UNIVERSITY OF EDUCATION, WINNEBA

THE EFFECT OF CLASS-WIDE PEER TUTORING IN IMPROVING STUDENTS' SCIENCE CONCEPT DEVELOPMENT IN SOME SELECTED TOPICS IN CHEMISTRY IN SENIOR HIGH SCHOOL

ERIC ETORNAM SUNFRA

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MARCH, 2015

DECLARATION

STUDENT"S DECLARATION

I, ERIC ETORNAM SUNFRA, declare that this Thesis, with the exception of quotations and references contained in published works which have all been identified and acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE: ……………………………………………………………………..

DATE: ………………………………………………………………………………

SUPERVISORS" DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of thesis as laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: PROFESSOR MAWUADEM KOKU AMEDEKER

SIGNATURE: ……………………………………………………………………..

DATE: ………………………………………………………………………………..

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Finally and most importantly, I give the resultant Glory and Honour to God, Who has seen me through this study, for without Him, this study would not have been successful. Thank you Seli.

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ABSTRACT

This study evaluated the effect of teacher interventions on students‟ science concept development. The study established the role of teacher interventions in students‟ science concept development using class-wide peer tutoring and the extent of students‟ science concept development after the intervention. In this study the Researcher taught using analogy, predict observe and explain where students‟ behaviour were observed and feedbacks provided by the peer tutors to their tutees were assessed. The study identified students‟ feedback to the questions asked during peer tutoring sessions. The progress of students‟ performance was monitored by the Researcher during the tutoring sessions with the implementation of class-wide peer tutoring instructional intervention. The extent of the intervention strategy on students‟ science concept development was determined. The study employed an action research strategy for data collection. Class-wide peer tutoring instructional strategy was employed in teaching five lessons during the intervention period. The strategy was used to teach 30 Form 2 chemistry students of the Kpando Senior High School in the Kpando Municipality of Volta Region of Ghana. This study used teaching and assessment of the learning outcome as the main instrument for data collection. The findings were that student-teacher and student-student interactions increasingly improved. A total of 105 observations were made during the peer tutoring time. 25(83.3%) of the peer tutors were observed praising their tutees for correct responses whiles 23(76.7%) of the tutors awarded marks to correct responses. Beside, students‟ participation in class-wide peer tutoring increased as activity oriented teaching method was used. Finally, on the basis of the results obtained in this study, it is concluded that more topics in science can be taught using class-wide peer tutoring for effective concept development in science.

CHAPTER ONE

INTRODUCTION

1.1 Overview

The study examines the effect of teacher interventions in improving students‟ science concept development in Senior High Schools in Ghana. Out of the many interventions acknowledged and highly acceptable to teachers, the Researcher adopted Class-wide Peer Tutoring (CWPT) intervention designed to enhance students‟ science concept development and the learning environment. This chapter is organized under the subheadings: background to the study, statement of the problem, purpose of the study, the objectives and research questions, the rationale and significance of the study, limitations and delimitations as well as the organization of the study.

1.2 Background of the Study

As the school-age population in Ghana becomes progressively more diverse, it is vital to develop a knowledge base that successfully promotes academic achievement, scientific development and equity for all students. This need is particularly critical in science education whereby it is important on the part of the teacher to put in instructional interventions or shape instructions in order to help improve students‟ science concept development.

However, students learning in many field of knowledge at once as found in second cycle institutions in Ghana often feel overwhelmed and frustrated. As a result of this, they are unable to grasp taught abstract scientific concepts. Since teaching and learning is increasingly concerned with improving students‟ attainment through focused implemented interventions, it is becoming the responsibility of individual teachers, subject teachers or coordinators to select the best intervention for their students from a stunning array of options.

Scientific concepts can only be acquired as a result of deliberate and systematic instruction in an educational setting. Hence, the instructional intervention implemented by a teacher in an environment such as the classroom is paramount and should be very effective in helping struggling learners to successfully master new academic skills, and to ensure that all the affected students succeed in the learning environment.

1.3 Statement of the Problem

An instructional intervention is a planned set of procedures that are aimed at teaching a specific set of academic or social skills to a student or students, typically a set of procedures rather than a single instructional component/strategy. It is obvious that interventions are very important means by which teachers ensure that students succeed in high stakes testing environments as far as science concepts development is concerned.

Most teachers in the basic and second cycle institutions often prefer to give out notes and explain scientific concepts to students with the aim of completing the syllabi on schedule and thereby ignore appraising the students to identify their weaknesses. Thus, little is done by teachers by putting in interventions to bridge the gap from the insights of learning to making the links to reliable approaches to interventions so as to focus on a particular student or students and on a particular set of skills or field of knowledge in order to help improve students‟ science concept development.

The present study therefore assessed the effect of interventions on students‟ science concept development in Kpando Senior High School located in Kpando Municipality of the Volta Region of Ghana.

1.4 Purpose of the Study

The purpose of the study is to evaluate the effect of Class-wide Peer Tutoring (CWPT) intervention on students" science concept development with respect to the degree to which students accept scientific concepts and use them. In view of this, the concept of chemical equilibrium was chosen among the several science concepts due to the several alternative conceptions and difficulties on the part of the students.

1.5 Objectives of the Study

The objectives of the study are to:

i. Establish the role of teacher interventions in students" science concept development.

ii. Implement class-wide peer tutoring intervention in teaching science concepts to students.

iii. Determine the extent of students" science concept development after teacher provides an intervention.

1.6 Research Questions

The study addressed the following research questions:

i. What is the role of teacher interventions in students" science concept development?

ii. How is class-wide peer tutoring intervention implemented in teaching science concepts to students?

iii. To what extent can students" science concept be developed after a teacher provides an intervention?

1.7 Rationale of the Study

The concept of instructional interventions in improving students" science concept development is a very broad subject and various issues can be looked at from different perspectives. Hence, there will be the need to bring this research into focus in order to effectively deal with the issues that will be of concern to the author. The extent to which students accept scientific concepts, develop and use them is largely dependent on the mode of teaching and the instructional interventions put in place.

Studies have however shown that students do not understand many chemical concepts even after they have been taught formally. In order to plan instruction for understanding, it is important for the teacher to be aware of students" conceptions and difficulties about chemistry concepts and hence, device extensive efforts in teaching these concepts.

1.8 Significance of the Study

This research and its findings are considered important to provide insight into the effect of instructional interventions in improving students" science concept development in second cycle schools in Ghana. Teachers and other stakeholders would also benefit from the findings and recommendations in order to improve upon their ideas, skills, and zeal as well as adopted instructional interventions. In addition, the study will serve as a reference for future studies on the instructional interventions in improving students" science concept development in Ghana. Finally, the study will add to the existing literature on instructional interventions viz-a-viz in students" science concept development and as a source of document for researchers in the academia.

1.9 Limitations of the Study

The research is based on instructional interventions employed in improving students" science concept development in Kpando Senior High School of which findings may not be generalized to other second cycle institutions in Ghana. For that matter, the research and its results are specific and limited to Kpando Senior High

School, which is the study area. The drawbacks encountered by the Researcher during the study were time constraints in preparing lesson notes. Besides, the time frame of allocated per period for teaching the concepts is too short and places limitations on the study.

1.10 Delimitations of the Study

The research is based on instructional interventions employed to improve students‟ science concept development in senior high school science. This study focused on concepts/conceptual issues on chemical equilibrium as enshrined in the Ghana Education Service‟s syllabus for Chemistry and as such the study did not consider any concept beyond the boundary of equilibrium.

1.11 Organization of the Study

This study is divided into five chapters. Chapter one is the introduction of the study which outlined the background of the study, statement of the problem, purpose of the study, objectives and research questions, rationale of the study, significance, the limitations as well as delimitations of the study. Chapter two is the literature review which deliberated on teaching strategies/instructional interventions, relationship between scientific and spontaneous concepts, the development of science concepts in students and other related concepts. Chapter three discussed the methodology employed. Chapter four dealt with the results/findings. Chapter five covered the discussions of results which is the final chapter outlined conclusions and recommendations of the study based on the findings.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

The main purpose of this chapter is to review literature related to the study. The importance of the constructivist theory and applications of teaching strategies which enhance the understanding of concepts were looked at. As a result, one of the useful structured constructivist teaching strategies namely Predict-Observe-Explain (POE) instructional approach was discussed. The importance of analogies in teaching and learning is treated. Indeed, analogy provides a link between pre-existing conceptual structure and new problems and domains hence help improve students‟ concept development. Due to this, the chapter discussed literature on peer-mediated methods or peer tutoring (PT) and its format in education with a focus on Class-wide peer tutoring (CWPT). The need for teaching and learning science and chemistry were also discussed.

2.2 Constructivist Theory and Teaching Strategies

The constructivist theory may be attributed to pioneers of psychological theories of learning such as John Dewey, Lev Vygotsky, and Jean Piaget (Proulx, 2006). Constructivism is a theory of knowledge epistemology that argues that humans generate knowledge and meaning from an interaction between their experiences and their ideas. Constructivist theory is one of the most important educational theories used in arousing learner‟s thinking and make him/her active, interactive and positive during the learning process (Merriam et al., 2007).

Constructivist theory emphasises the fact that education is an active process towards building knowledge, and concentrates on the internal factors affecting the learner and what occurs in his/her mind when faced with educational situations. The constructivist theory also considers the importance of students‟ pre-conceptions, which are deeply rooted in their cognitive structure on learning. In addition, constructivism is based on the principle that the student must be an active participant in the learning process, and employ meaningful learning strategies (Merriam et al., 2007).

Knowledge cannot be transmitted intact from one person to another; people must construct their own knowledge and their own understanding. Constructivism theory also supports this view. It supports the view that each child constructs his or her own meaning by combining prior information with new information in ways that make personal meaning. Constructivists believe that each learner must construct meaning for him or herself. New learning must be connected to the individual‟s already existing knowledge. What children learn is not a copy of what you teach them or what they observe, but rather it is a result of how they think about it and process the information (Driver, 1995).

Children begin their study of science with ideas about the world already in place. Some of these ideas are in line with currently accepted scientific understanding and some are not. Children have to experience for themselves events that contradict their currently held beliefs. A constructivist view of learning assumes that the student needs to construct meaning by the means of the interaction with the physical world and with their peers (Rubin, 1995).

The role of the teacher in constructivism is different from the traditional teacher. The traditional teacher does not consider students‟ pre-existing knowledge and only transmits knowledge to students by means of lecturing (Von Glasersfeld, 1995). On the other hand, the constructivist teacher elicits students‟ initial beliefs and ideas about the subject to be studied and then sets up situations that will cause dissatisfaction with existing ideas (Lewin, 1995). Realising that students" expectations affect their observations and that multiple approaches to problem solving are beneficial, the teacher monitors students" understandings, requests from them evidence and justification, provides constraints for their thinking, and gives them opportunities to represent their knowledge in a variety of ways. In sum, it can be said that the constructivist teacher guides, supports students in the process of constructing meaning (Driver, 1995).

Nonetheless, several cognitive psychologists and educators have questioned the central claims of constructivism. It is argued that constructivist theories are misleading or contradict known findings (Liu & Matthews, 2005; Kirschner et al., 2006). In the neo-Piagetian theories of cognitive development, it is maintained that learning at any age depends upon the processing and representational resources available at that particular age. That is, it is maintained that if the requirements of the concept to be understood exceeds the available processing efficiency and working memory resources then the concept is by definition not learnable.

Mayer (2004) argued that not all teaching techniques based on constructivism are efficient or effective for all learners, suggesting many educators misapply constructivism to use teaching techniques that require learners to be behaviourally active. Kirschner et al. (2006) described constructivist teaching methods as "unguided methods of instruction". Constructivism is an example of fashionable but thoroughly problematic doctrines that can have little benefit for practical pedagogy or teacher education and similar views have been stated by Meyer (2004). While there is much enthusiasm for Constructivism as a design strategy, "to us it would appear that constructivism remains more of a philosophical framework than a theory that either allows us to precisely describe instruction or prescribe design strategies" (Tobias, &

Duffy, 2009, p.4). Other constructivist ideas were centred on predicting events, observing how they happen and explaining the observed phenomena.

2.2.1 Predict-Observed-Explain Instructional Approach

White and Gunstone (1992) noted that one useful structured constructivist teaching strategy is the Predict-Observe-Explain (POE) instructional approach. This approach incorporates elements of both teacher-centred and student-centred instruction. POE according to White and Gunstone (1992) is a powerful strategy to conduct minds-on inquiry based demonstrations. In this approach, the teacher attempts to be a significant part of the learner‟s lived experience. This is achieved through facilitating students‟ reconstruction of their own knowledge in inquiry-based lessons by promoting interactions with objects in the environment, and engaging students in higher-level thinking and problem solving (Crawford, 2000).

POE includes the following five stages: (a) Teachers pose a problem for the students to predict the outcome of a demonstration before it is carried out; (b) Teachers ask students (in pairs) to make their personal predictions; (c) Students compare their predictions with each other before the conduct of the demonstration; (d) Students observe the demonstration as it is being carried out; and (e) Students participate in a discussion facilitated by the teacher for purpose of teaching the correct scientific concepts and remediate any misconceptions.

Watts and Jofili (1998) cited Fox‟s (1983) seven metaphors of a constructivist teacher which can be achieved through the constructivist POE instruction:

i. *Theatrical director* – directs and orchestrates learners‟ thinking,

ii. *Tour guide* – guides and chaperones learners,

iii. *Scaffolder* – provides structure and supports,

iv. *Provocateur* – challenges and struggles with the learner,

v. *Negotiator* – acts as a broker between learner and curriculum,

vi. *Committee chair* – reconciles, organizes and manages goals and agendas, and

vii. *Modeller* – shapes and moulds learners‟ knowledge (Watts & Jofili, 1998).

Conducting minds-on inquiry based lessons via constructivist POE instruction is ideal in promoting interactions with objects (analogy and the target) in order to prevent students‟ misconceptions and hence bring about conceptual change.

2.3 Analogies

An analogy refers to the comparisons of structures between domains. An analogy can be seen as a process of identifying similarities and differences between two objects (Venville & Treagust, 1996). An analogy is defined by three parts: the target, which is the new concept being studied; the analogy, which is the familiar concept to which the new concept is compared; and mapping, which is the outlining of the relationships between the target and analogy (Harrison & Treagust, 1994). Therefore, explaining the differences as well as similarities between the analogy and the target is necessary in order to prevent students‟ misconceptions. The study of Harrison and Treagust (2000) also supports this view by explaining that students who socially negotiated the shared and unshared attributes of common analogical models for atoms, molecules, and chemical bonds, used these models more consistently in their explanations.

Moreover, analogy plays a central role in conceptual change. Analogy supports the rapid learning of new systems since it provides a link between pre-existing conceptual structure and new problems and domains. Analogies are commonly accepted as a supportive tool used to facilitate conceptual change and overcome misconceptions to provide the conceptual understanding since they can build meaningful relations between what they already know and the new knowledge they will learn (Glynn, 1991; Venville & Treagust, 1997).

Analogies are believed to promote meaningful learning. Thus, they are used frequently by authors and teachers in order to explain scientific concepts to students (Harrison & Treagust, 1994). For instance, Brown and Clement (1989) found that the use of analogies help students to develop their ideas and to serve as a reference point to check on plausibility of their previous explanations. Analogies also make the new concepts intelligible. Duit (1991) supports the view that analogies are effective conceptual change agents because they enhance understanding by making connections between scientific concepts and the students‟ life-world experiences, and by helping students visualise abstract ideas. Duit (1991) added that analogies "provoke students" interest and may therefore motivate them.

Though analogies are effective tools for removing students‟ misconceptions, they can create misconceptions if used inappropriately. Therefore, they are double-edged swords; that is, they can hinder as well as help learning (Glynn, 1991). However, analogies have been successfully used to teach difficult abstract concepts (Brown, 1994; Lin et al., 1996). There are different presentations of analogies. Analogies may be presented to the learner as prepared elements of a lecture or they may be generated by the learners themselves. Presenting analogies with a planned teaching strategy has the potential to enhance student understanding of science concepts while reducing the incidence of misconceptions being formed.

According to Harrison and Treagust (1994), effective teaching using analogies appears to contain these steps: introduce the target concept to be learned; cue the students‟ memory of the analogous situation; identify the relevant features of the analogy; map out the similarities between the analogy and the target; indicate where the analogy breaks down; as well as draw conclusions about the target concept (Harrison & Treagust, 1994). Other effective techniques for promoting meaningful learning are peer-mediated approaches.

2.4 Peer Tutoring Systems

Different teaching techniques have different effects on learning: some have remarkable effects on learning, some are considered trivial, and some might even hinder the learning process (Becker & Carnine, 1981). To help practitioners implement instructional strategies in helping students develop science concepts, three basic categories of effective instruction can be described and they are teacher-directed, independent/semi-independent, and peer-mediated methods (Heron & Harris, 2001). Within each of these major categories, several instructional procedures can be selected, depending on the needs of the students, available resources, and teacher competence.

With respect to peer-mediated approaches, two procedures have been identified as effective and have been subjected to extensive study: co-operative learning and five systematic tutoring variations; that is: cross-age, one-to-one, small-group, home-based, and peer tutoring formats. Note that when reciprocal peer tutoring is used on a class-wide basis, it is referred to as class-wide peer tutoring (CWPT) (Lloyd et al., 1998). Of all tutoring formats, peer tutoring including class-wide variations, has been studied empirically for approximately thirty years, producing validated evidence of the effectiveness across classroom levels which include elementary, middle, and high school and content areas, for instance science, reading, mathematics to supplement the instruction of students (Lloyd et al., 1998). CWPT has produced a validated evidence of effectiveness across all classroom levels. In view of this, the Researcher undertake a discussion on CWPT, the mode of implementation and its benefits.

2.4.1 Class-wide Peer Tutoring

Effective intervention procedures are essential to breaking the cycle of school failure. Tobin and Sprague (2000) conducted a review of strategies that have shown to be effective with youth served in alternative education settings. Among those were instructional strategies, including tutoring. According to Greenwood et al. (1997), CWPT is an instructional strategy designed to effectively teach specific information to students with a variety of skill levels. CWPT is a well-researched instructional strategy that has proven effective for students with and without disabilities, and is one that helps prevent school failure (Greenwood & Delquadri, 1995).

Bloom (1984) modelled the „2 sigma problem‟: “Can researchers and teachers devise teaching-learning conditions that will enable the majority of students under group instruction to attain levels of achievement that can at present be reached only under good tutoring conditions?” (Bloom, 1984, p. 4). Class-wide peer tutoring (CWPT) may provide a solution to the “two sigma” problem (Johnson, 1999). Greenwood et al. (1989) opined that CWPT was developed from the observation that much of teacher-designed instruction fails to engage the academic behaviours of students of diverse abilities. Teacher-designed instruction did not have the ecological arrangements necessary to support student‟s academic responding and engagement, whereas CWPT was an instructional arrangement designed specifically to accelerate all students‟ levels of academic responding and engagement and to provide pacing, feedback, immediate error correction, high mastery level, and content coverage (Greenwood et al., 1991).

CWPT involves the entire class divided into student pairs (tutor and tutee dyads). The pairs are engaged reciprocally and simultaneously with instructional content (Delquadri et al., 1986; Allsopp, 1997; Heron et al., 2003). Tutors are trained and supervised by the classroom teacher (Delquadri, et al., 1986; Greenwood et al., 2002). CWPT utilizes an interdependent group contingency where students are held accountable for performance. CWPT also involves content materials to be tutored, new partners each week, partner pairing strategies, teams competing for the highest team point total, contingent individual tutee point earning, tutors providing immediate error correction, score‟s public posting and social recognition for the winning team (Delquadri et al., 1986).

Greenwood et al. (2002) in their study identified CWPT effective components to include: one-on-one reciprocal peer tutoring, group contingencies of reinforcement, tutor modelling the correct response which served as an error correction strategy, tutor task presentation and response opportunities, tutor monitoring of tutee performance and recording the tutee‟s earned points, posting of performance and feedback on progress.

2.4.2 Implementation of Class-wide Peer Tutoring

Research on the implementation of Class-wide Peer Tutoring (CWPT) began around 1980. It was first developed at the Juniper Gardens Children‟s Project (JGCP) in Kansas City, by collaborations of researchers and teachers who were seeking to find a successful instructional method for integrating children with special needs into general education settings. In 1983, Greenwood and colleagues developed Class-wide Peer Tutoring (CWPT) which incorporates similar principles as Reciprocal Peer Tutoring (RPT) (grouping of students to prompt, monitor and evaluate each other), and was initially designed to prevent future academic failure in poor and culturally diverse schools (Greenwood, Delquadri, Stretton & Hall, 1989). Moreover, RPT was developed in 1984 by Fantuzzo and his colleagues and tested the strategy for children with academic needs (Fantuzzo et al., 1984).

CWPT is a reciprocal peer tutoring (RPT) strategy that allows students to serve both as tutor (teacher) and tutee (student) to review and learn basic skills, for example spelling and reading; and content material, for instance chemistry, biology, physics, and mathematics. Also, students work together to learn a specific set of information. CWPT uses a combination of instructional components that include partner pairing, systematic content coverage, immediate error correction, frequent testing, team competition and point earning (Greenwood et al., 1997). Every student in the classroom is involved in the learning process with CWPT, which allows them to practice basic skills in a systematic and fun way (Terry, 2008).

The object of CWPT is for students to learn weekly information that is presented and to demonstrate their understanding of this information on assessments. Students will measure success by their scores on the assessments. In the CWPT presented here, there can also be a class game format used, so that student can also measure success by the number of points earned by themselves and their team. To begin, teachers use pre-tests to measure students‟‟ knowledge of information to be taught in the week ahead. Typically, knowledge would be low (for example, 20-40% correct) on the pre-test and increase to 90-100% correct (average) on the post-test (Greenwood et al., 1997). If the pre-test indicates items on the list are too easy or hard, the list should be modified.

In Greenwood et al.‟‟s (1997), CWPT a class is divided into two teams. Students in each team are paired with a partner from the same team for the week. Pairing can be set up randomly or by a student‟‟s skill level. In spelling and mathematics, students may be placed randomly with a partner as tutors are given answers to help monitor and make corrections. When using CWPT for reading, partners should be placed in pairs with contrasting skill levels. High-skill level readers are able to help those who are lower-skilled. Teachers should monitor pairing and make appropriate adjustments (Greenwood et al., 1997).

Once paired, each partner will take a turn tutoring the other partner by giving a word to be spelled, a math fact, or by listening to literature being read. The tutors give points for correct answers, while immediately correcting and recording errors. In addition, the teacher can provide award points to students for good behaviour. The two teams compete for points and social reinforcement. In CWPT, students spend approximately 30 minutes per day for four days, engaged in tutoring with the weekly lesson.

The fifth day is used for assessment and pre-testing for the following weekly lesson. In the first 10 minutes of each daily lesson, one student plays the role of tutor and the other as the tutee. For the next 10 minutes the roles are exchanged. The tutor is responsible for presenting each item on a weekly tutoring list. Two points are to be rewarded for correct answers. If the tutee answers incorrectly, the tutor makes an immediate correction and later in the lesson allows the tutee a second chance to answer and practice the correct response, using boxes 1-3 of the tutoring worksheet. At this point, if the student‟s answer is correct, the tutee earns one point. If the answer is still incorrect, no points are awarded for that particular item.

After ten minutes, the tutor and tutee will exchange jobs. If the tutoring pairs finish prior to the ten minute buzzer, tutors are to start the list again. If either member from a pair has a question, that student should raise the help sign for teacher assistance. During partner work, the teacher should tour the classroom, awarding 1-5 bonus points for appropriate behaviour. Students grade their partner"s assessment test and points are awarded for correct answers. When all points have been reported, the winning team is announced a positive verbal reinforcement is given or a celebratory round of applause. The winning team should also be directed to appropriately congratulate the other team for their efforts. Partners and teams change the following week (Greenwood et al., 1997).

2.4.3 Benefits of Class-wide Peer Tutoring

According to Arreaga-Mayer (1998), benefits of CWPT include being paired with a peer partner in one-to-one instruction, opportunities for error correction, earning points for correct responses, increased time spent on academic behaviours, increased positive social interactions between students that would not typically occur, encouraging students to work together (an important life skill), and helping students experience more success and feel more confident (Arreaga-Mayer, 1998).

Students are also able to change partners frequently, which helps keep things interesting. They are often excited to see which student they will work with next. In an alternative setting, the opportunities are not as flexible and varied, as class sizes are often much smaller. Within this setting, pairing students with peers for tutoring is sometimes determined by how well students are getting along with one another (King-Sears and Bradley, 1995; Arreaga-Mayer, 1998). Data on the instructional effectiveness of CWPT have shown that students retain more of what they learn and make greater advances in social competence with CWPT compared to traditional teacher-led instruction (Greenwood et al., 1991; Mathes & Fuchs, 1993). As a teaching strategy, CWPT has proven effective for improving students" test performance and accuracy (Kamps et al., 1994). Also, CWPT tend to produce validated evidence of effectiveness across content areas of which science is not an exception in order to supplement the instruction of students.

2.5 Teaching and Learning Science

It is important that we should be aware of reasons for teaching science since it affects the way in which science is taught (DeBoer, 1991). Some of the main purposes of science teaching are to help students acquire scientific knowledge, develop their curiosity about the world, enhance their scientific literacy, develop their problem-solving and decision making skills and stimulate mental discipline (DeBoer, 1991). The second crucial question is "How can we teach science effectively?" in order to fulfil these purposes of science education. The answer to this question is to have an idea about how students learn.

Learning is an active process in which students play an active role and construct their knowledge based on previous knowledge, ideas or experiences. During the learning process, students create their own personal meanings and the conceptual schemes are based on prior knowledge and experiences (Schunk, 2000). Ausubel et al (1978) stressed the importance of meaningful learning and distinguished rote and meaningful learning. Rote learning is like memorization and is not necessarily accompanied by any understanding of the terms. The new learned information remains as discrete piece of information without linked to any previous knowledge in the mind. Therefore, students are unable to apply information that is learned by rote.

On the other hand, meaningful learning is the learning that is related to previous knowledge, and it is understood well enough to be manipulated, paraphrased, and applied to novel situations. The famous statement of which is the most important single factor influencing learning is what the learner already knows which indicates the importance of students" previous knowledge. For students to develop abstract and difficult concepts attached to real-world experience can be done via teaching and learning of chemistry.

2.6 Teaching and Learning Chemistry

According to Davis (1997), teaching involves the interaction of students and a teacher over a subject. To Lave (1995), learning is a situation where students develop new concepts about a topic and formulate ideas to solve the thought-provoking problems. There may be one or several students in a class. The students can be young or old, bright or of below average intelligence, „normal" or physically challenged, highly motivated, male or female. The subject can be easy and straight-forward or difficult and complex.

Succinctly, teaching and learning is a process where the teaching group and the learning group interact for effective achievement of the set goal. The teacher is to keep students" interest and focus during teaching and learning. The presentation of information in many different ways and from different sources helps to keep students engaged during the lesson. Teachers and students acknowledge questions as a core function for both teaching and learning.

Action research is an interactive inquiry process that balances problem solving actions implemented in a collaborative context with data-driven collaborative analysis or research to understand underlying causes enabling future predictions about personal and organizational change (Reason & Bradbury, 2002). Action research or participatory action research is a reflective process of progressive problem solving led by individuals working with others in teams or as part of a „community of practice" to improve the way they address issues and solve problems (Alana et al., 2007). It is characterized by continuous cycles of problem diagnosing, action planning and action taking, evaluating and specifying learning (skills learnt by students). The linking of the terms „action" and „research" highlights the essential features of this method. Hence, there is the need to develop a framework for the study involving concepts discussed above.

2.7 Conceptual Framework

The Researcher developed a conceptual framework that uses teaching with analogies and predict-observed and explain (POE) instructional interventions as well as peer tutoring to improve students" comprehension of some science concepts in chemistry. Teaching and learning is increasingly concerned with improving students" attainment through focused interventions and it is becoming the responsibility of individual teachers, subject teachers or coordinators to select the best intervention for their students from a stunning array of options.

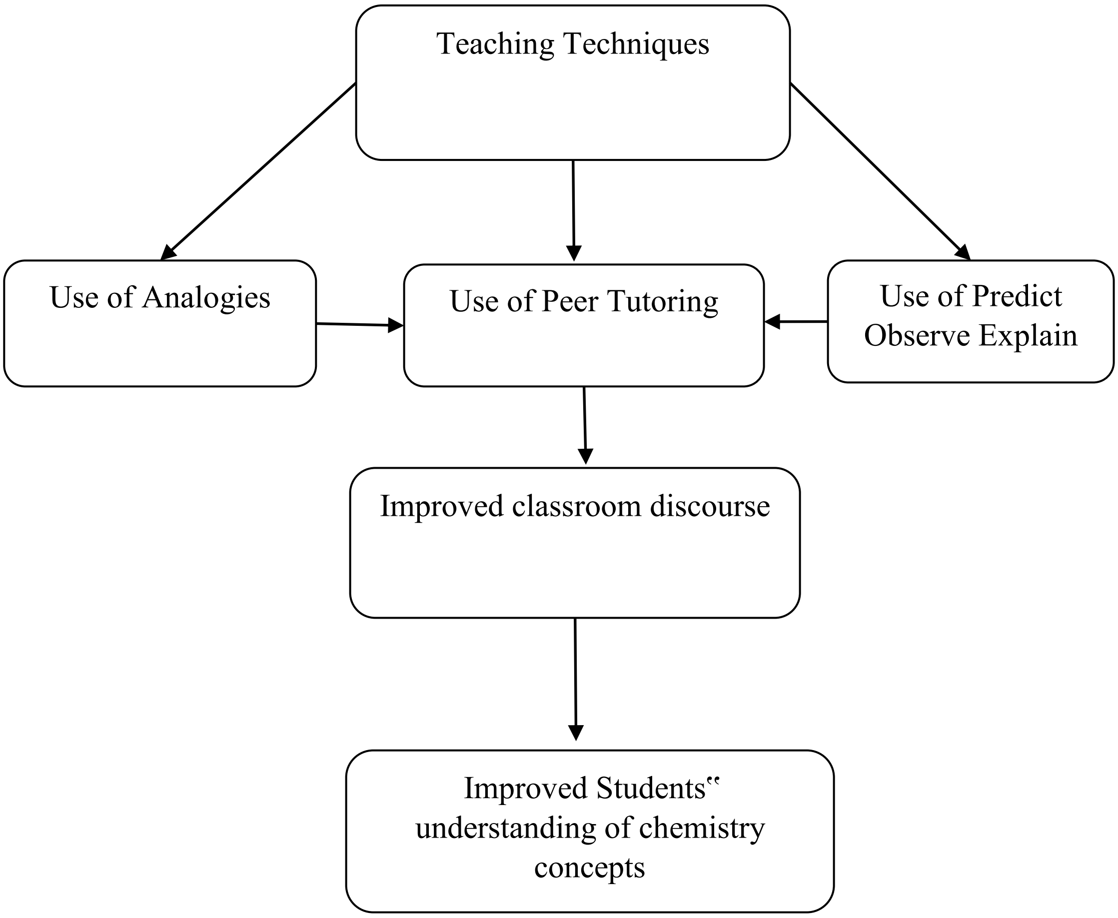


Figure 1: Conceptual Framework

Chemistry is difficult for many students because chemistry concepts are abstract and difficult to attach to real-world experience. When planning instruction in chemistry, for more effective teaching, teachers need to consider a broad range of issues which are: be aware of and take into consideration students‟ prior knowledge; the multiple ways in which chemistry phenomena can be represented; the meanings of the same and similar terms used in chemistry and in everyday life; and the chemistry of everyday life.

When students are engaged in their own learning, they frequently have a better understanding of chemistry and of the role of chemistry in their daily lives. Furthermore, the lessons are more pleasing experiences both for teacher and students. In the study of Treagust and Mann (2000) research had revealed that many difficulties in learning and understanding chemistry appeared to be caused by a view of chemistry instruction that was academic and not related to the chemistry of everyday life. Smith et al. (1993) stated that science teaching needs to develop conceptual understanding rather than rote memorization. In addition, an important goal of science teaching is to assist students as they come to understand important scientific concepts and relationships (Fellow, 1994). Therefore rote learning or simple addition of new knowledge to current knowledge is not enough to promote meaningful learning of science.

In this study the researcher developed a conceptual framework that uses Class-wide Peer Tutoring (CWPT) intervention to enhance the comprehension of students in some science concepts in chemistry. Since its development, CWPT has proven to be effective in the areas of spelling, vocabulary, reading, mathematics, social studies, and science (Greenwood et al., 1991). CWPT studies have reported secondary gains for students in the form of increased social attractiveness among peers (Fantuzzo et al., 1992) and decreased behaviour problems (Greenwood et al., 1991).

The framework consists tutoring techniques/formats that could improve students" classroom discourse and enable them to improve their comprehension in responding to conceptual questions. The framework makes use of objects of CWPT for students to learn weekly information that is presented and to demonstrate their understanding of this information on assessments. Students measure success by their scores on the assessments. To begin, Greenwood et al. (1997) indicated that teachers should use pre-tests to measure students" knowledge of information to be taught in the week ahead. Typically, knowledge would be low, for instance 20-40% correct on the pre-test and increase to 90 - 100% correct (average) on the post-test.

It is worth noting that CWPT has been proven effective with students from pre-school to high school levels, and has been used in both general and special education classroom settings. CWPT was initially designed for students in grades 1-6, with diverse skill levels, including students with learning disabilities, limited English proficiency, and other mild disabilities. It has since been expanded to include newer models that can be used at any grade level such as high schools with proper modification. New uses include „higher order" skills such as asking thought provoking questions in mathematics and science, and combining class-wide tutoring components with self-management (King, et al., 1998).

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter deals with the methodology of this study. Thirty (30) SHS chemistry students offering General Science programme from Kpando Senior High School of the Volta Region in Ghana were the sample selected. The instruments used for data collection includes diary of records which was used for recording classroom proceedings on daily bases. Data collection procedure was in three phases. The first phase, was intended to identify students and trained them for the intervention. The intervention phase involves teaching using Class-Wide Peer Tutoring and the evaluation phase where students achievements were determine through series of data collected during lessons taught. Finally, data collected were analysed using the thematic content analysis method to find out the effect of the intervention.

3.1 Research Design

A research design comprises the steps that were used to collect data. Research design deals with specific data analysis techniques or methods that the researcher used (Fraenkel & Wallen, 2000). A research design refers to the overall strategy that integrate the different components of the study in a coherent and logical way, thereby, ensuring effective addressing of research problems; it constitutes the blueprint for the collection, measurement, and analysis of data (De Vaus, 2001).

There are several research designs, these include: Case study design, causal design, cohort design, cross-sectional design, descriptive design, experimental design, exploratory design, historical design, longitudinal design, meta-analysis design, sequential design, philosophical design, observational design, action research design etc. According to Mills (2003) action research is “any systematic inquiry conducted by teacher researchers, principals, school counsellors, or other stakeholders in the teaching/learning environment to gather information about how their particular schools operate, how they teach, and how well their students learn" (p. 5). Action research is a form of collective self-reflective enquiry undertaken by participants in social situations in order to improve the rationality and justice of their own social or educational practices. Action research is an approach to improving education by changing it and learning from the consequences of changes. According to McKernan (1991) action research is a methodology which has the dual aims of action and research, action to bring about change in some community or organization or program, research to increase understanding on the part of the researcher or the client, or both (and often some wider community). According to Stringer (1996) Action Research is focused on solving specific problems that local practitioners face in their schools and communities.

This study is an action research which seeks to find out the effect of class wide peer tutoring on students‟ science concepts development. This study was implemented in three (3) phases as illustrated in Figure 2. The first phase was used to identify students‟ alternate science conception in selected topics taught. The students sample were given training in how Class-Wide Peer Tutoring works. This phase also comprised the instrument development, piloting and reviewing stages. The second phase of the design is the intervention and evaluation period. The Researcher taught a total of five lessons. This phase lasted for five weeks. Students were taught using analogies, predict observe and explain and then Class-Wide Peer Tutoring for five weeks and a week was used to analyse the findings of the study.

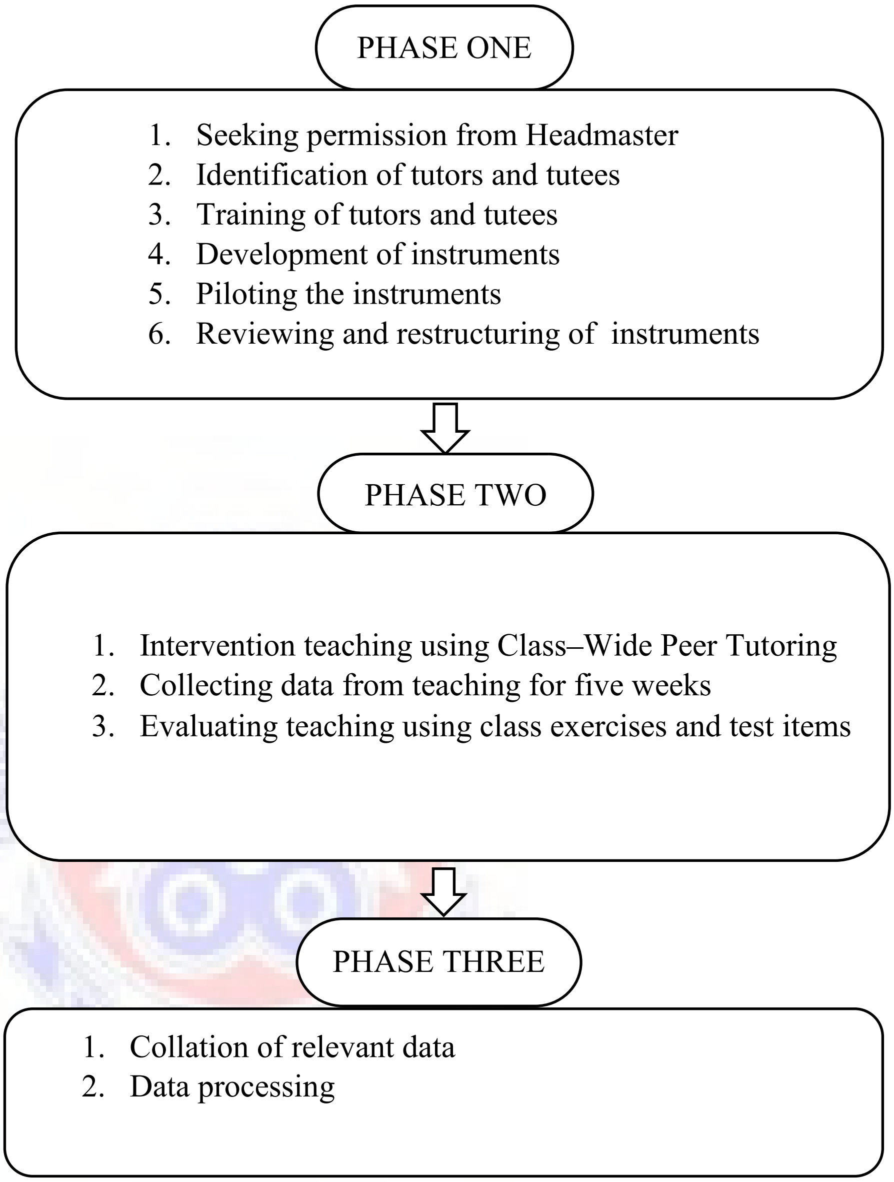


Figure 2: Plan for the Study

3.2 Population

According to Fraenkel and Wallen (1993), population is the group of interest to the researcher, the group to whom the researcher would like to generalise the result of the study. Population is the entire group of persons that have the characteristics that interest the researcher. A population, according to Punch (2006) is the target group of people about whom a researcher wants to develop knowledge. According to Neuman, (2003), population refers to the name for the large general group of many cases from which a researcher draws a sample and which is usually stated in theoretical terms. According to Fraenkel and Wallen (1993), the actual population (called the target population) to which a researcher would really like to generalise is rarely available. The population to which a researcher is able to generalise, therefore, is the accessible population. The population for this study consists of all science students at Kpando Senior High School of Kpando Municipality of Volta Region of Ghana. The second year group of the school offering chemistry are 165 students made up of four classes. 2C1, which is one of the classes made of thirty students was chosen as the sample. The class consist of 19 boys and 11 girls.

3.3 Sample and Sampling Technique

Sampling is the process of selecting units from a population of interest so that by studying the sample we may fairly generalise our results back to the population from which they were chosen (Trochim, 2006). A sample is a smaller group which is drawn from a larger population and studied (Robson, 2002; Punch, 2006). According to Fraenkel and Wallen (2000), sample is any group on which information is obtained for study. The two main types of samples are probability and non-probability samples (Cohen & Holliday, 1996). Probability sample is the type where every member of the population has equal opportunity to be selected into the sample. These include simple random sample, systematic sample, stratified sample, and purposive sampling.

Fraenkel and Wallen (1993) defines simple random sample as the type where each member of the population under study has equal chance of being selected into the sample. Simple random sample gives the opportunity to have homogeneous representation of the population. Systematic sample is the type in which the selected subject from the population list is systematic rather than the random fashion (Cohen, Manion & Morrison, 2007). This type is more convenient when dealing with a very large population and a large sample is needed.

Fraenkel and Wallen (2000) said stratified sample is the type where certain subgroups or strata are selected in the same proportion as they exist in the population. The stratified sample involves dividing the population into homogeneous groups, each group containing sample with similar characteristics. This sample type ensures that different strata in the population are represented. It also increases the precision of the sample and it is convenient for practical purposes.

According to Cohen, Manion, and Morison (2007), purposive sampling is the selection of sample on the basis of their judgment of their typicality or possession of the particular characteristics being sought. Ball (1990) noted that purposive sampling is done for those who have in-depth knowledge about the issue and by virtue of their experience. Patton (2002) defines purposive sample as the type in which the researcher handpicked the people to be included in the sample on the basis of their judgment of their typicality. They build a sample that is satisfactory to their specific needs. Patton (2002) said this type of sample focuses on selecting information-rich participant whose study illuminates the questions under study. It is also considerable less expensive to use and is perfectly adequate since the findings will not be generalised beyond the sample. This study used purposive sample type to select a sample of thirty (30) form two chemistry students for the study. The Researcher used purposive sample because among the accessible population they are the only group that has previous knowledge related to the topics to be covered under the study.

3.4 Research Instruments

A research instrument is a device used to collect data to answer the research questions. Data collection is an essential component in conducting research. O‟Leary

(2004), remarks that "collecting credible data is a tough task, and it is worth remembering that one method of data collection is not inherently better than another." Therefore, the data collection method to use would depend upon the research goals and the advantages and disadvantages of each method.

A questionnaire is a means of eliciting the feelings, beliefs, experiences, perceptions, or attitudes of some sample of individuals. As a data collecting instrument, it could be structured or unstructured (Pey, 1997). Again, according to Pey (1997) an interview is a direct face-to-face attempt to obtain reliable and valid measures in the form of verbal responses from one or more respondents. It is a conversation in which the roles of the interviewer and the respondent change continually. Atkinson (1992) said a diary of record is used for daily notes taken on the field while the activity is ongoing. As a data collecting instrument, it could be structured or unstructured (Pey, 1997)

This study employed teaching and assessment of the learning outcome as the main instrument. Materials used during the intervention include Worksheets consisting of a series of questions, five (5) items and another five (5) items in a test were given on every lesson that was taught every week. The purpose of using worksheets were to consolidate what students have learned in each lesson and measure how far they could meet the present instructional objectives of each lesson. Students 'academic performance was regularly checked through tests conducted on every lesson that was taught every week. Usually a 20-minute test was conducted to assess student's knowledge of the topics or sub-topics that had been taught in a single week. Questions set in the tests were at the same level of difficulty as questions set in the worksheets so as to measure the same skills and knowledge. Totally, five weekly test scores of the class was recorded.

3.4.1 Intervention strategy

During the period of intervention, five (80 minutes) lessons were taught, the first 35 minutes of each lesson was used to introduce new concepts and teaching materials as usual by the Researcher. Afterwards, CWPT was used. The class was firstly divided into two competing teams (A and B) and students drew numbered paper slips from a covered box to determine their team membership (Dupaul & Henningson, 2000; Greenwood et al., 1997) Students then paired up into their tutoring pairs and one student in each pair served as peer tutor while the other took the role of tutee for 15 minutes. After the time limit had expired, the tutoring pairs reversed the roles for the same interval of time (Harper et al., 1999).

3.4.2. The role of peer tutors and tutees during peer tutoring time

During tutoring time, where calculations were involved, peer tutor had to compare the steps of calculation that were provided by tutee with the model answer. If tutee made any mistakes, peer tutors point out where the problems were. If tutees could not correct the mistakes by themselves, peer tutors were responsible to provide some hints for the tutees. The peer tutor might write down a step or provide the hints verbally. His/her participation became more active and peer tutor did not merely check the answer. If tutees were able to provide the correct steps and answer, peer tutors notify the tutees they have got the correct answer. Finally, if tutees were able to provide the correct answer or correct their own mistakes in calculation, peer tutors praise the tutees to show his/her appreciation. Peer tutors needed to follow the prescribed teaching procedures closely and provide appropriate feedback.

3.4.3. Scoring System

If the steps and answers were both correct, the peer tutor would award three points to the tutee (two points for correct steps and one point for solving the problem without hints or peer tutor's help). 1f the steps or answers were incorrect, the peer tutor would request the tutee to write the steps and answer again; and award two points to the tutee if both were correct or a point if only one was correct. However, if the tutee refused or failed to correct his/her steps or answer, no point was awarded. This scoring system was not the same as Greenwood et al's method (1989) in which peer tutor gives two points for the correct steps and answer, and giving one point for correcting the mistake. The scoring system was modified so that the effort for formulating the steps was also appreciated especially for complicated questions. The objective of the tutoring game was to complete as many items as possible in a certain time limit. The more items students had completed, the more points they could earn for themselves and their team. (Harper et al., 1999)

Immediately after the tutoring session, the students summed up their daily points and recorded down on a record sheet. The monitor of the class then collected the record sheet of each pair and marked the result on the scoreboard in front of the classroom at the recess. The daily team total scores were calculated. Tutoring lessons took place once a week and were followed by a weekly exercise. Exercise were taken individually and students received points for each correct step and answer. Following the weekly exercise, all points, were totaled and the winning Team and Pair of the Week were announced the following week. (Arreaga-Mayer et.al., 1998). The winners would receive rewards and clapping of hands as positive reinforcement.

3.4.4. Researcher’s role during peer tutoring time

The role of Researcher during tutoring time was slightly different from Greenwood et al's method (1989) in which researcher moved about the classroom to give extra marks to the students, if students could follow the procedures of CWPT and provide the appropriate feedback. However, in this study Researcher taught using analogy and predict observe and explain then moved about to observe students' behaviors and help the students whenever they came across any difficulties, but no extra marks given. The Researcher also checked whether the peer tutors were able to provide appropriate feedback to their tutees. The purpose of this observation was to evaluate the implementation of CWPT to see whether any difficulties were encountered by students. The target behaviors of observation were the five different types of possible feedback the tutors might issue. They were: (1) notifying tutees of the incorrect steps of calculation, (2) giving hints to tutees how to correct the answers, (3) informing tutees their answers are correct, (4) praising tutees when their answers are correct or they are able to correct their wrong answers, and (5) giving accurate marks to correct steps or answers.

In each lesson, there was about 30 minutes tutoring time out of the 80 minutes for the lesson. The 30 minutes was divided into six intervals. Researcher observed two peer tutoring pairs in each CWPT lesson. Researcher observed one peer tutoring pair in the first interval and then observed another pair in the next interval. Then, Researcher went back to the first pair again. Researcher stayed with a tutoring pair to observe the performance of peer tutors after tutee answered one item of science problem within each interval and recorded down the target behaviors that the peer tutor performed. Hence, Researcher could observe two pairs of peer tutor and tutee for three times each in the tutoring time. Since there were altogether five CWPT lessons for the class during the period of intervention, Researcher could observe all peer tutoring pairs at least once.

3.5 Data Collection Procedures

The Researcher taught for five weeks. For each week, exercise was conducted whiles students were taught using CWPT. Worksheets and exercises were marked and recorded. A mark was awarded to objective type structured questions whiles three marks was awarded to questions involving calculation. The Researcher also observed five different types of possible feedback that peer tutors might issue. They were: (1) notifying tutees the incorrect steps of calculation, (2) giving hints to tutees how to correct the answers, (3) informing tutees their answers are correct, (4) praising tutees when their answers are correct or they are able to correct their wrong answers, and (5) giving accurate marks to correct steps or answers. The data collected is presented and analysed in the next chapter.

3.6 Data analysis

According to Adèr and Mellenbergh (2008), analysis of data is a process of inspecting, cleaning, transforming, and modelling data with the goal of highlighting useful information, suggesting conclusions, and supporting decision making. It is ascertained by Gay and Airasian (2003) that "data managing, reading/memoing, describing the context and participants, and classifying" (p. 229) are necessary steps for properly interpreting these types of data. Since this is an action research geared towards developing a teaching and learning strategy, reports were presented on each lesson taught, the kind of activities carried out, the interactions, the level of students‟ interest in the lesson and the progression of the lesson were all grounded in the reports. Analysis of the lesson was undertaken after each lesson and was guided by the research questions. Data was also analyzed by grouping responses from participants into themes based on scientific concepts. The target behaviours observed by Researcher were also tabulated and compared with team A and B with respect to their achievement during the intervention period.

CHAPTER FOUR

RESULTS/FINDINGS

4.0 Overview

This chapter deals with the presentation and analysis of data from week one to week five of teaching. The analysis of the reports were based on the teaching and learning activities that went on in the classroom, the procedure, the interaction and progression. Students" responses and attitudes towards the lesson were also factored into the analysis. The outcome of the teaching was presented in the form of findings.

4.1.0. Lesson one

4.1.1 Procedure and interactions

Topic; Nature of dynamic equilibrium and the equilibrium constant

P.K.: Students can write mathematical expression of rate of reaction.

Chemistry concepts to be learnt:

- Equilibrium chemical reactions are reversible chemical reactions.
- concentration of reactants decrease during reactions
- Products concentration increase during chemical reaction at equilibrium
- Backward reaction rate is the same as forward rate of reaction
- At equilibrium the concentrations of reactants and products do not change with time.
- The equilibrium constant K_{eq} compares forward and backward reactions rates
- Catalyst speed up both forward and backward reactions equally.

During the introductory stage, the Researcher asked the peer tutors and their tutees to resume their respective places. The Researcher explained to the students the nature of reversible reactions. Reversible reactions are chemical reactions where the reactants form products that in turn, react together to give the reactants back. Reversible reactions will reach an equilibrium point where the concentrations of the reactants and products will no longer change.

Disc analogy was then used by the Researcher to simulate dynamic Chemical equilibrium in the lesson and then students peer tutored on dynamic equilibrium as outlined in Appendix A. Disc analogy uses blue discs to represent reactants and yellow discs to represent products. The Researcher wrote an equilibrium equation on the board as follows, $A_{(g)} \rightleftharpoons B_{(g)}$. “A” was written with a blue colour and “B” with a yellow colour. “A” represents reactants and “B” represents products. The discs used in the analogy has one side painted blue and the other side painted yellow.

The Researcher explained the analogy to the students as follows.

	Analog	**Target**
1.	number of blue discs	concentration of reactants
2.	number of yellow discs	concentration of products
3.	time the turning of discs started	start of the chemical reaction
4.	at the start: only blue discs are present	at the start of the reaction only reactants are present
5.	during the turning of the discs from blue to yellow from yellow to blue	forward and backward reactions are taking place. Therefore the reaction is reversible
6.	number of discs turned/min	
	from blue to yellow	rate of forward reaction
	from yellow to blue	rate of backward reaction

Initially the blue side was made visible to the students and this represents the presence of reactants. As the reaction starts, the blue discs were moved to the product side and changed to yellow to represent products. This was done at time intervals. The backward reaction was also shown by turning yellow discs to blue discs at time intervals. The number of discs present at the reactant and product sides indicate the concentration of reactants and products at a particular time whiles the number of discs turned per minute indicates the rate of reaction. The analogy demonstrated how the concentration of reactants and products changes as the system approaches equilibrium, the constancy of the concentration of reactants and products once equilibrium is attained and show how the rate of the forward and backward reactions changes prior to and after the attainments of equilibrium.

Initially, students had challenges with the timing of turning the blue discs into yellow. This came to light as a result of the type of questions asked by the students during the lesson.

Student 1: how many discs should be turned in a minute?

The Researcher: There is no specific number of discs turned per minute, it varies as the rate increases.

Student 2: why were more blue discs turned per minute initially and this reduced before equilibrium was established?

The Researcher: the initial rate of reaction for forward reaction is faster than the initial rate of backward reaction.

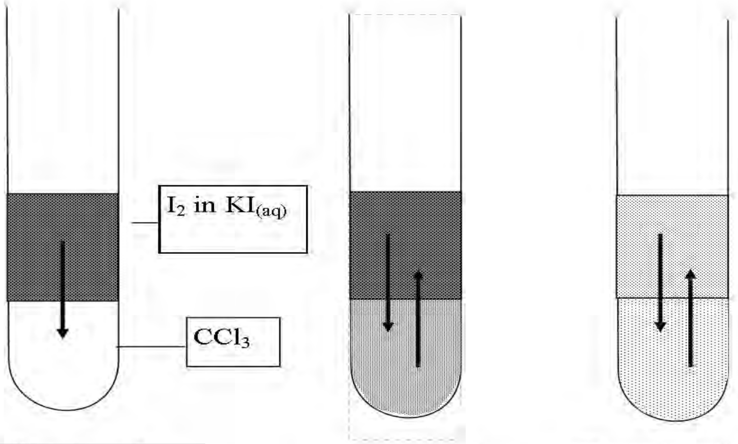
After two demonstrations of the analogy, the students asked the following questions.

Student 1: would the concentration of reactants and products be equal after equilibrium has been established?

Student 2: will the reaction stop after the equilibrium has been established?

The Researcher: although rate for forward reaction and rate for backward reaction would be equal, the concentrations of the reactants and products may not be equal after equilibrium has been established. To demonstrate dynamic equilibrium, the Researcher gave the peer tutors and their tutees three test tubes, 1M solution of potassium iodide prepared by dissolving iodine crystal in aqueous KI solution and trichloromethane. The peer tutors were asked by the Researcher to place the aqueous potassium iodide solution on top of an equal volume of the trichloromethane in a test tube. The students observed the initial concentrations before and after equilibrium has been established in terms of colour changes. Tutees with the help of their peer tutors recorded their observations and discussed their observations with each other.

After carrying out the activity, all the fifteen tutoring pairs were able to make the following observations. Iodine diffused into the trichloromethane. Some iodine diffused back into the aqueous potassium iodide layer. The iodide in potassium iodide produced a brown colour. The iodine in the terachloromethane is purple. As dynamic equilibrium was reached, iodine moves from the aqueous potassium iodide layer at the same rate as it returns to it from the tetrachloromethane layer.



Iodine crystals dissolved in aqueous trichloromethane place on top of an equal volume of trichloromethane

Iodine diffused into the trichloromethane.

Some iodine diffuses back into the aqueous potassium iodide layer. Iodine in potassium iodide produces brown colour. Iodine in CCl_3H is purple

Dynamic equilibrium is reached. Iodine moves from the aqueous potassium iodide layer at the same rate as it returns to it from the tetrachloromethane layer

Figure 3: Demonstration of dynamic equilibrium

After establishing the concept of dynamic chemical equilibrium, the students were guided by the Researcher to write the expression for the equilibrium constant K_{eq}. The equilibrium constant K_{eq} is the ratio of the rate constant for the forward reaction (K_f) to the rate constant for the backward reaction (K_b).

The Researcher: for the reaction $aA\ (g) + bB\ (g) \rightleftharpoons cC\ (g) + dD\ (g)$ on board, write the rate law equation for forward and backward reactions

Student 1: $R_f = K_f\,[A]^a\,[B]^b$

Student 2: $R_b = K_b\,[C]^c\,[D]^d$

The Researcher: good work done. At equilibrium rate of forward reactions and rate of backward reactions are equal hence $K_f[A]^a[B]^b = K_b[C]^c[D]^d$. Someone should express K_f over K_b.

Student 3: $$\frac{K_f = [C]^c\,[D]^d}{K_b = [A]^a\,[B]^b}$$

The Researcher: that is good. $K_{eq} = \dfrac{[C]^c\,[D]^d}{[A]^a\,[B]^b}$

This was followed by a discussion on the relationship between K_{eq} and the position of equilibrium.

The Researcher: if $K_{eq} = \dfrac{[C]^c\,[D]^d}{[A]^a\,[B]^b}$

When do you expect K_{eq} to be one (1)?

Student 1: when number of moles of reactants is equal to number of moles of products.

The Researcher: that is correct. This means equilibrium is neither to the left nor to the right. When do you think K_{eq} would be less than one?

Student 2: from the relation given on the board, when the concentration of products raised to their mole ratios is less than concentration of reactants raised to their mole ratios.

The Researcher: that is true. This means equilibrium would lay far to the left. When do you expect the K_{eq} to be greater than one?

Student 3: when the concentration of products raised to their mole ratios is more than concentration of reactants raised to their mole ratios.

The Researcher: that is true. This means that equilibrium would lay far to the right.

When the students were asked to indicate the function of a catalyst in an equilibrium reaction, almost the entire students in the class raised their hands.

The Researcher: what is the function of a catalyst in an equilibrium reaction?

Student 1: catalyst speed up rate of chemical reactions.

The Researcher: good.

The Researcher: how does a catalysts affect an equilibrium reaction?

Student 2: catalyst speed up a forward reaction.

The Researcher: yes you have tried

Student 3: catalyst would have no effect on reaction.

The Researcher: why?

Student 3: the reaction is in equilibrium state hence no effect.

The Researcher: catalysts speed up both forward reaction and backward reaction equally hence does not affect the equilibrium position.

4.1.2 Progression

The Researcher then distributed worksheets to peer tutors and their tutees to solve. The students were given five conceptual questions as outlined in Appendix B to answer with their peers. Peer tutors asked questions and tutees answered them. If tutee made any mistakes, peer tutors point out where the problems were. If tutees could not correct the mistakes by themselves, peer tutors were responsible to provide some hints for the tutees. The peer tutor might write down a step or provide the hints verbally, peer tutors" participation became more active and the peer tutors did not merely check the answer. Besides, if tutees were able to provide the correct steps and answers, the peer tutors notify the tutees they have got the correct answer. Finally, if tutees were able to provide the correct answer or correct their own mistakes, the peer tutors praise the tutees to show his/her appreciation. Peer tutors needed to follow the prescribed teaching procedures closely and provide appropriate feedbacks.

Initially the classroom environment was noisy, however, the noise was brought under control as the students became used to the class wide peer tutoring and there was order in the class. The Researcher using an observation schedule moved from one group to another to observe how peer tutors and tutees were fairing. After 30 minutes the students were asked to go back to their respective places but the students felt reluctant. They explained they wanted more tutoring time. The Researcher then discussed the questions with the class. Table 1 shows the observations made by the Researcher using observation schedule during the peer tutoring period.

Table 1 Number of target behaviour observed during lesson one

Target behaviour (Appropriate feedbacks of peer tutors)	Number of observations
1. Notify tutees their answer is incorrect	4
2. Give hints to tutees	3
3. Inform tutees their answer is correct	5
4. Praise tutees when their answer is correct	4
5. Award marks to correct answers	4
Total observation	**20**

A total of 20 observations were made by the Researcher during the peer tutoring session. Out of the fifteen peer tutors 4(26.7%) of them were observed notifying their tutees of their incorrect responses to questions. For giving hint to their tutees 3(20.0%) of the peer tutors were observed during the session. For informing tutees their answers were correct 5(33.3%) of the peer tutors were observed. Out of the 15 peer tutors 4(26.7%) praised their tutees for correct responses whiles 4(26.7%) of the peer tutors awarded marks for the correct answers as shown in Table 1

Major findings 1

During the peer tutoring sessions 26.7% of the peer tutors were observed notifying their tutees of their incorrect responses to questions. For giving hint to tutees 20.0% of peer tutors were observed. For informing tutees that their answers were correct, 33.3% of peer tutors were observed whiles 26.7% praised their tutees for their correct responses. For awarding the correct marks, 26.7% of peer tutors were observed.

4.2 Lesson two

4.2.1 Procedure and interactions

Topic: The effect of changing concentration of reactants and products on the equilibrium systems

P.K.: Students can explain the relationship between concentration and rate of chemical reaction

Chemistry concepts to be learnt.

- When a stress (concentration, temperature, pressure and volume of containing vessel) is imposed on a system at equilibrium, the equilibrium position shifts to a direction left or right so as to oppose, cancel or nullify the effect of the stress.
- Increasing concentration of any reactant of an equilibrium reaction shifts the equilibrium to the right so that the concentration of that reactant can decrease
- Increasing the concentration of any product shifts the equilibrium position to the left so as to decrease the concentration of that product again.
- The reverse tendencies hold for a decrease in concentration.

During the introductory stage of the lesson, as outlined in Appendix C, student were asked by the Researcher to move to their tutoring stations. The Researcher: Let us consider the factors that affect equilibrium position. Le Chatelier"s principle states that when a stress is imposed on a system at equilibrium, the equilibrium position shifts to a direction left or right so as to oppose, cancel or nullify the effect of the stress. The stress to be considered in this lesson is change in concentration. For homogenous equilibrium systems, when the concentration of a reactant or product is changed, the equilibrium position shifts in the direction of less concentration as a result of the change in order to re-establish equilibrium. For heterogeneous equilibrium systems, when the concentration of a pure solid or liquid is altered it does not affect the equilibrium position. The Researcher: Aqueous potassium thiocyanate solution is colourless. It forms a red solution of thiocyanateiron (III) complex with an aqueous iron (III) salt. The equilibrium reaction may be represented as

$$SCN^{-}_{(aq)} + Fe^{3+}_{(aq)} \rightleftharpoons [Fe(SCN)]^{2+}_{(aq)}$$

Colourless pale yellow deep red

The peer tutors and their tutees were then given the following; five test tubes label A, B, C, D, and E. Each of these test tubes contained 0.01 molar potassium thiocynate (KSCN) solution. They were also given 0.01M, 0.02M, 0.03M, and 0.04M solutions of iron (III) trioxonitrate (V).The peer tutors and their tutees using test tube A as control added the iron (III) trioxonitrate (V) solutions to the test tubes B, C, D and E respectively. After each addition the tutees and their tutors observed and recorded their observations. This was done for each of the four test tubes with 0.01M, 0.02M, 0.03M and 0.04M solutions of the iron (III) trioxonitrate (V).

After the activity, the Researcher then discussed with the students their observations.

The Researcher: What did you observe when 0.01M iron (III) trioxonitrate (V).solution (pale yellow) was added to test tube B (colourless)?

Group 1: Red solution observed

The Researcher: Good. What happened when the 0.02M, 0.03M and 0.04M solutions were added?

Group 2: The red solution became darker as the concentration increases.

Using a beaker, four test tubes, solid phenolphthalein, 0.1M NaOH solution, 0.1M HCl solution and a stirrer the students were taken through predict observe and explain task on phenolphthalein indicator solution represented as follows

$$HX_{(s)} \rightleftharpoons H_{(aq)} + X^{-}_{(aq)}$$

Colourless Pink.

The students were told that the phenolphthalein solution is a weak acid equilibrium system, they were also asked to make predictions and give reasons about what would happen when: (i) drops of dilute sodium hydroxide solution was added to phenolphthalein solution (ii) drops of dilute hydrochloric acid was added to phenolphthalein solution.

The Researcher: Predict the colour you will obtain when a drop of sodium hydroxide is added to the test tube content? The peer tutors and the tutees discussed their predictions with each other. The peer tutors led the discussions and then wrote their predictions down on paper. The students were then given two test tubes containing about 2cm^3 of the phenolphthalein solution which was slightly pink. The peer tutors added drops of dilute sodium hydroxide solution to the phenolphthalein solution. The peer tutors discussed observations made by tutees with them and recorded their observations. The exercise aroused students‟ ideas on how acid-base indicator shows different colours in acid and alkaline solutions. The Researcher then discussed with students their predictions and observations.

The Researcher: Why did you predict these colours?

Student 1: Pink because phenolphthalein in alkaline solution is pink.

Student 2: Red, phenolphthalein in base solution is red.

Student 3: Pink, the reaction is between an alkaline and a weak acid.

The Researcher: Give explanation for your observations.

Student 1: Phenolphthalein is a weak acid and it reacted with an alkaline (NaOH) hence the deep pink colour.

Student 2: Phenolphthalein in sodium hydroxide solution is pink

Student 3: Phenolphthalein is a weak acid which dissociate in alkaline solution to give pink colour.

The Researcher: You have all tried. The equilibrium equation was between colourless solution on the left and pink solution on the right. Upon adding the drops of alkaline solution we observed pink solution. What do you think happened?

Student 1: Equilibrium shifted toward right

Student 2: Concentration of products increased in the system

The Researcher: Good, when concentration of reactants is increased equilibrium shifts to the right as seen in your observations.

The Researcher: Predict the colour you will obtain when a drop of dilute Hydrochloric acid is added to the test tube content using the same equation

$$HX_{(s)} \rightleftharpoons H_{(aq)} + X^{-}_{(aq)}$$

Colourless Pink.

The peer tutors engaged the tutees in discussion. The students predicted expected colours after their discussions with each other and wrote down their predictions. The peer tutors then added drops of the dilute hydrochloric acid solution to the phenolphthalein solution in the test tube. The peer tutors and the tutees observed the colour change and discussed their observations with their partners. The Researcher then interacted with the class after the activity.

The Researcher: Give explanation for your predictions?

Student 1: Colourless because an acid is added to acid.

Student 2: Red, because HCl is an acid and phenolphthalein is a weak acid.

Student 3 Colourless because HCl is added to alkaline solution.

The Researcher: What reasons would you give for your observed colour change?

Student 1: Colourless because HCl is strong acid and is added to weak acid

Student 2: Colourless because equilibrium shifted towards the left.

Student 3: Colourless because reactants increased in the system

Student 4: Colourless because the addition of HCl increased concentration of products so equilibrium shifted to the left.

The Researcher: That is good. Increasing concentration of products shifts equilibrium position to the left. The reverse tendency holds.

Explanations provided by the students on their predications prior to the addition of drops of sodium hydroxide to the phenolphthalein solution was based on their previous experiences. After the activities the students were able to explain the colour change in terms of Le Chatelier"s principle. The explanation of the expected colour changes requires complex arguments involving analysis of how the reagents interact with the components of the system and causes a change in the concentration of a component, leading to a disturbance on the equilibrium system which causes a shift in equilibrium position in accordance with Le Chatelier‟s principle.

4.2.2 Progression

The Researcher then distributed worksheets to peer tutors and their tutees to solve. The students were given five conceptual questions as outlined in Appendix D to answer with their peers. Peer tutors asked the questions and tutees answered them. For example, the tutees were asked the question, what would be the effect of adding dilute NaOH solution to the equilibrium position in the system $H_2O + CH_3COOH \rightleftharpoons CH_3COO^- + H_3O^+$ and why?. The peer tutors expected the tutees to answer by saying equilibrium will shift to the right and when asked why the tutees should be able to say because OH^- ions from the base would be consumed by CH_3CHOOH to produce more CH_3COO^- ions in the system. If the tutees made any mistakes, peer tutors point out where the problems were. If tutees could not correct the mistakes by themselves, peer tutors were responsible to provide some hints for the tutees. The peer tutor might write down a step or provide the hints verbally. For example peer tutors gave hints to their tutees like "where is the acid to react with the base, reagent added is a base" The peer tutors .participation became more active and the peer tutors did not merely check the answers. Besides, if tutees were able to provide the correct steps and answers, the peer tutors notify the tutees they have got the correct answer. Finally, if tutees were able to provide the correct answer or correct their own mistakes, the peer tutors praise the tutees to show his/her appreciation. Peer tutors needed to follow the prescribed teaching procedures closely and provide appropriate feedbacks.

An orderly class environment was maintained throughout class wide peer tutoring session by continually monitoring and praising tutoring pairs following the rules, and administering brief time-outs by having students put their pencils down for

15 to 30 seconds when classroom noise becomes excessive. After 30 minutes of peer tutoring, students moved back to their respective places and the Researcher discussed the questions with the class. The Researcher using an observation schedule observed appropriate feedbacks of peer tutors during the session. Table 4 shows observation made by the Researcher.

Table 2 Number of target behaviour observed during lesson two

Target behaviour (Appropriate feedbacks of peer tutors)	Number of observations
1. Notify tutees their answer is incorrect	3
2. Give hints to tutees	1
3. Inform tutees their answer is correct	7
4. Praise tutees when their answer is correct	5
5. Award marks to correct answers	4
Total observation	**20**

A total of 23 observations were made during peer tutoring time. The Researcher observed 3(20.0%) peer tutors notifying their tutees of incorrect answers. 1(6.7%) peer tutor gave hint to a tutee to be able to answer correctly. 7(46.7%) of the peer tutors were observed informing tutees their answers were correct. Out of the 15 peer tutors 5(33.3%) praised their tutees for correct responses whiles 4(26.7%) of the peer tutors awarded marks to correct answers.

Major findings 2

During the peer tutoring session there was improvement in student-student interaction, 46.7% of the peer tutors were observed notifying tutees of their correct responses to conceptual questions whiles only 20.0% of the peer tutors were observed notifying tutees of their incorrect answers. For peer tutors giving hint to tutees, 6.7%.of them were observed. For praising tutees of their correct response 33.3% of peer tutors were observed. For awarding correct marks to correct response 26.7% of the peer tutors were observed.

4.3.0. Lesson three

4.3.1 Procedure and interactions

Topic: The effect of temperature change on equilibrium systems

P.K.: Students can explain energy changes in chemistry

Chemistry concepts to be learnt:

- For any reversible reaction if the forward reaction is exothermic the backward reaction is endothermic.
- Increasing temperature means supplying of heat and decreasing temperature means removal of heat.
- Increasing temperature of an equilibrium system shifts the equilibrium position to the endothermic direction, since it is that direction that can proceed to remove the added heat.
- Decreasing temperature of an equilibrium system shifts the equilibrium position to the exothermic direction, since it is that direction that can proceed to replace the lost heat.

During the introductory stage, peer tutors and their tutees were asked by the Researcher to resume their respective tutoring places. The Researcher: For reversible reaction such as, $A(g) + B(g) \rightleftharpoons C(g) + D(g)$, $\Delta H = -$ kJ, the forward reaction is exothermic because the sign of the enthalpy change for the forward reaction is negative or the system releases heat to the surrounding. The backward reaction is endothermic or absorbs heat from the surrounding because it is the reverse of exothermic reaction.

To demonstrate an exothermic and endothermic reactions the following were given to the tutoring pairs; distilled water, measuring cylinder, stirrer, spatula, thermometer, ammonium chloride, and concentrated tetraoxosulphate (VI) acid.

The peer tutors and their tutees poured $20cm^3$ of distilled water into a boiling tube, the students took the initial temperature of the distilled water. The students then added two spatula full of ammonium chloride salt to the water and stirred. The students were asked to take the temperature of the solution and also to touch the test tube and feel it. The peer tutors asked the tutees to record their observations. After the activities the peer tutors and their tutees discussed their findings.

The peer tutors and their tutees were asked by the Researcher to take another boiling tube and pour $25cm^3$ of distilled water into it. The students were asked to take the temperature of the water. The students poured $15cm^3$ of tetraoxosulphate (VI) acid slowly into the distilled water and stirred constantly. The students took the final thermometer reading of the solution. The peer tutors and their tutees discussed their findings after the activities.

The Researcher discussed the findings with the students and asked the students to represent the reactions that took place in the activities that were carried out with the ammonium salt and the tetraoxosulphate (VI) acid.

Group 1: $NH_4Cl_{(s)} + aq \longrightarrow NH4Cl_{(aq)}$ $\Delta H =$ positive

Group 2: $H_2SO_{4\,(l)} + aq \longrightarrow H_2SO_{4\,(aq)}$ $\Delta H =$ negative

The Researcher: When temperature is increased for a reversible reaction at equilibrium, the rate of endothermic reactions increase more than the rate of exothermic reaction and we say endothermic reaction is favoured by an increase in temperature. When temperature is decreased for a reversible reaction at equilibrium, the rate of the endothermic reaction decreases more than the exothermic reaction and we say endothermic reaction is disfavoured by a decrease in temperature The equilibrium position shifts in the direction favoured by a change in temperature and the concentration of reacting molecules increases in that direction.

To demonstrate the effect of temperature on equilibrium position, the Researcher took the students through the effect of heat on hydrated cobalt (II) chloride solution. The Researcher: Pink hydrated cobalt (II) chloride is a complex salt with the formula $[Co(H_2O)_6]Cl_2$. In aqueous solution, the complex cation $[Co(H_2O)_6]^{2+}$ interacts with Cl^- ions to form the $CoCl_4^{2-}$ complex anion represented by the equilibrium reaction as follows

$$[Co(H_2O)_6]^{2+}{}_{(aq)} + 4Cl^-{}_{(aq)} \rightleftharpoons CoCl_4^{2-}{}_{(aq)} + 6H_2O_{(l)},$$

pink **blue**

The Peer tutors and their tutees were asked to observed the colour of the solution and then heat the solution for about five minutes and record their observations. After the heating and the observation of the blue colour, students were asked to give explanation for their observations. Peer tutors led the discussions. Sample explanations from the students were as follows.

Group 1: heating causes the particles to expand.

Group 2: addition of heat shifts equilibrium position to the right so more products will be formed.

Group 3: addition of heat from Le Chatelier"s principle shifts equilibrium towards endothermic direction hence the blue colour.

Most of the students" explanations of the effect of temperature on the colour change of the cobalt (II) chloride salt upon heating was based on Le Chatelier"s principle. The students" conceptions on the effect of increasing temperature on the equilibrium system represented as $N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$, $\Delta H = +90.4kJ/mol$ was sought The peer tutors discussed with their tutees the effect of increasing and decreasing temperature on the equilibrium position for the equation above. After that the Researcher discussed the effects with the class.

4.3.2 Progression

The Researcher then distributed worksheets to peer tutors and their tutees to solve. The students were given five conceptual questions as outlined in Appendix F to answer with their peers. Peer tutors asked questions and tutees answered them. For example, the tutees were asked question on the reaction represented by the chemical equation $\mathbf{X\ (g) + Y\ (g) \rightleftharpoons Z\ (g);\ \Delta H = -50kJ.}$ Which of the reactions [forward or backward] is exothermic and why. The peer tutors expected the tutees to answer by saying forward reaction is exothermic and when asked why the tutees should be able to say because heat is evolved or released in forward direction. If the tutees made any mistakes, peer tutors point out where the problems were. If tutees could not correct the mistakes by themselves, peer tutors were responsible to provide some hints for the tutees. The peer tutor might write down a step or provide the hints verbally. For example peer tutors gave hints to their tutees like "what is the sign of the enthalpy change for the reaction" The peer tutors .participation became more active and the peer tutors did not merely check the answers. Besides, if tutees were able to provide the correct steps and answers, the peer tutors notify the tutees they have got the correct answer. Finally, if tutees were able to provide the correct answer or correct their own mistakes, the peer tutors praise the tutees to show their appreciation. Peer tutors needed to follow the prescribed teaching procedures closely and provide appropriate feedbacks The Researcher then went round to check whether the peer tutors were able to provide appropriate feedback to their tutees and to provide assistant to students having challenges with their tutoring materials. After 30 minutes of the peer tutoring, student were asked to resume their seats. The Researcher then discussed the questions with the class. The Researcher using an observation schedule observed appropriate feedbacks of peer tutors during the session. Table 3 shows observation made by the Researcher.

Table 3 Number of target behaviour observed during lesson three

Target behaviour (Appropriate feedbacks of peer tutors)	Number of observations
1. Notify tutees their answer is incorrect	2
2. Give hints to tutees	2
3. Inform tutees their answer is correct	7
4. Praise tutees when their answer is correct	5
5. Award marks to correct answers	6
Total observation	**23**

A total of 23 observations were made during the peer tutoring time. 2(13.3%) of peer tutors were observed notifying their tutees of their incorrect responses to the various questions. 2(13.3%) of the peer tutors gave hint to their tutees during the session. 7(46.7%) of the peer tutors were observed informing tutees their answers were correct. Out of this number 5(71.4%) praised their tutees for proving the correct responses and 6(40.0%) of the peer tutors awarded marks to correct answers.

Major findings 3

Students‟ participation in the peer tutoring during the lesson increased as activity oriented teaching method was used For notifying tutees of their incorrect answers, 13.3% of peer tutors were observed whiles 13.3% of the peer tutors were giving hint to their tutees. For correct responses, 46.7% of the peer tutors were observe. For praising tutees of their correct responses, 71.4% were observed. Those peer tutors who were observed for awarding correct marks was 40.0%

4.4.0. Lesson four

4.4.1 Procedure and interactions

Topic: The effect of changing pressure of reactants and products on the equilibrium systems

P.K.: Students can define gases

Chemistry concepts to be learnt:

- Increasing the volume of reaction vessel decreases the pressure of a system.
- Decreasing the volume of the reaction vessel increases the pressure of a system.
- Increase in pressure of a reaction system increases number of moles of gaseous species.
- Decrease in pressure decreases number of moles of gaseous species.
- Increase in pressure of an equilibrium reaction system, shifts equilibrium position to the direction that proceed with a decrease in number of moles of gaseous species.
- Decrease in pressure of an equilibrium system shifts the equilibrium position to the direction that proceed with an increase in number of moles of gaseous species.

During the introductory stage of the lesson, the students were asked to move to their tutoring stations. The Researcher wanted to see if students would be able to relate small volume of gases with high pressure and large volume of gases with low pressure. The peer tutors and their tutees were given two graphs. Graph 1: a graph of pressure against volume representing Boyle"s law. Graph 2: a graph of volume against temperature representing Charles law.

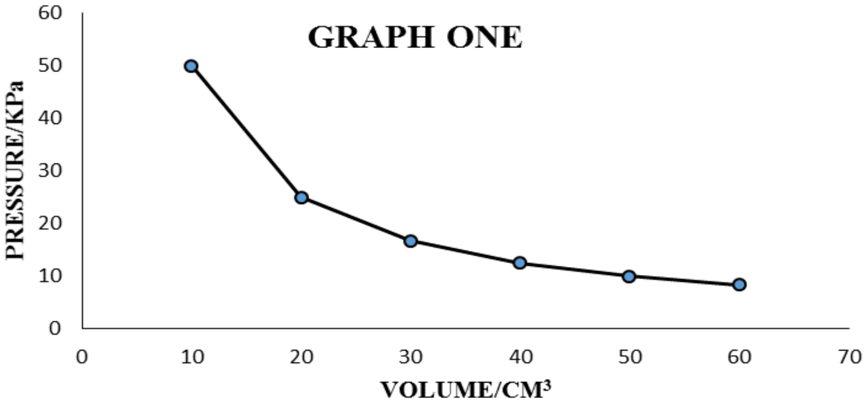


Figure 4: graph of pressure against volume of a gas

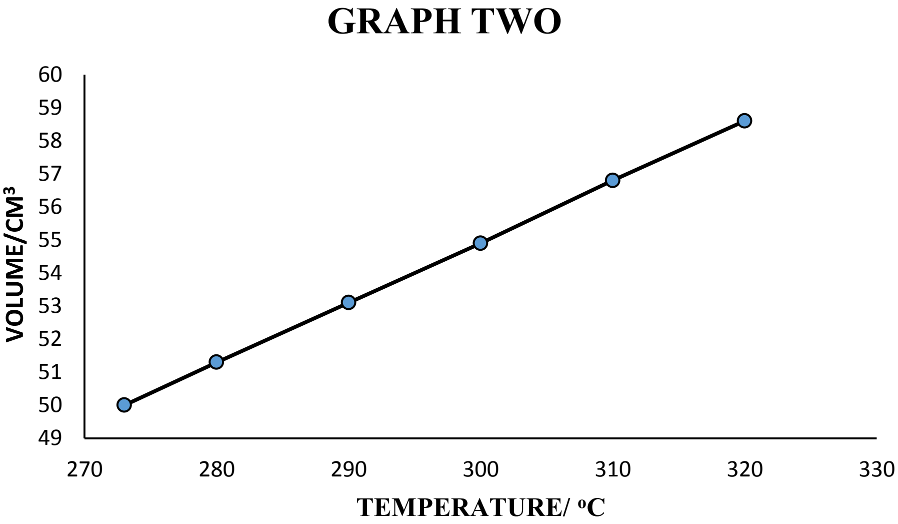


Figure 5: graph of volume against temperature of a gas

The peer tutors and their tutees studied and discussed the graphs, the students were asked to relate the volume of a gas to its pressure. The Researcher wanted to see if students would be able to relate small volume of gases with high pressure and large volume of gases with low pressure

The Researcher: What is the relationship between gas volume and its pressure?

Tutee 1: From graph 1, a gas with small volume would have a high pressure whiles a gas with larger volume would have low pressure this indicate Charles law.

The Researcher: You have tried but that is not Charles law.

Tutee 2: From graph 1, it is seen that ($P_1V_1 = P_2V_2$) increasing volume of a gas goes with low pressure and decreasing volume of gas goes with high pressure this follows Boyle‟s law.

The Researcher: That is good.

Using computer simulation the students were taken through predict observe and explain task. The student were then asked to predict the type of movement of gas particles in terms of slow, medium and fast as related to the gas volumes 30cm^3, 20cm^3 and 10 cm^3 with their peers. After the prediction, students viewed the computer simulation on a projected screen. Students recorded their observed description of the gas particle movement in their books. From their observation students relate the volume of the gas to its pressure. Upon checks by the Researcher on students‟ responses, it was observed that almost all the students had their predictions right.

The Researcher: The effect of volume change on equilibrium position is inversely proportional to that of pressure effect. Increasing the volume of reaction vessel means decreasing the pressure of the system and decreasing the volume of the reaction vessel means increasing the pressure of the system. Increase in pressure of a reaction system means increase in number of moles of gaseous species and decrease in pressure means decrease in number of moles of gaseous species. The volume of a gas at constant temperature and pressure is directly proportional to the amount of gas or number of molecules of the gas.

Using the reaction $\mathbf{2H_2}\,_{(g)} + \mathbf{O_2}\,_{(g)} \rightleftharpoons \mathbf{2H_2O}\,_{(g)}$ the peer tutors discussed with their tutees increasing pressure effect on equilibrium position, and then increasing volume effect on equilibrium position of the system and report their findings.

Group 1: increasing pressure of the system shifts equilibrium to the right since that is the direction with decrease in number of moles.

Group 2: increase in volume is the same as decrease in pressure, therefore equilibrium will shift to the left since that is the direction with more number of moles.

4.4.2 Progression

The Researcher then distributed worksheets to peer tutors and their tutees to solve. The students were given five conceptual questions as outlined in Appendix H to answer with their peers. Peer tutors asked the questions and tutees answered them. For example, the tutees were asked the question, what would be the effect of increasing pressure on the concentration of $SO_3\,_{(g)}$ in the system for the reaction $\mathbf{2SO_2\ (g) + O_2\ (g) \rightleftharpoons 2SO_3\ (g)\ \Delta H = }$ **negative** and why. The peer tutors expected the tutees to answer by saying equilibrium would shift to the right hence increased in concentration of $SO_3\,_{(g)}$ and when asked why the tutees should be able to say because when the pressure of an equilibrium reaction is increased, the equilibrium position shifts to the direction that proceed with a decrease in number of moles of gaseous species (decrease in pressure) such that the pressure of the system can be decreased. If the tutees made any mistakes, peer tutors point out where the problems were. If tutees could not correct the mistakes by themselves, peer tutors were responsible to provide some hints for the tutees. The peer tutor might write down a step or provide the hints verbally. For example peer tutors gave hints to their tutees like “which direction has the least number of moles” The peer tutors participation became more active and the peer tutors did not merely check the answer. Besides, if tutees were able to provide the correct steps and answers, the peer tutors notify the tutees they have got the correct answer. Finally, if tutees were able to provide the correct answer or correct their own mistakes, the peer tutors praise the tutees to show his/her appreciation. Peer tutors needed to follow the prescribed teaching procedures closely and provide appropriate feedbacks.

After 30 minutes peer tutoring, students moved back to their respective places and the Researcher discussed the questions with the class. The Researcher using an observation schedule observed appropriate feedbacks of peer tutors during the session. Table 4 shows observation made by the Researcher.

Table 4 Number of target behaviour observed during lesson four

Target behaviour (Appropriate feedbacks of peer tutors)	**Number of observations**
1. Notify tutees their answer is incorrect	1
2. Give hints to tutees	2
3. Inform tutees their answer is correct	8
4. Praise tutees when their answer is correct	5
5. Award marks to correct answers	4
Total observation	**22**

A total of 22 observations were made during the peer tutoring time by the Researcher. 1(6.7%) of the peer tutors were observed notifying their tutees of their incorrect response to questions. 2(13.3%) of the peer tutors gave hint to their tutees during the session. 8(53.3%) of the peer tutors were observed informing tutees their answers were correct. 5(33.3%) praised their tutees for correct responses whiles 4(26.7%) of the peer tutors awarded marks to correct answers.

Major findings 4

During the tutoring session, only 6.7% of the peer tutors were observed notifying tutees of their incorrect responses whiles 13.3% of the peer tutors were observed giving hint to their tutees .For correct responses, 53.3% of the peer tutors were observed notifying their tutees which indicated an improvement in students‟ response to conceptual

4.5.0. Lesson five

4.5.1 Procedure and interactions

Topic: Equilibrium constant K_c and K_p calculations

P.K.: Students can express K_c and K_p

Chemistry concepts to be learnt:

- K_c is an equilibrium constant calculated using the molarities of each reactant and product.
- K_p is an equilibrium constant calculated using the partial pressure of each reactant and product.
- The relationship between K_p and K_c is $K_p = K_c(RT)^{\Delta n}$
- K_c and K_p has no specific units.

During the introduction stage, the Researcher asked the peer tutors and their tutees to resume their respective places. The Researcher gave the students five equilibrium equations for them to write equilibrium constant K_c and K_p expressions for them.

The Researcher: Write down the K_c and K_p expressions for the following equations and predict the relationship between K_c and K_p.

- $PCl_{5\,(g)} \rightleftharpoons PCl_{3\,(g)} + Cl_{2\,(g)}$

- $N_2{}_{(g)} + 3H_2{}_{(g)} \rightleftharpoons 2NH_3{}_{(g)}$
- $H_2{}_{(g)} + I_2 (g) \rightleftharpoons 2HI_{(g)}$
- $CO_{(g)} + NO_{(g)} \rightleftharpoons CO_2{}_{(g)} + 1/2N_2{}_{(g)}$
- $CaCO3_{(s)} \rightleftharpoons CO_2{}_{(g)} + CaO_{(s)}$

The peer tutors and their tutees discussed the equations and helped each other in writing the K_c and the K_p expressions. The Researcher went round and inspected the work of the students. About 60% of the students were able to write the K_c and K_p expressions for the five equations based on their previous knowledge from lesson one. The Researcher then linked the K_c expressions with the ideal gas equation for the students.

The Researcher: One student should come and write the ideal gas equation on the board.

Student 1: $PV = nRT$.

The Researcher: That is good. Someone should also come and make pressure (P) the subject.

Student 2: $P = \frac{nRT}{V}$

The Researcher: Good. From your relation it means $P = [\ ] RT$. Do you agree?

Students: yes.

The Researcher: Write K_p expression for the equations using the partial pressure ($P = [\ ] RT$).

The Researcher went round to inspect work done by the peer tutors and their tutees. The students were thus guided by the Researcher in writing the K_c and K_p for the five equations besides using the ideal gas equation ($PV=nRT$). The Researcher: generally, $Kp = Kc (RT) \Delta n$ where Δn = total number of moles of gaseous products minus total number of moles of gaseous reactants, $Kp = Kc$ if $\Delta n = 0$. The Researcher assisted students to identify the relationship between K_c and K_p. The students compared their predicted relationship between K_c and K_p with the correct relationship between K_c and K_p expressions. The molar gas constant, R has the values: 8.314J mol^{-1} K^{-1} or 0.082atm dm^3 K^{-1} mol^1. A value of R = 0.082 atm dm3 K-1mol-1 or 8.2kPa dm3 K-1mol-1 agrees with the units for the Kc term.

For the reaction equation **H_2 (g) + I_2 (g) ⇌ 2HI (g)** the Researcher guided the students to determine the amount of substance that will react for each species and the amount of substance present at equilibrium for each species when 8.0 mols of H_2 (g) and 5.0 mols of I_2 (g) were mixed in a closed vessel and 9.06 mols of HI (g) was formed at equilibrium.

The Researcher: Someone should come and write the equation and the reaction moles.

Student 1:

H_2 (g) + I_2 (g) ⇌ 2HI (g)

8.0 5.0 0.0 (initial mols)

The Researcher: Well done. Another person should come and show amount consumed in the reaction.

Student 2:

H_2 (g) + I_2 (g) ⇌ 2HI (g)

8-(9.06/2) 5-(9.06/2) 9.06 (equilibrium mols)

The Researcher: That is right. What will be the amount left at equilibrium?

Student 3:

H_2 (g) + I_2 (g) ⇌ 2HI (g)

3.47 0.47 9.06 (equilibrium mols)

After equilibrium amounts have been established, the students were then guided to write the K_c and K_p expressions using the figures. The students then calculated the K_c and K_p values using the figures. Three girls and a boy who were not able to calculate the values. They were taken through the steps again by the Researcher. They were asked to try doing the work again which they did correctly. The students were guided by the Researcher to determine the unit for K_c and K_p by putting the various units into the expressions and cancelling them to come out with the final unit for K_c and K_p.

4.5.2 Progression

The Researcher then distributed worksheets to peer tutors and their tutees to solve. The students were given five conceptual questions as outlined in Appendix J to answer with their peers. Students engaged their peers to apply their current concepts learnt to solve problems on their work sheets. Peer tutors asked the questions and tutees answered them. For example, the tutees were asked the question to write the Kc and Kp and determine the relationship between Kc and Kp expression for the reaction equation $2CO\ (g) + O_2\ (g) \rightleftharpoons 2CO_2\ (g)$

The tutees were expected to write Kc as $\frac{[CO2]^2}{[CO]^2[O_2]}$ Kp as $\frac{P^2\,CO_2}{P^2CO.PO_2}$

But $P(CO_2) = [CO_2]^2\ (RT)^2$ $P(CO) = [CO]^2\ (RT)^2$ and $P(O_2) = [O_2]\ (RT)$

$$Kp = \frac{[CO_2]^2\ (RT)^2}{[CO]^2\ (RT)^2\ [O_2]\ (RT)}$$

$Kp = Kc\ (RT)^{-1}$

If the tutees made any mistakes, peer tutors point out where the problems were. If tutees could not correct the mistakes by themselves, peer tutors were responsible to provide some hints for the tutees. The peer tutor might write down a step or provide the hints verbally. For example peer tutors gave hints to their tutees like “[ ]” means concentration of reactants and products” The peer tutors participation became more active and the peer tutors did not merely check the answer. Besides, if tutees were able to provide the correct steps and answers, the peer tutors notify the tutees they have got the correct answer. Finally, if tutees were able to provide the correct answer or correct their own mistakes, the peer tutors praise the tutees to show their appreciation. Peer tutors needed to follow the prescribed teaching procedures closely and provide appropriate feedbacks. Points were awarded by peer tutors for correct calculated answers. During this period, the Researcher moved from group to group and observed how peer tutors were carrying out the peer tutoring. An orderly class environment was maintained throughout class wide peer tutoring sessions by continually monitoring and praising tutoring pairs who followed the laid down rules, and administering brief time-outs by having students put their pencils down for 15 to 30 seconds when classroom noise becomes excessive. After 30minutes of peer tutoring, the lesson came to an end after the Researcher took students through questions on their worksheets. Table 5 shows the observations made by the Researcher using observation schedule during the peer tutoring period.

Table 5: Number of target behaviour observed during lesson five

Target behaviour (Appropriate feedbacks of peer tutors)	Number of observations
1. Notify tutees their answer is incorrect	1
2. Give hints to tutees	3
3. Inform tutees their answer is correct	8
4. Commend tutees when their answer is correct	6
5. Award marks to correct answers	5
Total observation	**27**

A total of 27 observations were made during the peer tutoring time. 1(6.7%) of peer tutors were observed notifying their tutees of their incorrect response to questions. 3(20.0%) of the peer tutors gave hint to their tutees during the session. 8(53.3%) of the peer tutors were observed informing tutees their answers were correct. Out of this number 6(40.0%) praised their tutees for correct response whiles 5(33.3%) of the peer tutors awarded marks to correct answers.

Major findings 5

During the peer tutoring session, students" incorrect responses to questions were detected by peers and corrected immediately 6.7% of peer tutors were observed notifying their tutees of their incorrect responses. For giving hint to their tutees, 20.0% of peer tutors were observed whiles 53.3% were observed informing their tutees their answers were correct. For praising tutees of their correct responses to questions, 40.0% of peer tutors were observed whiles 33.3% of peer tutors awarded correct marks to questions answered correctly.

CHAPTER FIVE

DISCUSSIONS OF FINDINGS, IMPLICATIONS AND RECOMMENDATIONS

5.0 Overview

This chapter dealt with, discussions conclusion, recommendations, implications, and suggestions for further studies. The discussions were based on the findings identified in chapter four which happened to be the answers to the research questions. The implications of the findings of the study were also outlined. Out of the discussions some recommendations were made for teachers and curriculum planners. Finally suggestions were made for further studies.

5.1 Discussion of findings

The main purpose of this study was to find out the effect of class wide peer tutoring on students‟ science concept development in chemistry. The entire study took five weeks and a lesson lasted 80 minutes a week. It covered topics on chemical equilibrium. The success or otherwise of the class wide peer tutoring was based on the amount of interest generated and sustained by the lessons and the number of students who demonstrated the ability to answer questions correctly or otherwise. This was done during the lessons and at the tail end of the lesson with peer tutoring sessions where more oral and written questions in the form of exercises were given to students. The findings and observations made during the intervention lessons were used to discuss the research questions.

Research question 1: What is the role of teacher interventions in students' science concept development?

Research question 1 sought to find out the role of teacher interventions in students‟ science concept development. This research question was answered by the major findings 2 which indicated that there was an improvement in student-teacher and student-student interactions from one lesson to the other due the peer tutoring method, thus class wide peer tutoring instructional strategy employed by the Researcher during the classroom interactions that occurred within the five lessons taught. The student-teacher and student-student interactions increasingly improved as the lessons progressed. Students" interest in the lesson improved from lesson one to lesson five. As a result of these interactions through a constructivist approach, students were able to respond to conceptual questions correctly and gave appropriate explanations for their answers. According to Merriam et al. (2007), the constructivist theory argues that humans generate knowledge and meaning from an interaction between their experiences and their ideas. This theory is one of the most important educational theories used in arousing learner"s thinking and make students active, interactive and positive during the learning process.

The improvement in students" interest in the various lessons were due to the effective intervention procedures implemented by the Researcher which are essential to break the cycle of school failure. A review of instructional strategies that have shown to be effective with youth served in alternative education settings includes tutoring (Tobin & Sprague, 2000); for that matter Class wide peer tutoring. Class wide peer tutoring is an instructional strategy designed to effectively teach specific information to students with a variety of skill levels. Class wide peer tutoring is a well-researched instructional strategy that has proven effective for students with and without disabilities, and is one that helps prevent school failure (Greenwood & Delquadri, 1995).

This assertion reflected in the students" explanations during tutoring sessions. Students" confident level in answering questions had also risen. This was seen during the intervention lessons. After the intervention teaching, results of students" performance shows a significant effect of the intervention on students‟ achievement in the five exercises that was given to students. The intervention helped most of the low achievers in the class to improve on their performances. As the lessons were being developed week by week using the class wide peer tutoring with analogy and predict observe and explain, students began to interact with each other in class. Students‟ preconceptions about the evolution of the system as equilibrium is approached had changed after the intervention was put in. Students‟ preconceptions about conditions of reactants and product as equilibrium is established had also change after the intervention lesson.

Research question 2: What is the effect of class wide peer tutoring intervention in teaching science concepts to students?

Research question two sought to find out the effect of class wide peer tutoring intervention in teaching science concepts to students. This research question was answered by the major findings 3 which indicated that students‟ participation in the peer tutoring (class wide peer tutoring) during the lesson increased as activity oriented teaching method was used. The class was divided into two teams. Fifteen peer tutors and fifteen tutees. The students were paired for peer tutoring for thirty minutes after concepts to be learnt have been taught by the Researcher. The students in each team were paired with a partner from the same team for the week.

It is worth noting that of all tutoring formats, peer tutoring including class-wide peer tutoring variations, and has been studied empirically to have produced a validated evidence of effectiveness across all classroom levels (Lloyd et al., 1998). Greenwood et al. (1997) posited that in Class Wide Peer Tutoring (CWPT), a class is divided into two teams. Students in each team are paired with a partner from the same team for the week. Pairing can be set up randomly or by a student‟s skill. Teachers should monitor pairing and make appropriate adjustments (Greenwood et al., 1997). In addition, the pairs are engaged with instructional content (Heron et al., 2003). Peer tutors are trained and supervised by the classroom teacher (Greenwood et al., 2002).

Hence, pairing was by students" skill level. Peer tutors practiced questions on the concepts introduced in the lesson taught with their tutees. The peer tutors and their tutees work together to learn a specific set of concepts. Class wide peer tutoring was used to combine instructional components that include partner pairing, systematic content coverage, immediate error correction, frequent testing and team competition. Moreover, every student in the classroom is involved in the learning process with class wide peer tutoring, which allows them to practice basic skills in a systematic and fun way. This sustained the interest of the students throughout the lessons.

Delquadri et al. (1986) indicated that class wide peer tutoring utilizes an interdependent group contingency where students are held accountable for their performance. Class wide peer tutoring also involves content materials to be tutored, new partners each week, partner pairing strategies, teams competing for the highest team point total, contingent individual tutee point earning, tutors providing immediate error correction, score"s public posting and social recognition for the winning team.

During the period of the intervention, students activated their prior conceptions then a discussion environment was created with the help of the Researcher. The Researcher posed a problem for the students to predict the outcome of a demonstration before it is carried out. The Researcher asked peer tutors and their tutees to make their personal predictions. The students compared their predictions with each other before the conduction of the demonstration. The students observed the demonstration as it is being carried out. The students participated in a discussion facilitated by the Researcher for purpose of teaching the correct scientific concepts remediated any misconceptions.

The Researcher taught the concepts then the students peer tutored. As the tutees stated their answers to the conceptual questions asked by the peer tutors, the students became aware of their own conceptions through presentation to each other and by evaluation of those of their peers, the students became dissatisfied with their alternate conceptions, conceptual conflict begins to build. By recognising the inadequacy of their conceptions, the students became more open to changing them. Several researchers stated the importance of dissatisfaction of students‟ ideas for conceptual change (Hewson, 1992; Duit, 1999; Davis, 1997).

Data on the instructional effectiveness of Class wide peer tutoring have shown that students retain more of what they learn and make greater advances in social competence with Class wide peer tutoring compared to traditional teacher-led instruction (Greenwood et al., 1991; Mathes & Fuchs, 1993). A total of 112 target behaviours (appropriate feedbacks of peer tutors) were observed during the intervention period. This shows the level of peer tutors‟ involvement in the intervention teaching process.

Research question 3: To what extent can students' science concept be developed through class wide peer tutoring?

Research question three sought to find out the extent of students science concept development after the intervention. This research question was answered by the major findings 4 which stated that there was an improvement in students‟ response to conceptual questions through the use of class wide peer tutoring. Results in this study showed that class wide peer tutoring seemed to have positive effect on academic performance of second year chemistry students of Kpando Senior High

School. From the five intervention lessons taught it was seen that students" science concept development had improved drastically as depicted in the data collected and discussed.

Per the class wide peer tutoring approach implemented in the lessons taught, students" science concept on concentration of reactants, products and rate of reaction as chemical reaction approaches equilibrium state were developed which resulted in an overall improvement of students" concept development. When students are engaged in their own learning, they frequently have a better understanding of chemistry and of the role of chemistry in their daily lives. Furthermore, the lessons were more pleasing experiences both for teacher and students. Smith et al. (1993) noted that science teaching needs to develop conceptual understanding rather than rote memorization. In addition, an important goal of science teaching is to assist students as they come to understand important scientific concepts and relationships (Fellow, 1994).

According to Greenwood et al. (1997), the object of class wide peer tutoring is for students to learn weekly information that is presented and to demonstrate their understanding of this information on assessments. Typically, knowledge would be low (for example, 20-40% correct) on the pre-test and increase to 90-100% correct (average) on the post-test (Greenwood et al., 1997). The use of class wide peer tutoring provides the opportunity for students to be paired with a peer partner in one-to-one instruction, opportunities for error correction, earning points for correct responses, increased time spent on academic behaviours, increased positive social interactions between students that would not typically occur, encouraging students to work together (an important life skill), and helping students experience more success and feel more confident (Arreaga-Mayer, 1998). As a teaching strategy, Class wide peer tutoring has proven effective for improving students‟ test performance and accuracy (Kamps et al., 1994). Also, Class wide peer tutoring tend to produce validated evidence of effectiveness across content areas of which science is not an exception in order to supplement the instruction of students.

5.2 Summary of findings

This study sought to find out the effect of class wide peer tutoring on students‟ science concept development in chemistry. The findings of the study included the following:

Most peer tutors were able to notify their tutees of their incorrect and correct responses to conceptual questions asked them.

Peer tutoring sessions helped improved student-student interaction as peer tutors were able to ask their tutees a lot of conceptual questions.

Student‟s participation in the peer tutoring increased as activity oriented teaching method was used for the class-wide peer tutoring.

Peer tutors were able to give hints to their tutees to be able to answer conceptual questions correctly.

Students‟ incorrect responses to conceptual questions were detected by peer tutors and corrected immediately.

5.3 Implication of findings

The use of analogies, predict observe and explain to teach with class wide peer tutoring helped students to respond correctly to conceptual questions.

Adequate preparation of tutoring materials facilitated student‟s interaction with materials and their peers.

Activity methodology used in the class wide peer tutoring helped students to express their understanding of the concepts learnt.

Students to serve as peer tutors in class wide peer tutoring were trained to focus on the procedures of class-wide peer tutoring.

Early realisation of mistakes and corrections encouraged students to learn actively and have better academic performance.

5.4 Conclusion

Although this study is limited by the fact that the study was carried out in only one school in Kpando municipality in Ghana, some conclusions could be drawn regarding how class wide peer tutoring is used with analogy and predict observe and explain to develop students‟ science concepts in some selected topics in chemistry. On the basis of the results obtained in this study, it is concluded that more chemistry topics can be taught using class wide peer tutoring for effective concept development in science. Science teachers are therefore encourage to use class wide peer tutoring in their teaching strategies for better concept developments.

5.5 Recommendations

Based on the findings of the study, the following recommendations are given.

1. Owing to the limited time in each lesson, tutoring time can only be allocated in double lessons, so the tutoring time can be lengthened to 30 to 40 minutes. Or tutoring time is given for the whole period of a single lesson on one day with limited teacher's demonstration or illustration, but on the other day, no tutoring time is scheduled but only teacher's demonstration and illustration.

2. Although class wide peer tutoring may not be implemented daily but the total tutoring time can be lengthened.

3. Ideally, researcher should not act as the teacher of the study or the marker of the weekly test. The role conflict might affect the performance of teacher and the objectivity of marker. In turn, it might affect the reliability of the study. Hence,

researcher should frequently remind himself to perform their duties of teacher and marker as objective as he could.

4. Teachers should make it a point to use analogies, models and insightful activities in teaching science subjects especially chemistry. This could help students to respond to deep thinking questions promptly and correctly.

5. Students should be encouraged to participate in the development of lessons. They should be encouraged to interact with each other and the teacher to improve their understanding.

6. Questions given to students should involve more of thought provoking ones than simple recall.

7. Before instructing science students on chemical equilibrium, teachers should first find out students‟ alternate conceptions about chemical equilibrium. Teaching should then proceed with restructuring of students‟ ideas through analogies and discussions.

8. When teaching science students how acid – base indicators change colour in acid or base solution, chemistry teachers should explicitly draw students‟ attention to the chemical nature of indicators and how the indicators species interact with acids and bases to bring about colour change since students may be unaware of this. The teacher should let students realize that acid – base indicator solutions are chemical equilibrium systems and so equilibrium principles apply to them.

9. When teaching exothermic and endothermic reactions, chemistry teachers should not only give the definitions of the terms to students; they should help students identify exothermic and endothermic reactions on the reaction profile graphs as well as in equations of reversible reactions

10. Chemistry teachers should use the disc analogy in teaching chemical equilibrium to science students. Teachers must not rush through such lesson; they should proceed slowly so that low achievers can also understand what the analogy is trying to explain.

11. Chemistry teachers should use discussions supported by predict observe and explain demonstration of the effect of temperature on hydrated cobaltious chloride salt to help students construct how a change in temperature affects the equilibrium system.

5.6 Suggestion for further studies

This study was undertaken to unearth the effect of class wide peer tutoring on students‟ science concepts development in science. Teacher-students interactions, student-student interactions and the use of the analogy and predict observe and explain were closely observed for a period of five weeks. The following suggestions are made for further studies:

1. There was only one class with thirty students who participated in this study and so the sample size is small and the study may not represent the generality, thus .further studies can be conducted on a similar topic but with a greater sample size.
2. Further studies could be conducted in other science subject areas (physics, biology and integrated science) using class wide peer tutoring in developing students science concepts.
3. Study could also be done to find out if class wide peer tutoring works better for boys or girls.
4. Again the attitude of science teacher towards the use of innovative science teaching methods like class wide peer tutoring in class could be study.

5. Future research should consider the effect of class wide peer tutoring on students‟ science concept development for low achievers in Senior High School.

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APPENDIX A

LESSON ONE

Subject: Chemistry.

Duration: 80 minutes.

Topic: Chemical equilibrium.

Sub-Topic: Nature of dynamic equilibrium and the equilibrium constant

Objectives: By the end of the lesson students should be able to;

- explain reversible chemical reaction.
- explain how the concentration of reactants and products change prior to and upon attainment of equilibrium.
- explain how the rates of forward and reverse reactions change prior to and upon the attainment of equilibrium.
- explain the significance of the equilibrium constant
- Write the correct K_{eq} expression for different types of equilibrium systems

Relevant previous knowledge:

Students can mention the types of chemical reactions

Introduction (5 minutes)

Teacher pair peer tutors and their tutees and explain reversible reactions to students

Teacher/Students Activity: Simulating dynamic equilibrium. (35 minutes)

- Guide students to perform the activity, simulating dynamic equilibrium.
  a) Write the equilibrium reaction. $A (g) \rightleftharpoons B (g)$ on the chalkboard. Use blue chalk for the reactant and yellow chalk for the product.
  b) Discuss the similarities and the differences of the analog (discs) to the target concept with students:

Analog	Target
7. number of blue discs	concentration of reactants
8. number of yellow discs	concentration of products
9. time the turning of discs started	start of the chemical reaction
10. at the start: only blue discs are present	at the start of the reaction only reactants are present
11. during the turning of the discs From blue to yellow From yellow to blue	forward and backward reaction are taking place. Therefore the reaction is reversible
12. number of discs turned/min	
From blue to yellow	rate of forward reaction
From yellow to blue	rate of backward reaction

c) stress that not all the properties of the analog represents the properties of the system

- Explain the aim of the analogy to students. The analogy is intended to :
  a) show how the concentration of reactants and products change as the system approaches equilibrium
  b) Show the constancy of the concentration of reactants and products as the equilibrium is attained.
  c) Show how the rate of the forward and backward reaction change prior to and after the attainments of equilibrium
  d) Emphasize that more often the concentration of reactants and products are not equal at equilibrium
- Follow up with a class discussion using the analogy to explain the behavior of reversible reactions prior to and when equilibrium is attained.

- Use iodine in potassium iodide with tetrachloromethane to demonstrate to student dynamic equilibrium.
- Using students" previous knowledge in rate of reaction guide them to derive the mathematical expression for the equilibrium constant K_{eq} using the rates of reactions and their rate laws.
- Let students predict when they expect Keq to be equal to 1, greater than 1 and less than 1
- Discuss the relationship between K_{eq} and the position of equilibrium. Stress that a large value of the equilibrium constant shows that products are more plentiful in the system and that a very small value of the equilibrium constant shows that reactants are more plentiful in the system
- Introduce the students to the different ways of expressing the equilibrium constant for both homogeneous and heterogeneous systems.
- Explain the role of catalyst in an equilibrium reaction to students

Peer Tutoring Time (30 minutes): Let students seat at their tutoring stations and work in pair.

Give five conceptual questions to students to answer with their peer tutors

Teacher goes round to observe how the peers are tutoring their tutees and give assistant to students having problem with their peers.

Evaluation :(10 minutes)

Teacher discusses student"s answers with the class.

Core Points

- Reversible reactions are chemical reactions where the reactants form products that in turn, react together to give the reactants back. Reversible reactions will reach an equilibrium point where the concentrations of the reactants and products will no longer change.

- Chemical equilibrium is not static but dynamic. This means there is no instance that the reactions stop after they have started so far as the system is closed.
- Equilibrium can be reached from either side. This means the reaction can start with products and proceed to equilibrium or from reactants and proceed to equilibrium
- At the start when no time has elapsed (time is equal to zero) the system contains only reactant molecules.
- As the reactions proceed from the start towards equilibrium,
    a) the concentration of reactant(s) decrease(s) and the concentration of product(s) increase(s)
    b) the rate of forward reaction decreases while the rate of the reverse reaction increases
- when a reversible reaction attains equilibrium,
    a) The concentration of both the reactants and products remain constant.
    b) The observable (macroscopic) properties of the system do not change.
    c) The rate of the forward reaction is equal to the rate of the backward reaction
- The equilibrium constant K_{eq} is the ratio of the rate constant for the forward reaction (k_f) to the rate constant for the backward reaction (k_b).

$$K_{eq} = \frac{k_f}{k_b}$$

- The values of the equilibrium constant K_{eq} indicates whether there are more reactants or products in the system at equilibrium, or the extent of the reaction. If: K_{eq} is greater than $10^{2,}$ there will be far more products than reactants.

  K_{eq} is less than 10^{-2}, there will be far more reactant than products

  K_{eq} is between 10^{-2} and 10^{2}, both reactants and products will be in the system in noticeable amounts.
- A catalyst speed up the rate of both the forward and reverse reactions
- A catalyst does not affect the equilibrium position.

APPENDIX B

EXERCISE ONE

Answer all questions

A mixture of nitrogen (II) oxide gas and chlorine gas is place in a closed container.

$$2\ NO\ (g) + Cl_2\ (g) \rightleftharpoons 2\ NOCl\ (g) + heat$$

State in terms of increases or decreases how each of the following variables changes as the reaction approaches equilibrium

1. The concentration of Cl_2 (g)

   ………………………………………………………………………………………

   why………….……………………………………………………………………

2. The concentration of NOCl (g).

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why………………………………………………………………………………………..

3. The rate of the forward reaction.

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4. The rate of the backward reaction.

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5. What happens to reactants and products when a reversible reaction attains a state of equilibrium?

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APPENDIX C

LESSON TWO

Subject: Chemistry.

Duration: 80 minutes.

Topic: Chemical equilibrium

Topic: The effect of changing the concentration of reactants and products on the equilibrium systems

Objectives: By the end of the lesson students should be able to;

- Predict the direction of shift of the equilibrium position when the concentration of a reactant or product is changed for homogenous and heterogeneous equilibrium systems.

Introduction :(5minutes)

Students demonstrate the effect of concentration on chemical equilibrium using aqueous potassium thiocyanate solution and iron (III) trioxonitrate (V).solution of various concentrations.

Teacher activity (35minutes)

Obtain the following materials: A 200cm^3 beaker, four test tubes in a rack, solid phenolphthalein, spatula, 0.1M NaOH solution, 0.1M HCl solution, a stirrer a wash bottle full of distilled water and four dropping pipettes.

- Measure 100cm^3 of distilled into the beaker
- Add some phenolphthalein powder to the beaker and stir to dissolve.
- Add enough to make the solution saturated.
- Add some drops of the aqueous sodium hydroxide solution to raise the pH of the solution to about 9.
- At this pH the solution is slightly pink. You can check this by using a universal indicator.

Measure about 3cm^3 of the phenolphthalein solution into each of the four test tubes.

- Keep one of the solutions in the test tube as a control.
- Tell the students that you are going to add five drops of each reagent to the phenolphthalein solutions in the test tubes
- Tell students that before each addition they should independently predict what colour change they expect to observe and write down why they think they would observe the colour change they predicted.
- Tell students to record their answers in **Table 1** on their worksheets

Activity one: To one of the test tubes, add five drops of 0.1M NaOH solution

Activity two: To another test tube add 0.1M HCl solution

Activity three: To another test tube add about 2cm^3 of the phenolphthalein solution

- Perform the demonstrations and allow students to observe and explain their observation.
- Tell students to make amendments or change their ideas in the amendment of initial explanation column. After each demonstration, present the scientific explanation of the observed colour change
- Discuss with the whole class how Le Chatelier‟s principle applies, where it applies and where it does not apply.

The phenolphthalein indicator solution:

Acid-base indicators are either weak acids or weak alkalis. They dissociate very slightly to give ions with marked colour difference from the undissociated molecule. For example, phenolphthalein is a weak acid and its formula can be represented as HX. Its dissociation in water is shown below:

$$HX(s) \rightleftharpoons H^+(aq) + X^-(aq)$$

Colourless **Pink**

a) Read about the indicator solution and study the equation that follows carefully.

b) Teacher add about five drops of each reagent to one test tube containing the phenolphthalein solution.

c) Before each addition write down independently the new colour you expect to observe upon the demonstration and write down why you think you would observe the colour you predicted in **Table 1** below. Provide the best explanation as much as possible.

d) Observe the demonstration and note the new colour.

e) If the new colour is different from what you predicted provide another explanation that best explains the new observation. All answers should be written in the table

Table 1

Experiment	Predicted observation	Explanation.	Actual observation	Explanation
(I)Phenolphthalein solution+ drops of NaOH(aq)				
(II)Phenolphthalein solution + drops of HCl(aq)				

- Ask students to articulate how their initial ideas about the effect of changing the concentration of a reactant or product on the equilibrium system. Ask students to explain how the activities in the lesson have help to bring about this change.

Peer Tutoring Time (30 minutes)

- Students engage their peers to apply their current understanding to solve the problems on their worksheet.
- Teacher goes round to observe how the peers are tutoring their tutees and give assistant to students having problem with their peers.

Evaluation (10 minutes)

Teacher discusses student‟s answers with the class.

Core Points

- Homogeneous systems are those in which reactants and products are in the same phase. For example, $A\ (aq) + B\ (aq) \rightleftharpoons C\ (aq) + D\ (aq)$. Here all the equilibrium components are in the aqueous state
- $A\ (g) + B\ (g) \rightleftharpoons C\ (g) + D\ (g)$. Here all the equilibrium components are in the gaseous phase.
- Heterogeneous systems are those in which some of the components are in different phases from others. For example $A(s) + B\ (g) \quad C(s) + D\ (g)$. Here reaction components A and C are in the solid phase, and reaction components B and D are in the gaseous phase. $A\ (aq) + B(s) \rightleftharpoons C\ (aq) + D(s)$. here reaction components A and C are in the aqueous phase and components B and D are in the solid phase
- For heterogeneous systems pure solids and liquids are not considered as part of the equilibrium system because at equilibrium the system becomes saturated with the solid or liquid. Addition of a pure solid or liquid component of the system to the system at equilibrium only increases the amount of the component already in the system. As a result addition of pure solid or liquid to

system do not alter the concentration of the system‟s components and therefore these pure solid and liquids components do not appear in the equilibrium constant expression. Similarly the addition of inert gas to gaseous phase reactions does not alter the partial pressures of gaseous reactants and products the system.

- For homogenous equilibrium systems, when the concentration of a reactant or product is changed, the equilibrium position shifts in the direction of less concentration as a result of the change in order to re-establish equilibrium.
- For heterogeneous equilibrium systems, when the concentration of a pure solid or liquid is altered it does not affect the equilibrium position.

APPENDIX D

EXERCISE TWO

Answer all questions

6. What would be the effect of adding dilute NaOH solution to the equilibrium position in the system $H_2O + CH_3COOH \rightleftharpoons CH_3COO^- + H_3O^+$ and why?

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7. Which direction will equilibrium shift to if more $H^+_{(aq)}$ is added to the system above and why……………………………………………………………………………

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8. You are given a 0.100M acetic acid (CH_3COOH) solution. The following equilibrium exists in the solution $CH_3COOH\ (aq) + H_2O\ (1) \rightleftharpoons CH_3COO^-(aq) + H_3O^+\ (aq)$

Solid sodium acetate is then added to the acetic acid solution. Sodium acetate is a source of the acetate ion, CH_3COO^-. What will eventually happen to the concentration of H_3O^+ (aq) and why?

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9. $NiO\ (s) + CO\ (g) \rightleftharpoons Ni(s) + CO_2\ (g)$ is exothermic. How would addition of NiO (s) to the system affect the equilibrium position?

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10. At the instance when no time has elapse (time is equal to zero) what is the concentration of reactants and products?

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APPENDIX E

LESSON THREE

Subject: Chemistry.

Duration: 80 minutes.

Topic: Chemical equilibrium

Sub-Topic: The effect of temperature change on equilibrium systems

Objectives: By the end of the lesson students should be able to;

- Identify Exothermic and endothermic reactions in a reversible reaction from the thermochemical equation
- Explain how changes in temperature affect the rate of exothermic and endothermic reaction of the equilibrium reaction
- Predict the direction of shift of the equilibrium reaction following a change in temperature

Introduction: (5 minutes)

Let students move to their tutoring stations

Explain to students exothermic and endothermic reactions.

Teacher / student activity (35 minutes)

Give the following to students; distilled water, measuring cylinder, stirrer, spatula, thermometer, ammonium chloride, and concentrated tetraoxosulphate (VI) acid

Peer tutors and their tutees demonstrate exothermic and endothermic reactions using ammonium chloride and concentrated tetraoxosulphate (VI) acid in distilled water.

Teacher discusses findings with the students.

Teacher explain to student the effect of temperature on an equilibrium position.

- Obtain the following materials: some crystals of hydrated cobalt (II) chloride, $[Co(H_2O)_6]Cl_2$ salt, a150cm^3 beaker, distilled water, ice chunks a spatula and Bunsen burner.

- Weigh 10g of the cobaltous chloride salt into the beaker.
- Fill the beaker with water up to the 20cm^3 mark and stir to dissolve the salt.
- Show the solution to students and ask them to observe and record the colour of the solution
- Ask students to carry the activities with their peers.
- Ask students to read the passage about the hydrated cobalt (II) chloride salt and respond to the questions that follow on their activity sheet.

The hydrated cobalt (II) chloride solution:

Pink hydrated cobalt (II) chloride is a complex salt with the formula $[Co(H_2O)_6]Cl_2$. In aqueous solution, the complex cation $[Co(H_2O)_6]^{2+}$ interacts with Cl^- ions to form the

$CoCl_4^{2-}$ complex anion represented by the equilibrium reaction:

$$[Co(H_2O)_6]^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons CoCl_4^{2-}(aq) + 6H_2O(l), \quad \Delta H = -Z\,\mathbf{kJ}$$

pink **blue**

Ask students to indicate in which reaction (forward or backward) is

1. Heat given out to the surrounding (exothermic)
2. Heat absorbed by the system (endothermic)

Ask students to provide explanation for their answers.

Activity 1

- Ask the students to write down the new colour that would be observed if the solution in the beaker is heated on the Bunsen burner for about five minutes.
- Ask them to provide the best explanation as possible to their predicted observation and discuss these with their peers.
- Place the beaker of solution on the Bunsen burner for about five minutes.
- Allow time to focus on observation.

- Ask students to write down what they do observe.
- Ask students to amend or add to their explanation to take account of the observation.
- Present the scientific explanation of the observation to students ask them to compare this to their ideas judge which of them is more sensible
- Ask the students to independently write down the new colour that would be observed if the solution in the beaker is placed in the ice bath for about five minutes.
- Ask them to provide the best explanation as possible to their predicted observation and discuss these with their peers.

Peer tutoring time (35 minutes)

Students engage their peers to apply their current understanding to solve the problems on their worksheet

Teacher goes round to observe how the peers are tutoring their tutees and give assistant to students having problem with their peers.

Evaluation :(10 minutes)

Teacher discusses student"s answers with the class.

Core Points

For a reversible reaction such as, $A(g) + B(g) \rightleftharpoons C(g) + D(g)$, $\Delta H = -$ kJ

a)The forward reaction is exothermic because the sign of the enthalpy change for the forward reaction is negative or the system releases heat to the surrounding.

b)The backward reaction is endothermic or absorbs heat from the surrounding because it is the reverse of exothermic reaction c)When temperature is increased for a reversible reaction at equilibrium, the rate of endothermic reactions increase more than the rate of exothermic reaction and we say endothermic reaction is favoured by an increase in temperature.

d)When temperature is decreased for a reversible reaction at equilibrium, the rate of the endothermic reaction decreases more than the exothermic reaction and we say endothermic reaction is disfavoured by a decrease in temperature

e)The equilibrium position shifts in the direction favoured by a change in temperature and the concentration of reacting molecules increases in that direction, shows the extent of the reaction and will increase or decrease depending on which reaction is favoured by an increase in temperature.

APPENDIX F

EXERCISE THREE

Answer all question.

For the reaction represented by the equation

$$\mathbf{X\,(g) \quad + \quad Y\,(g) \rightleftharpoons Z\,(g);\ \Delta H = -50kJ.}$$

11. Which of the reactions [forward or backward] is?

Exothermic …………………………………………………………………….

Why ………………………………………………………………………………

Explain how each of the following variables changes when temperature is increased

12. Concentration of X ……………………………………………………………..

Why ………………………………………………………………………………….

13. Concentration of Z ……………………………………………………………...

Why ……………………………………………………………………………………

14. Consider the reaction $\mathbf{3O_2\,(g) \rightleftharpoons 2O_3\,(g)}$; enthalpy change is +284 KJmoi^{-1}

What happens to the ozone (O_3) concentration when temperature is lowered?

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Why ……………………………………………………………………………………

15. What will be the effect on equilibrium constant in term of magnitude when temperature is lowered for the equation above?

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Why……………………………………………………………………………………

APPENDIX G

LESSON FOUR

Subject: Chemistry.

Duration: 80 minutes.

Topic: Chemical equilibrium

Sub-Topic: The effect of changing pressure of reactants and products on the equilibrium systems

Objectives: By the end of the lesson students should be able to;

- Predict the direction of shift of the equilibrium position when volume of a reactant or product is changed for homogenous (gases) equilibrium systems.
- Predict the direction of shift of the equilibrium position when pressure of a reactant or product is changed for homogenous equilibrium systems.

Relevant previous knowledge:

Students have learnt about volume and pressure of gases.

Introduction (5minutes)

Let students relate the volume of a gas to its pressure using graphs.

Teacher/student activity (35 minutes)

Teacher demonstrate to student the effect of changing volume of a gas on its kinetic energy using computer simulation.

Worksheet 1

Let students predict the type of movement of gas particles in terms of slow, medium and fast as related to the gas volumes 30, 20 and 10 $cm^{3.}$

Let them watch the simulation and record the observed description of the gas particle movement in their worksheets

Let student relate the volume of the gas to its pressure from their observation

What happens to pressure of gas when volume of a gas is increase and what happens when volume of a gas is decrease?

Volume of gas on computer/cm^3	Predicted description of movement of gas	Observed description of movement of gas
30		
20		
10		

Relate Avogadro‟s law to number of particles of gas present in gas phase.

Using the reaction $\mathbf{2H_2}_{(g)} + \mathbf{O_2}_{(g)} \rightleftharpoons \mathbf{2H_2O}_{(g)}$ let students predict increasing and decreasing pressure effect on equilibrium position, then increasing and decreasing volume effect on equilibrium position.

Discuss the answer with students after their predictions.

Peer Tutoring Time (35 minutes): Let students pick their peer tutors and tutees and work in pair.

Teacher goes round to observe how the peers are tutoring their tutees and give assistant to students having problem with their peers.

Evaluation (10 minutes)

Discuss the various answers with the class.

Core Points

There is negligible effect of pressure on equilibrium system which do not contain gases.

- The effect of volume change on equilibrium position is inversely proportional to that of pressure effect.
- Increasing the volume of reaction vessel means decreasing the pressure of the system and decreasing the volume of the reaction vessel means increasing the pressure of the system.

- Increase in pressure of a reaction system means increase in number of moles of gaseous species and decrease in pressure means decrease in number of moles of gaseous species.
- When the pressure of an equilibrium reaction is increased, the equilibrium position shifts to the direction that proceed with a decrease in number of moles of gaseous species (decrease in pressure) such that the pressure of the system can be decreased.
- On the other hand if pressure of a system is decreased, the equilibrium position shifts to the direction that proceed with an increase in number of moles of gaseous species (increase in pressure) so that the pressure of the system can be increased again.
- In both cases the equilibrium constant remains the same provided the temperature is kept constant.

APPENDIX H

EXERCISE FOUR

Answer all questions

For the reaction **$2SO_2 (g) + O_2 (g) \rightleftharpoons 2SO_3 (g)$ ΔH = negative**

16. What is the effect of increasing pressure on the concentration of SO_3 (g) in the system?

…………………………………………………………………………………………

Why……………………………………………………………………………………

17. Decreasing the volume of the reaction vessel will shift the equilibrium position to…………………………………………………………………………………

Because…………………………………………………………………………………

18. What happens when the volume of the reacting vessel is increase?

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Why……………………………………………………………………………………

For the reaction **$3H_2 (g) + N_2 (g) \rightleftharpoons 2NH_3 (g)$ ΔH = $-92KJmol^{-1}$**

19. What effect will increase in pressure have on the yield of ammonia?

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Why…………………………………………………………………………………..

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20. Will an increase in volume of the reacting vessel have an effect on equilibrium constant?

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Why……………………………………………………………………………………

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APPENDIX I

LESSON FIVE

Subject: Chemistry.

Duration: 80 minutes.

Topic: Chemical equilibrium

Sub-Topic: Equilibrium constant Kc and Kp calculations.

Objectives: By the end of the lesson students should be able to;

- write and determine the relationship between Kc and Kp
- calculate equilibrium constant Kc and Kp for given reactions
- calculate quantities present at equilibrium given appropriate data.

Relevant previous knowledge:

Students can write the types of equilibrium constants in previous lesson.

Students can define gases and writethe ideal gas equation.

Introduction :(5minutes)

Give five equilibrium reactions both homogeneous and heterogeneous to students to write the Kc and Kp expressions for them.

For the five equilibrium reactions let students predict the relationship between Kc and Kp for each.

Teacher/Student activity (35 minutes)

By the use of the ideal gas equation, PV= nRT, which implies that P = (n/V) RT, Partial pressure (P) can be express as P = [ ] RT where [ ] represent concentration of species.

Let students rewrite the Kp expressions for each equation using the partial pressure expression in terms of [ ] RT for all the five equations.

- $PCl_5 (g) \rightleftharpoons PCl_3 (g) + Cl_2 (g)$
- $N_2 (g) + 3H_2 (g) \rightleftharpoons 2NH_3 (g)$
- $H_2 (g) + I_2 (g) \rightleftharpoons 2HI (g)$
- $CO (g) + NO (g) \rightleftharpoons CO_2 (g) + 1/2N_2 (g)$

- CaCO3 (s) ⇌ CO_2 (g) + CaO (s)

Let students compare the written Kp with Kc and find if any similarity between Kc and Kp exist.

Teacher help students to relate Kp with Kc

Let student compare their predicted relationship between Kc and Kp with the correct expressions

Using the reaction equation PCl_5 (g) ⇌ PCl_3 (g) + Cl_2 (g), assuming that the initial concentration is C moldm^{-3} and the amount that dissociate at equilibrium is x moldm^{-3}, guide students to calculate both Kc and Kp in terms of x and determine their units.

PCl_5 (g) ⇌	PCl_3 (g) +	Cl_2 (g)	
C	0.0	0.0	(initial mols)
C-x	x	x	(equilibrium mols)

For the reaction equation H_2 (g) + I_2 (g) ⇌ 2HI (g) guide students to determine amount of substance that react for each species and amount of substance present at equilibrium for each species when 8.0 mols of H_2 (g) and 5.0 mols of I_2 (g) were mixed in a closed vessel and 9.06 mols of HI (g) was formed at equilibrium.

H_2 (g) +	I_2 (g) ⇌	2HI (g)	
8.0	5.0	0.0	(initial mols)
8-(9.06/2)	5-(9.06/2)	9.06	(equilibrium mols)
3.47	0.47	9.06	(equilibrium mols)

Peer tutoring time (35minutes)

Students engage their peers to apply their current understanding to solve the problems on their worksheet

Teacher goes round to observe how the peers are tutoring their tutees and give assistant to students having problem with their peers.

Evaluation (10 minutes)

Teacher discusses student‟s answers with the class.

Core Points

- Equilibrium quotient. The term on the right-hand side of the mathematical form of the law of mass action is referred to as the equilibrium quotient. It contain only concentration or partial pressures
- Whether the equilibrium constant carried units or not depends upon the form of the equilibrium quotient.
- The concentration of a gas is most easily expressed in terms of its pressure. This is why equilibrium constants for gaseous reactants are expressed by the pressure of the gases.
- From the general ideal gas equation, p = nRT/V = cRT, where c = concentration of the gas in moldm^{-3}.
- At constant temperature , the pressure of a given gas is proportional to its concentration
- Generally, Kp = Kc (RT) $^{\Delta n}$ where Δn = total number of moles of gaseous products minus total number of moles of gaseous reactants, Kp = Kc if Δn = 0.Units of R must be chosen such that it agrees with the expression of Kc as a molar concentration term.
- The molar gas constant, R has the values: 8.314J mol^{-1} K^{-1} or 0.082atm dm^{3} K^{-1} mol^{1}. A value of R = 0.082 atm dm3 K-1mol-1 or 8.2kPa dm3 K-1mol-1 agrees with the units for the Kc term.

APPENDIX J

EXERCISE FIVE

Answer all questions

21. For the reaction 2CO (g) + O_2 (g) ⇌ 2CO_2 (g) write the Kc and Kp and determine the relationship between Kc and Kp expression for the equation.

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22. For the reaction N_2O_4 (g) ⇌ 2NO_2 (g) determine the Kc and Kp units for the reaction.

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23. When one mole of pure ethanol is mixed with one mole of ethanoic acid at room temperature, the equilibrium mixture contains 2/3 of a mole each of the ethylethanoate and water.

Calculate the equilibrium constant Kc for the reaction.

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24. Calculate the number of moles of the ethanoate formed at equilibrium at room temperature when 3 moles of the ethanol are mixed with 1 mole of the ethanoic acid.

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25. For the reaction PCl_5 (g) ⇌ PCl_3 (g) + Cl_2 (g) if the initial concentration is C moldm^{-3} and the amount that dissociate is x moldm^{-3}. Write down the Kc expression in terms of x.

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