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Chemistry Teachers' Perception of the Use of Simulation Games in Chemical Equations Balancing

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Abstract:- This study investigated the senior high school (SHS) chemistry teachers' perception of the use of simulation games (SGs) in chemical equations balancing (CEB). The study employed a type 1 developmental research design in which SGs were designed, pilot-tested and finally developed. The developed SGs were implemented and evaluated in a two (2) day workshop using 35 chemistry teachers (made up of 20 males and 15 females) drawn from ten (10) SHS in the Sekondi-Takoradi Metropolis in the Western Region of Ghana. Questionnaire and interview were the two (2) instruments used for the study. The findings showed that majority (33 out of 35) chemistry teachers representing 94.2% agreed that SHS students had learning difficulties with regards to simple CEB. Again, all the 35 SHS chemistry teachers representing 100% indicated that they enjoyed the use of SGs materials and instructional approach in teaching simple CEB and that they wanted more of the SGs materials to be developed and used in teaching abstract chemistry concepts. It was recommended that stimulating experiments such as SGs approach should be designed and developed to interest students in the exciting field of chemistry so that more students may be drawn into studying chemistry.

Keywords:- *Chemistry, teachers, perception, simulation games, chemical, equation, balancing.*

I. INTRODUCTION

Researches (Johnstone, 1993; Khoo & Koh; 1998; Dhindsa & Treagust, 2009) in science education show that many students especially all over the world find chemistry concepts difficult to learn and understand. Studies by (Boujaoude & Barakat, 2000; Coll & Treagust, 2002) are deeply concerned about secondary students' perception of chemistry being difficult and their experiencing difficulty in learning the chemistry subject. The findings from these studies have shown that secondary school students have learning difficulties when it comes to the study of chemistry. For example, in a national evaluation made by the French Ministry of Education (1995) on 112 pupils' opinion pool on the difficulties of the courses offered at the secondary school, chemistry came out worse than physics. These perceived difficulties associated with the learning of chemistry may have impacted negatively on the students' academic performance and their attitudes towards chemistry.

Globally, the study of chemical equations balancing (CEB) has been part of SHS chemistry syllabus for many years yet SHS chemistry students find it difficult to understand it (Dun, 2005). For instance, a typical real-life example of a SHS 2 or grade eleven (11) 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 balancing simple and ionic equations. The detailed notes which contained the explanations for ionic 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 ionic equations. The following excerpt about Andrea does reflect the predicament of many chemistry students of which Ghanaian SHS students are of no exception.

"I'm trying to make sense of all this balancing stuff but visually and mentally it is making me dizzy. I just don't understand!" (Ebenezer & Erickson, 1996, p. 182).

Moreover, a survey study conducted by the French Ministry of Education in 1995 on 112 pupils' opinion pool on the perceived difficulties on CEB using interview sessions. Interviews with ten (10) of the pupils with 23 question items, nine of which concerned CEB revealed the following: For a majority of pupils, quote.

"In school we spend too much time writing and balancing equations of reaction with formulae of which we don't understand". This use of chemical symbolism seems to constitute, a real stumbling block: "We found chemical balancing... very hard in school". "It is hard to balance. Julien agrees: "I have difficulty in manipulating it... my approach to these equations is somewhat blurred and I wish it is not part of my course" (Laugier & Dumon, 2000a).

A similar study carried out by Anamuah-Mensah and Apafo (1986) revealed that Ghanaian SHS students perceived CEB as a difficult concept in chemistry. The study indicated that about 66% of the respondents found this concept very difficult to grasp. Moreover, the WAEC Chief Examiner's Reports of 2014 also indicated that SHS students perform poorly when it comes to the CEB. The reports further indicated that majority of the students failed to write correct balanced chemical equations for the reaction between HCl and NaOH; as well as H_2SO_4 and $Cu(OH)_2$ (Chief Examiner's Reports of 2014 July).

From the above analyses, it presupposes that students' difficulty in understanding this concept is universal. Studies (Missen & Smith, 1989; Lythcott, 1990; Dhindsa & Treagust, 2009) have shown that part of this difficulty can be traced to the "traditional trial and error method" with emphasis on rote learning used in teaching this abstract concept in schools. Lythcott in his study on the method used in teaching chemical

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equations balancing pointed out that, "much of what we teach this concept is so mechanical that a student can follow the rules of "trial and error" without ever really struggling after the chemical meanings" (Lythcott, 1990, p. 251).

Recent studies reports (Jacobs & Dempsey, 1993; Plos & Sneider 1994) have shown that simulation games coupled with instructional materials could be used to teach abstract scientific concepts and develop positive attitudes in learners.

It is against this background that the study was conducted to examine the SHS chemistry teachers' perception of the use of SGs in CEB.

A. Statement of the Problem

Studies (Anamuah-Mensah & Apafo, 1986; Apafo, 1992) have shown that majority of Ghanaian SHS students have learning difficulties with regards to simple CEB. This difficulty has been ascribed to the abstract nature of the concept and poor methods often used by chemistry teachers in teaching the concept with little or no activities (Yarroch, 1995; Laugier & Dumon, 2000; Dun, 2005)

In most countries attempts have been made by several researchers (e.g. Nash, 1978; Harsch, 1987; Harrison & Buckely, 2000; Dun, 2005) to develop and equip chemistry teachers with innovative instructional strategies that could be used to teach this abstract concept in a more practical way.

However, in Ghana very little work have been done in developing SHS chemistry teachers competencies in teaching this abstract concept. It is in the light of this that this study was conducted to develop and equip SHS chemistry teachers with innovative strategies that could be used to help SHS science students to overcome their learning difficulties in simple CEB.

B. Purpose of the Study

The purpose of the study is to examine the SHS chemistry teachers' perception of the use of simulation games (SGs) in CEB. Specifically, the study intends to.

- To assess SHS chemistry teachers' perception about the use of SGs materials in CEB.
- To evaluate the views of the SHS chemistry teachers about CEB using SGs materials.

C. Research Questions

The following two (2) investigative questions directed research activity in the study.

- How do SHS chemistry teachers perceive SGs materials approach to CEB?.
- What are the views of SHS chemistry teachers about CEB using the SGs materials approach.

II. REVIEW OF RELATED LITERATURE

Historically, the use of SGs in education is well documented in past and recent literature. They have been used in preschool, K-12, the university, military, business and by older adults (Dempsey, Lucassen, Haynesly & Casey, 1997).

Cruickshank (1980) is of the opinion that simulations are the products that result when one creates the appearance of something else and considered games as contests in which both players and opponents operate under rules to gain specified objective(s). He distinguishes SGs as academic and non-academic games. To him non-academic games are for fun while academic games for or based upon learning. Cruickshank further classified academic games into two (2) as simulation and non- simulation games. Non-simulation games are those in which a player solves problems in a school subject such as spelling or mathematics by making use of principles of that discipline whereas academic simulation games are the simulation in which participants are provided with a simulated simulation in which to play to obtain knowledge.

A search in literature reveals that the first SGs called Monopologs for teaching business management appears to have been introduced in 1955. This game was developed by the Rand Corporation for teaching logistics to U.S Air Force personnel (Faria, 1990). In 1956, the American Management Association introduced Top Management Business Game, which was meant for training top management. The computations were performed on an IBM 650 computer (Kibbee, Craft & Nanus, 1961). In this game, the players filled a form indicating their decisions, this information was punched into cards, and the computer program was run. The computer provided performance reports, and the cycle was repeated.

By 1961, 31 computerised SGs had been listed, five of which were production simulators (Kibbee et al., 1961). Since then there has been a steady increase in the number, sophistication and the use of wide range of SGs ranging from board games to computerised simulations for teaching and learning purposes (Wu, 1989; McKenna, 1991).

Ruohomäki (1995) discusses the use of SGs from the viewpoint of learning theory. According to Ruohomäki (1995) SGs combine the features of games (competition, cooperation, rules, roles, etc) and simulation (abstraction of reality by a model); and are used when there are no possibilities for students to obtain experience of the situations in the real life or where reality is too expensive, complex, fast, or slow. According to Ruohomäki, simulation games provide: cognitive learning outcomes (information, principles, critical thinking); attitude changes (increased interest towards the subject matter and oneself) and student- centred learning (learning by doing with positive effects on groups).

Gilbert (2005) in a review of SGs indicated that SGs help in developing understanding of theory through practical work and they also maximise the use of visualisation of the abstract concept taught. Studies (Nash, 1978; Harsch, 1987; Harrison & Buckely, 2000) have shown that the use of SGs can have positive influence on students' conceptual understanding on scientific concepts and thereby changing their negative perceptions towards the concept.

In his study, Harsch (1987) found out that active playing with lottery games yielded better students' performance than

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demonstration alone. Nash (1978) also reported that students greatly enjoyed playing the Periodic Table game. In a similar study, Harrison and Buckely (2000) developed SGs for introducing dynamic equilibria using an overhead projector transparency while coins were used to represent the molecules of reactants and products. The study revealed that students who were exposed to the SGs performed better in the word association tests (WAT) than the control group.

It is obvious that literature is full of enough evidence to suggest that SGs are important tools in teaching and learning scientific concepts particularly in chemistry.

III. METHODOLOGY

A. *Research Design*

The study employed a developmental research design. Developmental research is disciplined inquiry conducted in the context of the development of a product (program) for the purpose of improving either a thing being developed or developer's capabilities to develop better things of this kind or both (Walker & Bressler, 1993). Richey and Nelson (1996) classified developmental research into two (2) types as Type 1 and 2. The Type 1 is the study of a specific program design, development and/or evaluation project whereas Type 2 is the study of design, development and/or models aiming at generating knowledge on how to design.

This study employed the type 1 design in which SGs materials were designed, pilot-tested and finally developed. The developed SGs materials (board-card-game and computer software) were implemented and evaluated in two (2) days workshop for selected chemistry teachers. This design was used because it provides flexibility in developing an intervention stage-by-stage within the problem context; and seen as a means to influence educational practice by experimenting with promising intervention(s) and seeing whether they work in real classroom settings (Van den Akker, 1999). A similar study following this line of investigation was done in Tanzania by (Mafumiko & Ottevanger, 2002) that showed great promise in developmental research design approach.

B. *Sample and Sampling Procedure*

The sample consisted of 35 SHS chemistry teachers (made up of 20 males & 15 females) drawn from ten (10) SHS in the Sekondi-Takoradi Metropolis in the Western Region of Ghana. A purposive sampling technique of the non-probability sampling procedure was used to pick the sample for the study. These SHS chemistry teachers were selected because of their in-depth knowledge in the teaching and learning of CEB concept in the Ghanaian SHS.

C. *Research Instruments*

Questionnaire and interview were the two (2) research instruments used for the study. The questionnaire constituted the quantitative part whereas the interview constituted the qualitative part of the instruments. The interview was done using a semi-structured interview guide.

The validity of the instruments was established by a two (2) senior chemistry lecturers from the Science Education Department, UEW.

D. *Data Collection Procedure*

For an effective data collection, permission was sought from various SHS authorities and the chemistry teachers concerned to carry out the study. Two (2) days were used to conduct the study.

On the first day of the implementation of the SGs materials approach, the researcher had open and frank discussions with all the selected respondents about the importance of the workshop. The teachers were then introduced to the main aspects of the SGs materials (board-and-card game & the computer-based instructional game - CBIG) as well as the procedure governing the approach.

Later, the researcher demonstrated to the teachers how to use the board-and-card game to balance some equations written on the board for them to observe. After the researcher had balanced about five (5) different simple chemical equations with the appropriate cards, each teacher was made to use the CBIG to balance several chemical equations. Using the board-and-card game to balance the reaction between magnesium (Mg) and hydrochloric acid (HCl) have been illustrated IN Figure 1 below.

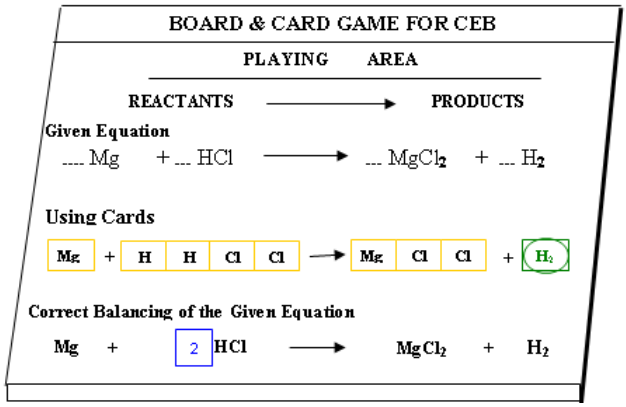

Fig 1:- A board-and-card game showing a balanced reaction

E. *between Magnesium (Mg) and hydrochloric acid (HCl)*

On the second day, teachers were introduced to CBIG to balance some simple chemical equations. In this computer game, the researcher used power point presentation to demonstrate to the teachers how the game was played to balance a given simple chemical equation at the ICT laboratory. This game showed the teachers the correct balanced chemical equations of the reactants and the products. After, several demonstrations and discussions, each teacher was then made to use CBIG to balance several chemical equations. Using the CBIG to balance reaction between oxygen (O_2) and hydrogen (H_2) have been illustrated in Figure 2 below:

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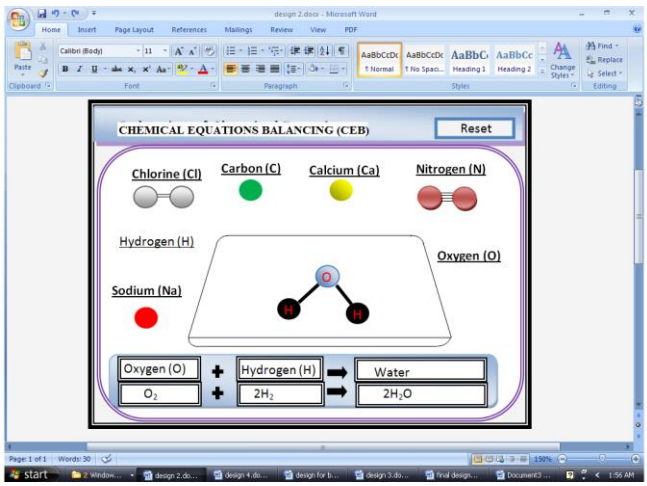

Fig 2:- A CBIG showing a balanced reaction between oxygen (O_2) and hydrogen (H_2)

After the SGs approach lessons, questionnaires were administered to all the teachers to respond in my presence which lasted for 30 minutes. After the stipulated time, all the questionnaires were collected and this ensured 100% retrieval rate. After, the administration of the questionnaires, a focus-group interview was conducted for the teachers which lasted 30 - 40 minutes using interview guide.

F. Data Analysis Method

The study used both quantitative and qualitative methods of data analysis. Data from the questionnaire were analysed quantitatively using descriptive statistics namely frequency and percentages whereas data from the interview guide were analysed qualitatively. The recorded conversations were transcribed and summarised thematically to answer the research questions.

IV. RESULTS AND DISCUSSION

A. Analysis of the Results

The analyses of the results were done to answer the 2 research questions posed by the study.

B. Research Question 1: How do SHS chemistry teachers perceive SGs materials approach to CEB?

In order to find out SHS chemistry teachers' perception about the SGs materials approach to CEB, all the selected 35 SHS chemistry teachers' responses to the questionnaire items were analysed using frequency and percentages and are presented in Table 1 below:

No	Teachers' perception of SGs materials workshop.	D (%)	N (%)	A (%)	Total (%)
1.	My students had learning difficulties with regards to simple CEB.	2 (5.8)	0 (0)	33 (94.2)	35 (100)
2.	SGs approach taught at the workshop was better than the "traditional trial and error method" used in teaching CEB.	0 (0)	1 (2.9)	34 (97.1)	35 (100)
3.	I did not enjoy the workshop on the SGs materials approach in teaching simple CEB.	35 (100)	0 (0)	0 (0)	35 (100)
4.	SGs approach will make the teaching of simple CEB more interesting to my students.	3 (8.6)	2 (5.8)	30 (85.7)	35 (100)
5.	SGs approach can be used to teach my students CEB in a more practical way.	1 (2.9)	2 (5.8)	32 (91.3)	35 (100)
6.	SGs materials approach cannot help my students to learn simple CEB with ease.	31 (88.5)	1 (2.9)	3 (8.6)	35 (100)
7.	The SGs materials approach has change my negative perception about teaching simple CEB	1 (2.9)	1 (2.9)	33 (94.2)	35 (100)
8.	SGs materials approach did not provide analogical situation for teaching CEB	30 (85.7)	1 (2.9)	4 (11.4)	35 (100)
9.	SGs materials were very clear and presented the CEB concept in simple and logical sequence.	2 (5.8)	0 (0)	33 (94.2)	35 (100)
10	I want more of the SGs materials to be developed for the teaching of abstract chemistry concepts.	0 (0)	0 (0)	35 (100)	35 (100)

Table 1. SHS Chemistry Teachers' Responses on the Use of SGs

C. Materials in CEB.

Source (Teachers' questionnaire, 2017). Keys: D = (Disagree); N = (Not sure); A = (Agree)

From the responses in Table 1, it is clear that majority (33 out of 35) representing 94.2% agreed that SHS students had learning difficulties with regards to simple CEB. Again, all the 35 SHS chemistry teachers representing 100% indicated

that they enjoyed the workshop on the SGs materials approach in teaching CEB and that all of them wanted more of the SGs materials to be developed for the teaching of abstract chemistry concepts.

On the issue of whether the SGs materials approach can be used to teach SHS chemistry students CEB in a more practical way, as many as 32 teachers representing 91.3% agreed; 1 teacher representing 2.9% disagreed, with 2 teachers representing 5.8% were not sure to the same statement. Asked if SGs approach taught at the workshop was better than the "traditional trial and error method" used in teaching simple CEB in schools, as many as 34 chemistry teachers representing 97.1% agreed to the statement, with only 1 teacher representing 2.9% was not sure about the same statement.

As many as 33 respondents (out of 35) representing 94.2% were of the view that the SGs materials approach has change their negative perception about teaching simple CEB. The observation made from this research question and the responses of the respondents clearly showed that chemistry teachers' perception about the use of SGs materials approach to CEB was very positive.

D. Research Question 2: What are the views of SHS chemistry teachers about CEB using the SGs materials instructional approach?

To find out the views of the SHS chemistry teachers' responses during the focus group interview session about CEB using the SGs materials approach were analysed. The results from the interviews session were very interesting.

The SHS chemistry teachers' views and experiences with the SGs materials approach were very positive. All the 35 SHS chemistry teachers' representing 100% were of the conviction that, the approach was very good because their professional competence in teaching this abstract concept had improved tremendously. Two (2) SHS chemistry teachers' comments emphasized these benefits and their responses are captured in their words below:

"The SGs materials approach has helped improved my method of teaching this abstract concept very well. I have improved my method of teaching balancing of simple chemical equations greatly" (Tommy).

"There has been an improvement in my teaching strategy since I started the SGs materials approach workshop. In the beginning, I was afraid getting my students to grasp the balancing of the simple chemical equations, but now I can confidently teach this concept to my students without any difficulty" (Eliza).

With regards to whether the SGs approach was simple, a typical response is captured in the words of a female SHS chemistry teacher;

"The SGs approach was very simple, easy to comprehend and use to balance any given simple chemical equation. I just click the mouse and drag the associated elements and then you are there balancing chemical equation" (Theresah).

When asked if they have ever used SGs materials approach in teaching any chemistry concepts in their schools. Some of the respondents indicated that they had used computer games to teach some aspect of the chemistry but all of them pointed out that they have not use SGs materials to balance chemical equations. All the 35 respondents indicated that the SGs workshop provided them with the first time opportunity to use SGs to learn CEB.

All the SHS chemistry teachers' were pleased with the SGs materials approach in teaching CEB and they were of the opinion that more of such materials should be developed and used to teach other abstract chemistry concepts.

E. Discussion of the Results

The results of this study showed that majority of the chemistry teachers who took part in the study indicated that their SHS students had learning difficulties with regards to simple CEB. This difficulty might be attributed to the abstract nature of the concept coupled with the poor methods used by teachers to teach this concept. This finding is in agreement with the results of (Anamuah-Mensah & Apafo, 1986; Apafo, 1992) that majority of Ghanaian SHS students have learning difficulties with regards to CEB.

The teachers' views and experiences about the use of SGs materials approach were very impressive and positive. All the 35 chemistry teachers indicated that they enjoyed the use of SGs materials approach in teaching simple CEB. This approach might have provided the teachers to visualise and conceptualise this abstract concept through the manipulation of physical objects. This finding is in consonance with the results of Gilbert (2005) that SGs help in developing understanding of theory through practical work and also help to maximise the use of visualisation of the abstract concept taught.

Critical reflections from the SHS chemistry teachers' responses from the interview revealed that SGs materials were very clear and also presented the concept under study in a simple, logical and sequential manner. The teachers indicated that the approach was very good because it had greatly improved their professional competencies and that their negative perceptions about CEB have been changed after the use SGs approach. This finding lend credence to the results of some pioneer researchers (e.g. Nash, 1978; Harsch, 1987; Harrison & Buckely, 2000) that the use of SGs can have positive influence on students' conceptual understanding of scientific concept taught and thereby changing their negative perceptions towards the concept.

V. CONCLUSIONS

This study has shown that Ghanaian SHS students who took part in the study had learning difficulties with regards to simple CEB and these difficulties were ascribed to the abstract nature of the concept coupled with poor methods often used by teachers to teach this concept to students. It can also be

concluded that teachers were pleased with the SGs approach and they suggested that more of such materials should be developed by experts for the teaching and learning of other abstract chemistry concepts. It was established that this study yields considerable argument in favour of the use of SGs materials approach in teaching abstract chemistry concepts such as CEB.

One significant finding was that, the use of the SGs materials approach was very good because it had greatly improved the professional competence of chemistry teachers and that their negative perceptions about teaching and learning of CEB had changed after the use SGs approach.

A. Recommendations

Based on the findings and conclusions drawn from this study, it was recommended that stimulating experiments such as SGs approach should be designed and developed to interest students in the exciting field of chemistry so that more students may be drawn into studying chemistry. Hence more students may be drawn into studying chemistry since the country now needs more chemists.

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