ENHANCING STUDENTS' PERFORMANCE AND ATTITUDE IN CHEMICAL EQUATION BALANCING: THE USE OF COMPUTER-BASED INSTRUCTIONAL GAME

Assafuah-Drokow Anthony
Tutor
Science Education Department
Foso College of Education, Assin Foso, C/R, Ghana

Abstract: This study investigated the effect of computer-based Instructional game (CBIG) in teaching chemistry at the senior high school (SHS). The purpose of the study was to determine how the use of computer game as an instructional strategy would enhance the performance and attitudes of SHS students towards balancing of chemical equations (BoCEs). It also examined the effect of gender on these outcomes. The study adopted developmental research approach employing the case study method. The research sample consisted of 40 (25 males and 15 females) second year chemistry students. Test, questionnaire and interview were the instruments used for the study. The CBIG was implemented and evaluated in one science class of a selected SHS in the Central Region of Ghana for four weeks. The findings showed that students' performance in the BoCEs improved significantly after the intervention period. The findings also showed that the students' attitudes towards BoCEs improved significantly after the study. However, the study showed no significant differences in the performance and the attitudes of the male and the female students towards the BoCEs using the CBIG intervention. The findings also showed that the students were of the view that the CBIG intervention stimulated their interests and minimised their negative perceptions associated with the BoCEs concept.

IndexTerms **- Computer-based instructional game, performance, attitudes, perceptions, interventions..**

I. INTRODUCTION

Researches in science education show that many senior high school (SHS) students have serious difficulties in acquisition of basic concepts in science particularly in chemistry (Anamuah-Mensah & Apafo, 1986; Cater & Brickhouse, 1989; Eminah & Assafuah-Drokow, 2010). According to Cater and Brickhouse (1989) students at all educational levels perceived chemistry as a difficult subject. The perceived difficulty associated with chemistry has had adverse effect on the performance and the attitudes of the students towards the subject. Part of this difficulty could be traced to factors inherent in the content; primarily its multi-level knowledge base (Johnstone, 1993; Ogunniyi, 2002). The causes of the consistently decline performance and poor attitudes of the students towards chemistry in schools have been the focus of attention of some researchers for some time now (Bajah & Godman, 1984; Johnstone, 1991; Koosimile, 2005). In spite of the efforts by these researchers, students' performance and attitudes towards chemistry have not improved significantly over the years. These researchers have identified a number of factors militating against students' performance and attitude towards chemistry. The commonest factor identified by these researchers is the inappropriate and uninspiring traditional teaching methods employed by science teachers (Johnstone, 1993; Nwagbo, 2001; Ogunniyi,2002). These researchers have expressed the view that science teachers have always relied on uninspiring teaching strategies that are teacher-centered where students are just passive listeners.

Within Sub-Saharan Africa including Ghana, researchers (e.g. Ogunniyi, 2002; Koosimile, 2005) have noted the prevalence of "chalk and talk teaching styles, regurgitation and recall of factual knowledge, dearth of practical work, pervasiveness of chorus answers raised by students and other factors would continue to hamper students' performance and attitude in science if proper measures are not taken. In this line of reason, the question that comes into one's mind is:- What changes in science instructions bring about improved performance and desirable changes in the students negative attitudes towards science particularly chemistry as a school subject?.

Studies (Bajah, 1983; Brown, 1987; Thomas & Emereole, 2002; Koosimile, 2005) have shown that an instructional strategy is very crucial to the understanding of scientific concepts as well as the development of positive attitude in students. According to Brown (1987) effective instruction requires the teacher to step outside the realm of personal experience unto the world of the learners. It is the learners who must be engaged actively for learning to occur. Kozma (1991) and Thomas and Emereole (2002) also pointed out that science educators can improve the performance and sustain positive attitude of the students in science by taking the advantage of the effective instructional strategies such as the use of multi-media approaches including computer-based instructional game (CBIG).

Balancing of chemical equations is a major topic in both elective chemistry and integrated science at the Ghanaian senior high schools for decades. Many concepts in this topic are necessary to understand other areas of chemistry. These include oxidation-

reduction reactions, electrolysis, chemical equilibrium, acid-base titrations and electrochemistry. A mastery of these areas requires the mastery of the basic concept of balancing chemical equations.

Balancing of chemical equations is considered to be one of the most difficult topics in chemistry (Yarroch, 1985; Ebenezer & Erickson, 1996; Dun, 2005). For instance, a typical real-life example of a grade eleven (11) senior high school chemistry student, Andrea, described by Ebenezer and Erickson (1996) as a capable and hardworking student who, at one stage, felt confused in learning chemical (ionic) equations. The detailed notes which contained the explanations for chemical equations provided by her teacher and the demonstration on the conductivity of various salts to ionic equations conducted by her teacher, did not seem to help much in her understanding of balancing the chemical equations. The following excerpt about Andrea does reflect the predicament of many chemistry students particularly Ghanaian students:

> *"I'm trying to make sense of all this balancing stuff (i.e., the symbols for the elements, ions, and their respective states), but visually and mentally it is making me dizzy. I just don't understand!" (Ebenezer & Erickson, 1996, p. 182).*

It is in the light of this, that this study was carried out to help improve the performance and attitude of students towards balancing of chemical equations concept using CBIG.

1.1 Statement of the Problem

Studies conducted by (Anamuah-Mensah & Apafo, 1986; Apafo, 1992; Assafuah, Ameyaw & Eminah, 2010) on balancing chemical equations revealed that majority of Ghanaian senior high school students perceived this topic to be difficult and thus experienced learning difficulties in this topic.

The difficulty in understanding this topic has been ascribed to its abstract nature (Yarroch, 1985; Laugier & Dumon, 2000; Dun, 2005). This has been compounded by the fact that the teaching of chemical equation balancing has been characterised by the "traditional trial and error" instruction with little or no activities by the students. This made it difficult for the students to understand and thereby develop negative attitudes towards this concept.

Studies (Kulik & Kulik, 1991; Dun, 2005; Keengwe & Anyawu, 2007) have shown that the use of computer-based instructional game (CBIG) can have positive influence on students' conceptual understanding as well as their attitudes towards concepts in science. In one of these studies, Dun (2005) developed a chembalancer computer game to teach this concept. The results showed that students who played the game performed better and developed positive attitudes towards the concept.

It is therefore desirable to find out if a CBIG designed to teach balancing of chemical equations could generate interest among students and improved their performance in the concept under study.

1.2 Purpose of the Study

The purpose of the study was to investigate the influence of the CBIGon senior high school students' performance and attitudes towards chemical equations balancing.

1.3 Research Questions

The following five (5) investigative questions directed research activity in the study:

1. What are the differences in performance of the students before and after the CBIG intervention with regards to chemical equation balancing?
2. Will the performance of the females and males be differently affected by the CBIG intervention?
3. What are the differences in the attitudes of the students taught using the CBIG with regards to the chemical equation balancing before and after intervention?
4. What are the gender differences in the students' attitudes after exposure to the CBIG intervention with respect to chemical equations balancing?
5. How do students perceive the CBIG approach to chemical equations balancing?

II. Review of Related Literature

Positive impact on students' performance and attitude in using computer-based instruction (CBI) has been reported by several researchers (e.g. Vinsonhaler & Bass, 1972; Hulme, 1999; Dun, 2005; Keengwe & Anyawu, 2007). The earliest efforts to evaluate the influence of CBI in schools were made by Vinsonhaler and Bass (1972). In their review of ten (10) studies, Vinsonhaler and Bass found that CBI had more positive effects on students' cognitive achievements and attitude than that of the traditional instruction (TI). On his part, Hulme (1999, p.17) reported that "the appropriate use of CBI can enhance the learning process at all levels of education".

Between 1970 and 2007, researchers (e.g. Kulik & Kulik, 1991; Kozma & Clark, 1993; Dun, 2005; Kun-Yuan & Jia-Sheng, 2007) conducted several meta-analysis and narrative synthesis studies on the effectiveness of CBI programme applications in schools. They concluded that computer-based instructional games (CBIG) have positive effect on students' learning outcomes.

In meta-analysis of 254 comparative CBI studies, Kulik and Kulik (1991) found that students of varying ability levels all displayed significant positive learning gains and also developed positive attitude towards the subject matter than those who were exposed to the TI. They concluded that those students had better examination scores, better attitude towards the instruction and required substantially less instructional time than students receiving TI. Kozma and Clark (1993) reviewed research literature on

CBI and concluded that the CBI can be a powerful tool for assisting learning because they can create "dynamic, symbolic representation of non concrete, formal constructs that are frequently missing in the mental models of novices".

On their part, Kun-Yuan and Jia-Sheng (2007) reported that students who have studied in science classrooms with CBI had better or remarkable performance in science achievement. Summarising the outcome of several studies, Helgeson (1998) reported that:

> The microcomputer clearly has many possible applications in the science classroom. It is equally clear that we have just begun to tap the potential of the microcomputer in education…..in the effective domain, both student attitudes and interest seem to be positive regarding the use of microcoputers in science instruction. There are many encouraging indicators but much remains to be understood (p.2).

It is obvious that literature is full of enough evidence to suggest that CBI are important tools in the teaching and learning scientific concepts particularly in chemistry. It must therefore be explored in the teaching of chemistry to the benefit of the students at all levels of education.

III. METHODOLOGY

3.1 Research Design

The study adopted the developmental research approach employing the case study method. The developmental research approach was employed in which CBIG intervention was developed, implemented and evaluated in one of the science class of the selected school pursuing chemistry as an elective subject. The developmental research was chosen because it provided flexibility in developing an intervention stage-by-stage within the problem context (Van den Akker, 1999). The case study method was also employed because it provides a holistic and in-depth understanding of the expected behaviours (in this study, performance and attitudes) to be exhibited by the students through the use of the intervention and seeing whether they work in real classroom settings and reported on such behaviours within the classroom context. Similar studies done in Tanzania (Mafumiko & Ottevanger, 2002) and Philippines (Locaylocay, 2002) showed great promise in this research approach.

3.2 Sample and Sampling Procedure

The sample consisted of 40 second year chemistry students of an intact science class made up of 25 boys and 15 girls. This class was purposively selected due to its large size compared with other science class. The intact class was used because the intervention was incorporated into the normal school teaching periods and therefore, random selection and assignment were not possible. The second year chemistry students were chosen because the students were studying the topic under study at the time of the research.

3.3 Research Instruments

The study used a combination of quantitative and qualitative data-gathering instruments. Three (3) instruments namely test, attitude-scale questionnaire and interview were used to collect data. The test and attitude-scale questionnaire constituted the quantitative part while the interview constituted the qualitative part of the instruments. In addition, written documents such as diary notes and audiotapes were made to augment information that was obtained from the main instruments.

3.4 Data Collection Procedure

The data collection procedure with the CBIG intervention of balancing chemical equations on the students lasted for four (4) weeks. The students were taught how to balance a given chemical equation using the CBIG approach. The students were pre-tested and post-tested using pretest and posttest of comparable standards. This was done to compare the conceptual understanding of the students on the topic under study before and after intervention period. In addition, the pre-attitude and post-attitude-scale questionnaires were also administered to compare the attitude of the students towards the concept under study before and after intervention period. Four (4) students (2 boys and 2 girls) from the class were randomly selected and interviewed to find out their views and experiences about the balancing of chemical equations using the CBIG intervention.

3.5 Data Analysis Method

The study employed both quantitative and qualitative methods of data analysis. Data from the tests and the attitude-scale questionnaire were analysed quantitatively using the mean, standard deviation and the t-test computation. The t-test was used to investigate whether any significant differences existed in the mean score of the tests and attitude-scale questionnaire of the students. Data from the interview sessions were analysed qualitatively. The recorded conversations with the students were transcribed, analysed and summarised thematically after the interview session.

IV. ANALYSIS OF THE RESULTS

The analysis of the results were done to answer the 5 research questions posed by the study.

Research Question 1: What are the differences in performance of the students before and after the CBIG intervention with regards to chemical equation balancing?

To investigate possible differences in performance among the students taught chemical equation balancing with the CBIG before and after the intervention, the students' scores in the pretest and posttest were analysed using the means, standard deviations and t-tests. The analysis of the data in the pretest and posttest scores of the 40 students are presented in Table 1 below:

Table 1: Means, Standard Deviation and t-Tests of the Pretest and Posttest Scores of Students

Test Type	Sample Number	Mean Test Scores	SD	t- Value	p-Value
Pretest	40	5.98	3.66	- 0.144	0.886 [a]
Posttest	40	11.13	2.96	2.962	0.004*

a = Not Significant; p > 0.05; * = Significant; p < 0.05; SD = Standard Deviation

As the data in Table 1 shows, the mean test score of the students in the posttest was higher than their pretest score. The students had lower pretest mean score of 5.98 while the same students had higher posttest mean score of 11.13. The t-test analysis of the pretest mean score of the students shows no significant difference ($t = -0.144$; $p = 0.886$; $p > 0.05$). However, the t-test analysis of the posttest mean score of the students shows significant difference ($t = 2.962$; $p = 0.004$; $p < 0.05$). It was concluded that students performed better in the posttest than in the pretest. This indicated that students had better conceptual understanding of the concept taught after the exposure to the CBIG intervention.

Research Question 2: Will the performance of the females and males be differently affected by the CBIG intervention?

In order to find out whether the performance of the males and the females was affected by the CBIG intervention, the pretest and posttest scores of the males and the females were further analysed using the means, standard deviations and t-tests. The results have been summarised in Table 2 below:

Table 2: Mean, SD and t-Test of Pretest and Posttest Scores of Male and Female Students

Gender	Test Type	N	Mean TestScore	SD	t-Value	p-Value
Male	Pretest	25	5.5200	3.38034	-1.015	0.317 [a]
Female	Pretest	15	6.7333	4.09646		
Male	Posttest	25	10.6400	2.99833	-1.351	0.185 [a]
Female	Posttest	15	11.9333	2.81493		

a = Not significant; p > 0.05; N= Number of students; SD = Standard Deviation

Table 2 above, shows that the mean tests score of the female students was slightly higher than the male students in both the pretest and posttest. The female students had higher pretest mean score of 6.7333 and posttest mean score of 11.9333 while their male counterparts had a slightly lower pretest mean score of 5.5200 and the posttest mean score of 10.6400. However, the t-test analysis of the mean score of both the pretest and posttest shows no significant differences between the male students and the female students ($t = -1.015$; $p = 0.317$; $p > 0.05$ and $t = -1.351$; $p = 0.185$; $p > 0.05$) respectively. It was concluded that there was no significant difference between the performance of the male and female students. This implies that both male and female students were comparable in their conceptual understanding of the concept before and after the intervention. Therefore, gender did not seem to have any influence on the performance of students through the use of CBIG approach.

Research Question 3: What are the differences in the attitudes of the students taught using the CBIG with regards to the chemical equation balancing before and after intervention?

Studies (Dun, 2005; Keengwe & Anyawu, 2007) have shown that CBIG have positive influence on students' attitudes. In order to corroborate this and perhaps get more information on the differences in attitudes, the students' responses in both the pre - and post-attitude-scale questionnaires were analysed using the means, standard deviations and t-tests and are presented in Table 3 below:

Table 3: Means, Standard Deviation and t-Tests of Pre- and Post-Attitude Scores of Students

AttitudeScale	Sample Number	Mean Attitude Scores	SD	t- Value	p-Value
Pre- Attitude	40	28.2250	2.91317	-0.175	0.862 [a]
Post- Attitude	40	40.5750	3.06249	2.888	0.005*

a = Not Significant; p > 0.05. * = Significant; p < 0.05. SD = Standard Deviation

As the data in Table 3 shows, the mean attitude score of the students in the post-attitude scale was higher than the pre-attitude scale. The students had lower pre-attitude mean score of 28.2250 while the same students had higher post-attitude mean score of 40.5750. The t-test analysis of the pre-attitude mean score of the students shows no significant difference ($t = -0.175$; $p = 0.862$; $p > 0.05$). However, the t-test analysis of the post-attitude mean score of the students was found to be statistically significant ($t = 2.888$; $p = 0.005$; $p < 0.05$). It was therefore concluded that there is a significant difference in the attitude of the students after the CBIG intervention. This indicated that the students had positive attitude towards the chemical equation balancing after the CBIG intervention.

Research Question 4: What are the gender differences in the students' attitudes after exposure to the CBIG intervention with respect to chemical equations balancing?

In order to investigate possible differences in attitude between male and female students exposed to the CBIG of balancing chemical equations, the means, standard deviation and t-tests of both pre-and post- attitude scale questionnaire were analysed and are presented in Table 4 below:

Table 4: Mean, SD and t-Test of Pre-and Post-Attitude Scores of the Males and Females

Gender	AttitudeScale	N	Mean AttitudeScore	SD	t-Value	p-Value
Male	Pre- Attitude	25	27.8800	2.86240	- 0.966	0 .340 [a]
Female	Pre- Attitude	15	28.8000	3.00476		
Male	Post-Attitude	25	34.1600	3.03699	-1.094	0.281 [a]
Female	Post-Attitude	15	35.2667	3.19523		

a = Not significant; p > 0.05. N= Number of students; SD = Standard Deviation

The mean attitude score of the female students was higher than the males in both pre- and post-attitude scales. The female students had higher pre-attitude mean score of 28.8000 and post-attitude mean score of 35.2667 while their male counterparts had a slightly lower pre-attitude mean score of 27.8800 and the post-attitude mean score of 34.1600. The t-tests analysis of both pre- and post-attitude mean scores were not statistically significant (t = -0.966; p = 0 .340; p > 0.05 and t = -1.094; p =0.281; p > 0.05) respectively. It was concluded that there was no significant difference between the attitude of male and female students who were exposed to the CBIG approach. Thus, CBIG intervention seems to have no differential attitude between male and female students.

For eight (8) of the post-attitude items (1, 2, 3, 5, 6, 7, 8 & 10) the two extreme responses were merged into single categories as follows (strongly agree & agree) as agree and (strongly disagree & disagree) as disagree. This was done to see variations in the intensities of the responses of the male and female students to each of the selected items. The percentages of male and female students that agreed and disagreed to each of these eight (8) selected attitude items are shown in Table 5 below:

Table 5: Proportion of the Males and Females that Agreed and Disagreed to Attitude Items

No	Attitude Scale Items	Females		Males	
		Agree	Disagree	Agree	Disagree
1	I enjoy balancing of chemical equations.	93.3%	6.7%	88.0%	12.0%
2	I wish balancing of chemical equation is not part of the chemistry syllabus.	20.0%	80.0%	24.0%	76.0%
3	Getting correct coefficient numbers to balance chemical equation is easy	86.7%	13.3%	84.0%	16.0%
5	I want all my lessons to be like the way balancing of chemical equation was taught to me	93.3%	6.7%	92.0%	8.0%
6	I did not know that balancing of chemical equations can be fun and interesting.	73.3%	26.7%	80.0%	20.0%
7	I hate balancing of chemical equations.	6.7%	93.3%	12.0%	88.0%
8	I can boldly and confidently answer any question when it comes to balancing of chemical equations.	86.7%	3.3%	84.0%	16.0%
10	Balancing of chemical equation is the most difficult task I have encountered in school.	13.3%	86.7%	16.0%	84.0%

From Table 5, it was found that in all cases, a higher proportion of the female students agreed to all the four (4) selected positive attitude items (i.e. Items 1, 3, 5 & 8) than their male counterparts. For example, whereas 93.3% of the female students agreed that they enjoyed balancing of chemical equations; only 88.0% of their male counterparts gave identical response. Similarly, a slightly higher proportion of the female students disagreed with all the four (4) selected negative attitude items (i.e. Items 2, 6, 7 &10) compared to their male counterparts. For example, whereas 93.3% of the female students disagreed that they hate balancing of chemical equation, 88.0% of their male counterparts gave identical response for the same negative attitude item 7.

Research Question 5: How do students perceive the CBIG approach to chemical equations balancing?

To find out the views and experiences of the students, the responses of the four (4) students (2 boys and 2 girls) that were randomly selected and interviewed were analysed. The results from the interviews indicated that students' opinions and experiences with the CBIG approach were very positive. About 100% of the interviewees were of the conviction that, the approach was very good because their performance as well as their attitudes had improved tremendously. Two (2) students' comments emphasized these benefits and their responses are captured in the words below.

> The CBIG has helped improved our studies. I have improved my performance in balancing of chemical equations very well and I have interest in it than at first. My negative attitude towards this topic has changed tremendously. I now like this topic (Dan).

> The CBIG has helped me a lot in learning this difficult concept very well. I enjoyed playing the computer game and "seeing" the results on the computer screen. In fact, it makes the invisible visible and concrete. I just click the mouse and could

see chemical equations displaying on the screen I wish learning of chemistry continues this way until we write our final examination (Tina).

All the students were pleased with the CBIG intervention and they were of the opinion that teachers of other disciplines should use CBIG intervention in their teaching.

V. DISCUSSION OF THE RESULTS

The results of this study showed that the use of the CBIG approach brought about a significant improvement in the performance of the students. The significant improvement in the performance of the students after the treatment may have resulted from the exposure of the students to the CBIG intervention. The CBIG served as teaching aids which helped to organise the students' conceptual structure in a particular way to aid in better conceptual understanding of the concept taught.

It was also found that the female students had a slightly better performance towards balancing of chemical equations than their male counterparts in both pretest and posttest mean scores. The difference in performance was not statistically significant, although it seems to indicate that the female students would perform better towards the concept under study using CBIG than the males.

The results of the study also showed that the students had a higher positive attitude towards chemical equation balancing after the exposure to the CBIG intervention than prior to the start of the intervention period. The higher positive attitude score of the students after the treatment might be attributed to the enjoyment and interest derived by the students from CBIG intervention on a prolonged basis.

The study also revealed that the female students had a slightly higher positive attitude towards chemical equation balancing than their male counterparts in both pre-and post-attitude mean scores. Although the difference was not statistically significant, it seems to indicate that the female students would be more favourably disposed towards balancing of chemical equations using CBIG intervention than their male counterparts. As the review of the data showed (see Table 5), a greater proportion of females than males agreed with attitude items that depicted positive tendencies with respect to the concept under study using the CBIG intervention.

Interviews with the students revealed that all the four (4) students seemed content with the CBIG approach in which they used to learn balancing of chemical equations. Reflections from students' responses from the interviews revealed their enthusiasm in the use of CBIG intervention for the teaching and learning of the topic under study.

The findings from this study lend credence to the findings of some pioneer researchers (e.g. Vinsonhaler & Bass, 1972; Kulik & Kulik, 1991; Kun-Yuan & Jia-Sheng, 2007) in their investigation that students exposed to CBIG interventions performed better or had significant positive learning gains and also develop positive attitude towards a concept taught than the traditional instruction.

VI. CONCLUSION

This study has shown that students exposed to the CBIG learning approach performed better and retained significantly the scientific concept taught them. The study therefore yields considerable argument in favour of using CBIG approach in teaching science. It also revealed that students exposed to the CBIG intervention developed positive attitudes towards the topic under study. The study further revealed that all the students were pleased with the CBIG intervention and they were of the opinion that teachers of other disciplines should use CBIG intervention in their teaching.

One significant finding was that, the use of the CBIG helped to develop students' interest and generally increased their attitude positively towards the concept taught. Although the result of the study indicated no statistical significant difference existed between the performance and the attitude of male and female students exposed to the CBIG intervention.

In conclusion, the results of the present study are in consistent with the findings of (Kozma & Clark, 1993; Dun, 2005) showed that students exposed to CBIG intervention had better performance and showed positive attitude towards science than those exposed to the traditional instruction.

VII. RECOMMENDATIONS

This study should be replicated using a much larger sample. This would provide a basis for more generalisation of conclusions to be arrived at about the use of CBIG intervention in teaching the topic under study. It is also recommended that more developmental researches should be undertaken in the area of educational technology where softwares that can be used to teach abstract scientific concept are designed and developed so to improve the development of science in the country.

VIII. ACKNOWLEDGMENTS

The author acknowledged the authors of the books and materials consulted for the study and all who contributed in diverse ways to ensure the successful completion of this work especially Professor J. K. Eminah at the Science Education Department, UEW, and Dr. Nana K. Asiedu, principal of Foso College of Education.

REFERENCES

[1] Anamuah-Mensah, J., & Apafo, N. T. (1986). Students' perceived difficulties with ordinary level chemistry topic. *Chemistry and Industry Proceedings*, 38-39.

[2] Apafo, N.T. (1992). *A Comparative Study of the Traditional Approach and the Simulation Games' Approach to Balancing of Simple Chemical Equations*. An M.PHIL Dissertation: University of Cape Coast.

[3] Assafuah, T., Ameyaw, Y., & Eminah, J. K. (2010). Students' conceptions on balancing of chemical equations. *International Journal of Chemistry and Applications* (IJCA): 2 (1), 179 - 188.

[4] Bajah, T., (1983). *Teaching integrated science creatively*. Reader in science education. University of Ibadan, Ibadan, Nigeria.

[5] Bajah, S. T., & Godman, A. (1984). *Chemistry: a new chemistry approach*. Essex: Longman.

[6] Brown, B. L. (1997). New Learning Strategies for Generation. *Eric Digest* No. 184.

[7] Cater C.S., & Brickhouse, N. W. (1989). What Makes Chemistry Difficult? Alternate Perceptions. *Journal of Chemical Education, 66* (5), 223-225.

[**8**] Dun, S. (2005). A Chembalancer Game. Retrieved on April 7, 2014, from http://funbasedlearning.com/chemistry/default.htm.

[9] Ebenezer, J. V., & Erickson, G. L. (1996). Chemistry students' conceptions of solubility: A phenomenography. *Journal of Science Education, 80* (2), 181-201.

[10] Eminah, J. K., & Assafuah-Drokow, A. (2010). Electrochemistry problem-solving approaches and difficulties of senior high school students: *Journal of Education and Leadership Development, 2* (1), 50 – 65.

[11] Helgeson, S. L. (1998). Microcomputers in the Science classroom. ERIC/SMEAC Science Education. Retrieved on July 22, 2010 from http:// www. Ed. Gov/ databases/ERIC- Digest.

[12] Hulme, M. (1999). Intercultural e-mail exchange educational problems. *Computer Education*, 14 -18.

[13] Johnstone, A. H. (1993). The development of chemistry teaching: a change response to changing demand. *Journal of Chemical Education, 70* (5), 701- 705.

[14] Johnstone, A. H. (1991). Why Science is Difficult to Learn? Things are Seldom What They Seem" *Journal of Computer Assisted Learning, 2* (2), 175-181.

[15] Keengwe. J., & Anyawu, O. (2007). Computer technology-influenced learning enhancement. *Journal of Science Education and Technology, 16* (5), 387-393.

[16]Koosimile, A.T. (2005). Induction of pupils into secondary school science in Botswana. *African Journal of Research in Mathematics, Science and Technology. Education 9* (1) 39 - 48.

[17] Kozma, R. B. (1991). Learning With Media. *Review of Educational Research*, 61,179-211.

[18] Kozma, R. B., & Clark, R.E. (1993). *Media or Method?*. A debate at the International Convention of the European Association for research on learning and instruction. Aixen Provence, France.

[19] Kulik, J. A., & Kulik, C.C. (1991). Effectiveness of Computer-Based Instruction: An updated analysis. *Computers in Human Behaviour, 7*, 75 – 94.

[20]Kun-Yuan Y., & Jia-Sheng H. (2007). The impact of internet virtual physics laboratory instruction on the achievement in physics, science process skills and computer attitudes of 10th Grade students. *Journal of Science Education and Technology, 16*, 457- 461.

[21]Laugier, A., & Dumon, A. (2000a). The equation of reaction: a cluster of obstacles which are difficult to overcome. *Chemistry Education: Research and Practice, 1*, 61-75.

[22] Locaylocay, J. R. (2002). *Changes in college students' conceptions of chemical equilibrium.* Ph.D. Thesis, University of the Philippines.

[23] Mafumiko, F., & Ottevanger, W. (2002). Micro-Scale experiment in improving practical chemistry in Tanzania secondary education. In K. Osaki, Et Al. (Eds.), *Science Education Research and Teacher Development in Tanzania*. The Netherlands: Vrije Universiteit Amsterdam.

[24] Nwagbo, C. (2001). The relative effect of guided discovery and expository on the achievement in biology of students of different level of scientific literacy. *Journal of the Science Teachers Association of Nigeria, 36* (1 & 2) 43 – 51.

[25]Ogunniyi, M. B. (2002). Curriculum development in science, technology and mathematics education challenges of the 21st Century. In P. A. Chakalisa, C. D. Yandila, H. U. Emereole, I. J. Kyeleve, G. J. Ramorogo and A. A. Babugura (eds), *Science, Technology and Mathematics Education in Africa* 2 – 12. Gaborone: University of Botswana.

[26]Thomas, P. Y., & Emereole, H. U. (2002). The effect of computer-based instruction on performance in physics. *African Journal of Research in Mathematics Science and Technology Education, 6*.

[27] Van den Akker, J. (1999). Principles and methods of developmental research. . In J. Van Den Akker, R. Branch, K. Gustafson, N. Nieveen, & T. Plomp, (Eds), *Design Approaches and Tools in Education and Training*, 1-14. Dordrecht: Kluwer Academic Publishers.

[28] Vinsonhaler, J.F., & Bass, R. K. (1972). A Summary of ten major studies on CAI drill and practice. *Educational Technology, 12*, 29-32.

[29]Yarroch, W. L. (1985). Student understanding of chemical equation balancing. *Journal of Research in Science Teaching*, 22 (5), 449-459.