrated lessons aroused students' interest and enhanced their research skills.

Analysis of the perception of students towards the integration of ICT into chemistry showed that 76.7% of the students agreed that ICT should be integrated into Chemistry while 23.3% did not agree. This is in line with findings from studies conducted by Aksela and Lundell [13], Tasker and Dalton [21] and Kozma and Russell [12], who found that chemistry students perceive that the combination of practical work through different kind of ICT visualisation techniques promote the teaching and learning of difficult chemical concepts. The integration of ICT also aroused interest and the development of research skills [11].

Students' interest became heightened and this made them to try to answer all the questions and move to the next page to see what was in store. This enabled learning in an exciting and innovative way. As Pernaa and Aksela [4] report, the ICT environment promotes the learning of concepts and chemical phenomena. In this current study it encouraged the students to study further and allowed for critical thinking because the questions were open ended and not easy to make guesses. Concepts had to be understood thoroughly before moving on to subsequent exercises. A teachers' attention were drawn if a student completed a phase of their exercise or when they encountered difficulties.

The students said that it was fun, interesting, satisfying, innovative, and exciting. Yet, it promoted the illustration of concepts very well and enabled them to understand chemical phenomena of bonding better. Other comments are that it was enjoyable, collaborative, interactive, and enabled communication. Other responses were that learning with ICT was colourful, and moved gradually from simple to difficult assignments. However, they were not bothered about the complexity because they always had acquired the knowledge that they needed in previous exercises for the 'said' complex exercises. They also added that the response rate or feedback was very fast and encouraging. Majority of the students were of the view that ICT should be incorporated in the teaching and learning of chemistry particularly chemical bonding. Their good performance on the post-test was considered as a good indicator of the effectiveness of the integration. Their opinions in the analysed questionnaire also proved positive. Only a few students were not conversant with the use of modern electronic technology. An informal observation of their performance through the study showed that they were slow to catch up with their colleagues who were already conversant with its use. This might have contributed to their dislike of the new pedagogy and tool and could have made adverse comments on its introduction. This reaction is normal. Teachers would have to ensure that majority of their students are on a same footing when a new technology or mode of instruction is to be introduced in their class. This would ensure that ideally everyone catches on well. It was realised that the use of ICT in the teaching and learning of chemical bonding resulted in the high student performance [11]. This goes to indicate that there is the need to incorporate the use of ICT (or various software applications and other tools such as projectors) in the teaching and learning of chemistry in order to create illustrative images and possibly sounds which will leave a more lasting impression of mental models of chemical bonds and other phenomena on students and there by enhance cognitive retention. Access to technology, a supportive school culture, and adequate time for teachers and students to explore its educational use are essential for successful technology integration. Most students knew the social value of ICT and were able to transfer it successfully to enhance their conceptions about chemical bonding. Students perceived that the use of ICT should be an integral part in the teaching of Chemistry (chemical bonding) to improve students' performance.

VI. CONCLUSION

The study focused on integrating ICT in chemistry to support student-centred learning. The ICT exercises exposed students to some of their own alternative conceptions about chemical bonding and were able to develop process and deductive learning skills, among others, as they were encouraged by the ICT sequenced interphase to work harder. They felt motivated by its sequential illustrative presentation, exploratory environment, rapid constructive feedback received in real time and the gain in knowledge about research. Altogether, the students showed gain in knowledge through their post-test performance at the end of the intervention period. Students demonstrated abilities to visualise abstract concepts like models of atoms, molecules and bonds through animation and simulation. Their investigative skills were improved. Participating teachers were equally enthused with the study and admitted that it could enable them to teach difficult chemical phenomena so as to enable students enhance their own conceptions. A lesson learned from the study was that exposing teachers to new ideas, resources and opportunities broaden their awareness of possible changes in pedagogy and student learning. Integrating ICT therefore has the potential to change the way chemistry it taught and learned.

VII. IMPLICATIONS

The study has implications for science teachers in the design of web-based interactive activities for their students, as they facilitate the formation of scientific mental models among students. It could also help less confident teachers to self-teach themselves and be in a better position to teach chemical concepts correctly to their students.

VIII. RECOMMENDATIONS

The following recommendations were made:

- The chemistry laboratories of senior high schools in Ghana must be provided with ICT tools like projectors, laptops computers, screens and chemistry related software to enhance and make teaching and learning more interactive and more fun to students.
- The Curriculum Research Development Division (CRDD) of the Ghana Education Service in collaboration with the Ministry of Education should review the Chemistry curriculum and revise the existing Chemistry syllabus to state explicitly how ICT tools should be used in the teaching and learning concepts.
- Teachers must be trained in the use of ICT tools so that learners/students could tap into the knowledge and skills about ICT tools from their teachers.

IX. REFERENCES

[1]. D. Gabel, "Improving teaching and learning through chemistry education research: A look to the future," Journal of Chemical Education, vol. 76, no. 4, pp. 548-554, 1999.

[2]. N. Yildrim, S. Kurt and A. Ayas, "The effect of worksheets on students' achievement in chemical equilibrium," Turkish Science Education, vol. 8, no. 3, pp. 44-58, 2011.

[3]. Z. Zakaria, L. Latip and S. Tantayanon, "Organic chemistry practices for undergraduates, using a small lab kit," Procedia-Social and Behavioural Sciences, vol. 59, no. 1, pp. 508-514, 2012.

[4]. J. Pernaa and M. Aksela, "Problems of education in the 21st century," Chemistry Teachers' and Students' Perceptions of Practical Work Through Different ICT Learning Environments, vol. 16, pp. 80-89, 2009.

[5]. F. Mikre, "The Roles of Information Communication Technologies in Education," Review Article with

Emphasis to the Computer and, vol. 6, no. 2, pp. 1-16, 2011.
[6]. D. Stevenson, "Information and communications technology in UK schools:," Information and communications an independent inquiry March 1997. Independent ICT in Schools Commission., 1997.
[7]. E. I. Mwengah, "Pedagogical Issues and E-learning Cases," Integrating ICTs into Teaching and Learning Process, 2009.
[8]. L. M. Triona and D. Klahr, "Point and click or grab and heft: Comparing the influence of physical and virtual instructional materials on elementary school students' ability to design experiments," Cognition and Instruction, vol. 21, no. 2, pp. 149-173, 2003.
[9]. N. Pachler, "Using the Internet as a teaching and learning tool," Learning to teach using ICT in the secondary school, pp. 51-70, 1999.
[10]. V. Tinio, "ICT in Education:UN development programme," 2002. [Online]. Available: https://ju.edu.et/ejes/sites/default/files/The%20role%20of%20ICT%20in%Education.pdf.
[11]. A. Hofstein and V. N. Lunetta, "The laboratory in science education: Foundations for the twenty-first century," Science Education, vol. 88, no. 1, pp. 28-54, 2004.
[12]. R. Kozma and J. Russel, "Students becoming chemists: Developing representational competence," in Visualisation in science, Dordrecht, Springer, 2005, pp. 121-146.
[13]. M. Aksela and J. Lundell, "Computer-based molecular modelling: Finnish school teachers' experiences and views," Chemistry Education Research and Practice, vol. 9, pp. 301-308, 2008.
[14]. I. Eilks, Teaching chemistry- A study book, London: Sense Publishers, 2013.
[15]. M. Volman, "Variety of roles for a new type of teacher: Educational technology and the teacher profession," Teacher and Teacher Education, vol. 21, pp. 32-44, 2005.
[16]. S. A. Jegede, "Curriculum studies," International Journal of Education & Literacy Studies, vol. 1, no. 1, pp. 46-58, 2013.
[17]. D. L. Lowther, F. A. Inan, J. D. Strahl and S. M. Ross, "Does technology integration work when key barriers are removed?," Educational Media International, vol. 45, pp. 195-213, 2008.
[18]. C. Bhukuhani, L. Kusure, V. Munodawafa, A. Sana and I. Gwizangwe, "Preservice teachers' use of improvised and virtual laboratory experimentation in science teaching," International Journal of Education and Development using Information Technology, vol. 6, no. 4, pp. 27-38, 2010.
[19]. S. J. Fu, "ICT in Education: A critical review and its implications," International Journal of Education and Development using Information and Communication Technology, vol. 9, no. 1, pp. 112-125, 2013.
[20]. J. W. Creswell, "Educational Research:," Planning, Conducting and Evaluating Quantitative and Qualitative Research, (4th edn)., 2012.
[21]. R. Tasker and R. Dalton, "Research into practice: Visualisation of the molecular world using animations," Chemistry Education Research and Practice, vol. 7, no. 2, pp. 141-159, 2006.
[22]. A. C. Onley and S. Barnes, Collecting and analyzing evaluation data. Planning and Evaluating Health Information Outreach Projects, Booklet 3. Outreach Evaluation Resource Center. National Network of Libraries of Medicine, National Library of Medicine, 2008.
[23]. M. Saunders, P. Lewis and A. Thornhill, Research Methods for Business Students (4th ed). England: Pearson Education Limited., 2007.
[24]. J. R. Fraenkel and N. Wallen, How to design and evaluate research in education, (5th ed.). New York: McGraw-Hill Publishing Co., 2003.
[25]. M. Joppe, "The Research Process. Retrieved on October 25, 2010, from http://www.ryerson.ca/~mjoppe/rp.htm," 2000.
[26]. Z. C. Zacharia, "Comparing and combining real and virtual experimentation: An effort to enhance students' conceptual understanding of electric circuits," Journal of Computer Assisted Learning, vol. 23, no. 2, pp. 120-132, 2007.

X. APPENDICES

APPENDIX A: PRE-TEST QUESTIONS

Time: 25 minutes **Serial No. …………………..**

Instruction: Tick the most appropriate answers in the circles provided

1. Sulphate (SO_4^{2-}) is a ____________.
   - a. monatomic anion
   - b. polyatomic cation
   - c. monatomic cation
   - d. polyatomic anion

2. An ionic compound that will conduct an electric current when it forms an aqueous solution is a/an _________.
   - a. Non electrolyte
   - b. crystal lattice
   - c. molecular compound
   - d. electrolyte

3. Which metal is the lightest?
   - a. magnesium
   - b. boron
   - c. aluminium
   - d. lithium

4. Why is the calcium ion (Ca^{2+}) more stable than the calcium atom (Ca)?
   - a. The two electrons more than the noble gas configuration is more stable.
   - b. Twenty electrons are more stable than eighteen electrons.
   - c. The noble gas configuration is more stable.
   - d. Eighteen electrons are less stable than twenty electrons.

5. Which of the following elements is most likely to form a negatively-charged ion?
   - a. Br
   - b. I
   - c. F
   - d. Cl

6. An element or an inorganic compound that is found in nature as solid crystals is a
   - a. salt
   - b. mineral
   - c. trace element
   - d. solution

7. Which of the following was the first trace element shown to be essential to human nutrition?
   - a. aluminium
   - b. iron
   - c. nickel
   - d. zinc

8. What characteristic do atoms in the same group of elements share?

Period 1	hydrogen	$1s^1$	$1s^1$
Period 2	lithium	$1s^2 2s^1$	$[He]2s^1$
Period 3	sodium	$1s^2 2s^2 2p^6 3s^1$	$[Ne]3s^1$
Period 4	potassium	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$	$[Ar]4s^1$

   - a. They have the same number of electron orbital.
   - b. They have the same number of valence electrons.
   - c. They have the same atomic mass.
   - d. They have similar physical properties.

9. Which ion has the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^6$?
   - a. Br^-
   - b. Cl^-
   - c. F^-
   - d. H^+

10. Why is the sodium ion (Na^+) more stable than the sodium atom (Na)?
   - a. The one electron more than the noble gas configuration is more stable.

b. Eleven electrons are less stable than ten electrons.

c. The noble gas configuration is more stable.

d. Eleven electrons are more stable than ten electrons.

11. What is the charge on the simple monatomic ion that sulphur forms?

a. 1^-

b. 2^-

c. 1^+

d. 2^+

12. How are ionic bonds formed?

a. gain of electrons by atoms

b. loss of electrons by atoms

c. electrostatic forces between ions

d. sharing of electrons between atoms

13. What hybridization is present in an octahedral molecular geometry?

a. sp^{3d}

b. sp^3

c. sp^2

d. sp^3d^2

14. The ionic compound, sodium chloride, is formed from atoms of the elements sodium and chlorine. What happens to the size of each atom when it forms an ion?

a. Sodium increases in size and chlorine decreases in size.

b. Sodium increases in size and chlorine increases in size.

c. Sodium decreases in size and chlorine increases in size.

d. Sodium decreases in size and chlorine decreases in size.

15. What is the formula for ammonium bromide?

a. NH_4Br

b. $(NH_4)_2Br$

c. NH_4Br_2

d. NH_3Br

16. Which of the following is a mixture of elements that has metallic p

a. a suspension

b. a gas

c. an alloy

d. a pure metal

17. When two or more atoms join together by sharing their outermost electrons, ________.

a. a solution is formed

b. a mixture is formed

c. an ionic compound is formed

d. a molecular compound is formed

18. In the compound H_2SO_4, which element will be the central atom in the molecular structure?

a. both S and O

b. H

c. O

d. S

19. An atom with the electron configuration $1s^22s^22p^6\ 3s^23p^64s^2$ is most likely.........................

a. a metal that forms a positive ion

b. a metal that forms a negative ion

c. a non metal that forms a positive ion

d. a non metal that forms a negative ion

20. When atoms of sodium (Na) and chlorine (Cl) combine to form NaCl, the Na^+ is smaller than the Na atom, while the Cl^- ion is larger than the Cl atom. Why?

a. The Na and Cl atoms both lost electrons.

b. The Na and Cl atoms both gained electrons.

c. The Na atom lost an electron, while the Cl atom gained an electron

d. The Na atom gained an electron, while the Cl atom lost an electron.

APPENDIX B: PRE-TEST MARKING SCHEME

Number	Answer	Number	Answer	Number	Answer	Number	Answer
1	D	6	B	11	B	16	C
2	D	7	B	12	C	17	D
3	C	8	B	13	D	18	D
4	C	9	B	14	C	19	A
5	C	10	C	15	A	20	C

APPENDIX C: STUDENTS QUESTIONNAIRE

Instructions

Please tick [√] in the appropriate space provided below and supply answers where required. There are no right or wrong answers. Your personal opinion is what is required. Do not discuss your views with anyone else. Your answers will be treated confidentially.

Familiarity with computers

1. .Do you have a computer laboratory in your school? YES NO
2. Do you have a computer at home? YES NO
3. Have you been taught chemistry with specialised software? YES NO
4. Have you participated in any class/ excursion/ programme related to the integration of ICT in the learning of chemistry? YES NO

Do you use computers to do the following activities? Please tick.

No.	I use computers	Yes	No
5.	To download work pages on topics I have been taught		
6.	To play games		
7.	To make presentations		
8.	To watch videos		

9. Did your teacher explain how you would work through the web-based exercises and notes?
11. Do you think ICT should be used to study chemistry? YES NO
12. List 2 things that you liked about the ICT lessons and explain why.
……

13. List two things that you disliked about the ICT lessons and explain why.

……
14. How were the lessons and activities different from your regular chemistry lessons?
……..
15. Any other comments/suggestions?
……..

APPENDIX D: TEACHERS' ONLINE QUESTIONNAIRE

1. Please describe your general impressions about the integrated ICT lessons based on:
   a. Relevance
   b. Content
   c. Structure
   d. Illustrations
   e. Impact
2. What did you like and dislike about the integration of ICT?

Liked most	Reason
Disliked	Reason

3. Were the software materials appropriate for the intention for which it was used?
4. Did the illustrations enable you to understand the concept of bonding better?
5. What suggestions would you make for improvement?
6. What do you think about time spent on the ICT lessons?
7. What do you think about inclusion of ICT lessons in normal chemistry class?
8. Do you think students liked the approach? Why?
9. Any other comments?

Submit your responses to maameruby@yahoo.com