ISSN 2250-3153

Investigating Into Students' Challenges During Teaching And Learning Of Acid-Base Titration Practical: A Study At Berekum Presbyterian Senior High School In The Bono Region Of Ghana

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DOI: 10.29322/IJSRP.11.05.2021.p11359
http://dx.doi.org/10.29322/IJSRP.11.05.2021.p11359

Abstract- This study sought to find out students' challenges face during the teaching and learning of acid-base titrition. The research design used the study was a case study. The study took place at Berekum Presbyterian Senior High Schools in the Bono Region of Ghana. This study adopted social constructivism theory of learning. The social constructivism involves the engagement of students in a process of shared meaning-making, guided by the teacher. The target population in the study consisted of thirty chemistry final year students of 2014 / 2015 academic year from Presbyterian Senior High School Berekum in the Brong Ahafo Region. The research instruments used in the study were likert scale questionnaire and interviews. These were used to collect data and for triangulation purposes. Purposive sampling technique was used to select the sample for the study. A five-item questionnaire was developed from the research questions stated. The respondents were to place a tick (√) in a box of their choice was used to collect the quantitative data. The Statistical Package for Social Sciences (SPSS) version 20 for windows 2007 was used for the analysis. Students' should be introduced to acid-base titration practical early to enable acquire the process skills for the task assign to them.

Index Terms- Constructivism, Titration, Purposive Sampling, Quantitative, Engagement

I. Introduction

Background

Chemistry has been considered as a challenging lesson, because of the difficulty in building abstract concepts Ayas and Damirbas, 1997). The results of the research from Akani (2017), showed that out of eighteen (18) chemistry topics, there are eight (8) topics that are considered as difficult among the eight are; acid-base titration analysis, rate of reaction, nonmetallic and metal composition, astronomical chemistry and finally nuclear chemistry.

In line with this, sheppard (2006) explained that the biggest difficulty is in acid-base titration analysis. This is because students are less able to link the acid-base concept accurately, lack of students understanding about the underlying chemistry principle and finally their lack of understanding about the microscopic form of the material.

Cuttance (2001) argues that capturing students interest in chemistry at senior secondary school level is a crucial aspect to improving the uptake of chemistry at tertiary levels. For this reason, it is suggested that there is a need to improve the way chemistry is taught in schools so that students are more engaged and recognise the relevance of the science through more real-life practical activities. Minds-on as well as hands-on activities that engage students in active learning are important in any chemistry classroom.

Likewise, Njoku (2004) stressed that the teacher needs to be trained how to use activities that will make learners do and experience science instead of just reading about science. Current learning theory indicates that students need to be actively engaged in learning tasks if they are to develop a meaningful understanding of chemistry. A study of chief examiners' reports on the Senior Secondary School Certificate Examination (SSSCE) in 2008 chemistry practical results revealed that some of the candidates could not use the mole concept to solve problems posed in quantitative analysis. This affected their results in chemistry and their inability to pursue further studies. According to the report a number of them also could not quote the correct units for the titre value, molar masses and concentrations of the solutions used.

Titration in the senior high school chemistry syllabus covers simple acid-base titrations, back titrations, redox titrations, water of crystallization and double indicator titrations. There is also the theoretical aspect of titration that has to be well understood before the students are introduced to acids and bases and their properties and how to identify them by their reactions in the presence of indicators and other chemicals. Students often get confused with choosing the right indicator for a particular titration where and indicator is needed and when it is to be added to the solution being titrated. In the actual practical work students faced the challenges of proper handling and usage of the titration equipment comprises pipettes, burettes and conical flasks.

Students encounter difficulties in pipetting solutions and transferring them into conical flasks. Some students read levels of solutions in burettes wrongly as they determine the initial and final volumes in the course of titrations. Other students are not able to determine the correct end point during titrations. Another problem area is the presentation of titration results. This involves drawing a table of values and the selection of consistent titre values for the calculation of an average titre. Others are balancing of reaction equations and finally the application of the mole concept in calculating the concentrations of solutions of acids, bases etc. and the associated calculations.

Students should understand different learning styles, as well as the strengths of their personal learning styles (Boström, 2012; Oskay et al., 2010). It is informative for teachers to be aware of students' learning styles (Lujan, & Di Carlo, 2007). No single teaching method is appropriate for all learning styles and a mismatch between teaching methods and students' learning styles can be detrimental to the learning process (Boström, 2012).

Looking at above numerated students' performance in titrimetry, it appears that application of the mole concept through computational problem- solving in titrimetry will help to enhance students' performance in titrimetry. The students would be equipped with adequate knowledge and skills to carry out titration calculations effectively. It was for this reason that this study was designed.

II. Statement of the Problem

During titrimetric analysis lessons, the researcher identified that majority of the students were unable to perform the titration practical. They faced difficulty in the proper handling and usage of titration equipment, for example they found it difficult reading the level of solutions in pipettes and burettes correctly as a result of wrong placement of the eye when observing the meniscus. It was also found that during acid-base titration, the students usually exceeded the end point or did not arrive at the end point value before taking the reading. According to Eminah (2015) indicated that a high proportion of SHS chemistry teachers find the mole concept difficult to teach. He stated further that the Ministry of Education noted that the abstract nature of the concept was a challenge to them. In view of this the researcher investigated the causes of students' difficulty during titrimetric practical lessons in chemistry.

III. The Purpose of the Study

The study was designed to enable students to overcome their difficulties in acid-base titrimetric analysis during chemistry practical lessons. The activities were targeted at developing the cognitive skills (the mind) the psychomotor skills (the manipulative skills) the affective skills (the interest or motivation) of students in acid-base titration. The study may also serve as a source of information for further research in titrimetry.

IV. Research Questions

The following research question was addressed in the study:

a) What difficulties do the students face during lessons on acid-base titrimetric analysis?

V. Literature Review

Students who do not fully understand the mole concept experience difficulties in understanding the subsequent topics (Musa, 2009). Especially, in stoichiometry problems since the calculations revolve around the mole concept.
Stoichiometry calculations have been considered difficult by students in general chemistry.

This is due to the many different facets a student must master, such as the mole concept, balancing chemical equations, algebraic procedures and interpretation of a word problem into mathematical equations that serve as procedural steps which would then lead to the correct answer. Case and Fraser (1999) has shown that students have acute difficulties in dealing with the abstract concepts required of them to perform stoichiometric calculations using the mole concept. They also found that for students to solve stoichiometric problems, they must also be able to apply a thorough understanding of the principles involved in mole ratio and proportion.

Science cannot be meaningful to students without worthwhile practical experiences in the laboratory (Hofstein, 2004). Laboratory experiments (activities) are characteristic features of science teaching at all levels of education (Adam & Adams 2011). Laboratory activities serve as indispensable parts or component in this regard since origin of the use of laboratory method in science teaching long time ago (Hofstein & Lunetta, 2004; Hofstein & Mamlok-Naaman, 2007. Borman, 2008). Nowadays, it is rare to find any science course without a substantial component of laboratory activity in teaching institutions. During such laboratory experiments students are provided with work guide or manual and some sort of equipment which help them to investigate scientific problems in order to understand theories and principles in chemistry subject.

Titrimetry is used in high school and college chemistry laboratories to determine unknown concentrations of substances. In titrimetry a titrant (solution with known concentration) and a reaction takes place. Knowing the volume of the titrant allows the student to determine the concentration of the unknown substance (Nelson & Kempt, 1997). Medical laboratories and hospitals use automated titration equipment for basically the same purpose.

Importance of Laboratory Work in Improving Titrimetry Skills of Students

Science cannot be meaningful to students without worthwhile practical experiences in the laboratory (Hofstein, 2004). Laboratory experiments (activities) are characteristic features of science teaching at all levels of education (Adam & Adams 2011). Laboratory activities serve as indispensable parts or component in this regard since origin of the use of laboratory method in science teaching long time ago (Hofstein & Lunetta, 2004; Hofstein & Mamlok-Naaman, 2007. Borman, 2008). Nowadays, it is rare to find any science course without a substantial component of laboratory activity in teaching institutions. During such laboratory experiments students are provided with work guide or manual and some sort of equipment which help them to investigate scientific problems in order to understand theories and principles in chemistry subject. In the laboratory the students work with instrumentation, glassware and other by which the Chemistry Laboratory goals are associated with psychomotor domain (Fay, 2008 ;). There are seven levels of psychomotor domain from lowest to highest; perception, set, guided response, mechanism, complex overt response, adaptation and organization. At 'organization', the highest level, the proficiency level is very high, the performance is smooth and spontaneous (Rehman 2004; Linn & Gronlund, 2005). Imitation is a characteristic of third level 'guide response' of psychomotor domain where the students' control and confidence on his or her performance is low, however, they are taught how to minimize human errors. Reif and John (1979, as cited in Lippman, 2003) argue that students must be capable to use general measuring techniques to improve reliability and precision. According to Fay (2008) hold the trust in the aim of practical work as to encourage accurate observation and careful recording. According to Linn and Gronlund (2005), learning is conceptualized as being hierarchial, with high-order skills dependent on a linear development based on a foundation of lower-level, that is essential skills. Students have a lot to benefit from practical activities which may include increasing students' interest and abilities in science subjects as well as their achievement in science (Pavesic, 2008). Demonstrations by instructors can also be used as an option to support theories and lectures given in classroom in institutions without adequate facilities to let students do the experiments by themselves (Mckee et al 2007).

Keobi (2004) meaningful learning is possible from a laboratory experiments if the students are given ample opportunities to operate equipments and materials that help them to construct their knowledge of phenomena related to scientific concepts. There are reports that emphasize teaching science with the help of laboratory experiments to be more enjoyable and stimulating to students than teaching the same subject matter only through lecture method (Hofstein, 2004 and Teibo, 2001). Similar to other science teaching chemistry is also supported by laboratory experiments (Reid & Shah, 2007). The original reason for development of chemistry laboratories experiments was the need to produce skilled technicians for industry and highly competent workers for research laboratories .Chemistry practical classes are believed to help students in understanding theories and chemical principles which are difficult or abstract. Moreover they offer several opportunities which include handling chemicals safely and with confidence, gain hands-on-experience in using instruments and apparatus, develop scientific thinking and enthusiasm to chemistry, develop basic manipulative and problem solving skills, gain opportunities to students as investigators of the experimental work identify chemical hazards and learn to assess and control risks associated with chemicals (Lagowski, 2002; Carnduff & Reid, 2003; Ravishankar & Ladage, 2009).In doing laboratory practical a student is given an opportunity to engage in deep learning. This would provide an opportunity in identifying the main objectives of the work and in planning it, identifying the conceptual and practical difficulties encountered, recording and discussing the results and observations and suggesting practical alterations and improvements.

Titrimetry and Its Importance in Chemistry

Titrimetry was first introduced by Jean Baptist Andre Dumas, a French chemist. He used it to determine the composition of nitrogen combined with other elements in organic compounds. It is a method of quantitative analysis using measurement of volumes. For gases, the main technique is in reacting or absorbing gases in graduated containers over mercury, and measuring the volume changes. For liquids, it involves titration it can also be said to be a method of determining chemical differences and principles of redox (reduction-oxidation) reactions between molecules. Chemicals under this topic are classified based on the results obtained from titration. The process of creating a balanced chemical equation 'in vitro' is called titration. It typically uses a volumetric flask, hence, called volumetric flask titration. There are three types of volumetric titration, which are classified based on the rate of their reaction. They are the Direct Titration Method, (DTM) the Indirect Method (IMD) and Back Titration Method (BTM) the DTM involves a one-step titration process. The ITM involves a two- step titration process and the BTM uses a three-step titration process. The quantitative relationship between two reacting solutions is important to the chemists. Up to some point in chemical analysis involving solutions, solid precipitates of chemical reactions between such solutions were dried, separated and massed. The technique is called gravimetric analysis. It is used in quantitative experiments determine mass relationships. The technique is useful, but it is not always practically efficient. It is difficult and in many cases a waste of efforts and materials to separate and measure mass of products of a reaction while they are in solutions. Titrimetry looks a better and faster technique, especially if the substances involved are acids and bases. They can be titrated against another for better quantitative results. Titrimetry is used in high school and college chemistry laboratories to determine unknown concentrations of substances. In titrimetry a titrant (solution with known concentration) and a reaction takes place. Knowing the volume of the titrant allows the student to determine the concentration of the unknown substance (Nelson & Kempt, 1997). Medical laboratories and hospitals use automated titration equipment for basically the same purpose. Beside these the process has found ample use in analytical laboratories and industries like ones that manufacture drugs, fine chemicals, petrochemicals, beverages and food processing, benefit immensely by the application of this process. For example, it is used to determine the presence of volatile component in the ejecta flow of crater cavity volume in ecological study to determine biodiesel industry. It is also used to determine the acidity of a sample of vegetable (Ackerman, 2005). By knowing the precise amount of base that is needed to neutralize a sample of vegetable oil, scientists know how much base to add to neutralize a sample of vegetable oil; scientists know how much base to add to neutralize the entire amount. Volumetric analysis has also been used in space science to study the relationship between brain structure and sensory ecology of aquatic animals (Lisney, Bennett & Collins, 2007).

Theoretical Framework of the Study

The conceptual framework of the study was based upon constructivist theory, particularly in regard to the constructivist paradigm for conducting research and constructivist pedagogy. Past researchers have focused on student learning of stoichiometry from the students' point of view rather than from a theoretical framework introduced by the teacher (Agung & Schwartz, 2007; Dahsah & Coll, 2007).

Researchers can use constructivist theory to analyze the quantitative data collected from the test item and questionnaire. Constructivism is a view of knowing or understanding.

The theory is based upon the notion that constructivism can help to explain how people learn (Taskin-Can, 2011). In this study, constructivism refers to the ability of the students to develop new learning (i.e., an understanding of stoichiometry) based upon previous knowledge (i.e., writing a compound, writing a balanced equation, and comprehending the concept of a mole). Constructivist-based research suggests that an informal science experience lays the critical foundations for deep conceptual understanding (Jones & Rua, 2000). As such, constructivists hold the view that learners' understanding of school science, to a large extent, is conditioned by their present commonsense experiences.

VI. Methodology

The research design used in this study was a Case study. The case study is a strategy for conducting research, which involves an empirical investigation of a particular phenomenon within its real life context using multiple source of evidence (Creswell, 2012). It involves an in-depth exploration of bounded process or individuals' system based on extensive data collection (Yin, 2009). The bounded system could be an individual, a classroom of students or a particular mobilization of professionals (Stake, 1995). Also, a case study as a bound system means that the study is located within a geographical boundary, which is limited by number of informants providing the data for the study (Yin, 2009). In this study the cases under examination is Berekum Presbyterian Senior High Schools in the Bono Region of Ghana. This is to get a deeper understanding of the phenomenon under investigation. Therefore, I am interested in information-rich cases in order to come out with the most information rich of each case. The focus of the study was on chemistry students at Berekum Presbyterian Senior High School in the Brong Ahafo Region in Ghana. The target population was the science students in the school. To be precise, the population was the 2014/2015 Berekum Presbyterian Senior High School science students was used.

The target sample in the study consisted of thirty chemistry final year students of 2014 / 2015 academic year from Presbyterian Senior High School – Berekum in the Brong Ahafo Region. The research instruments used in the study were likert scale questionnaire and interviews. These were used to collect data and for triangulation purposes. Purposive sampling technique was used to select the sample for the study.

The participants comprised ten (10) females and twenty (20) males. A five-item questionnaire was developed from the research questions stated. The respondents were to place a tick (√) in a box of their choice was used to collect the qualitative data. The Statistical Package for Social Sciences (SPSS) version 20 for windows 2007 was used for the analysis.

VII. Results/Discussion

Research Question: What difficulties do the students face during lessons on titrimetric analysis?

This research question posed to find out some difficulties students encounter during titrimetric analysis lessons. A research questionnaire elaborating on some of the difficulties students encounter were given to the students in both the control and experimental group to answer. A descriptive analysis was used to analyse the questionnaires answered by the students. The questionnaire was set in a three-point Likert scale.

The results have been summarised in table 1

Table 1: Descriptive Statistics on Students' questionnaires

Questions	Agree (%)	Not sure (%)	Disagree (%)
1. Do you often go to the chemistry lab for practical lessons on titrimetric analysis?	23.1	3.3	72.6
2. Are you able to balance chemical equations in titrimetric questions?	33.0	6.6	59.4
3. Are you able to calculate for the end point during titrimetric analysis practical work?	6.6	9.9	82.5
4. Are you able to calculate the concept of mole, concentration and molar mass?	42.9	0.0	56.1

Table shows the analyses of students' questionnaires in percentages on how students answered the selected questions involved in the questionnaires to solicit for some of the difficulties students face during titrimetric analysis practical works. The questionnaire was answered by students in both the control and the experimental group. The first question on the students' questionnaire wanted to find out how often the students go to the chemistry laboratory for practical lessons on titrimetric analysis. 7 (23%) of the students agreed that they often go to the chemistry laboratory, 1(3.3%) was not sure and 22(72.6%) agreed that they often go the laboratory for practical lessons. The question two wanted to know the academic performance of students on balancing chemical equations. 10(33.0%) of the students agreed that they know how to balance chemical equations, 2(6.6%) were not sure and 18(59.4%) were not able to balance chemical equations. Question three asked about students' ability to calculate for the end point or recognise the end point when they reach there in titrimetric analysis. 2(6.6%) insisted that they can calculate for the end point, 3(9.9%) were not sure and 25(82.5%) suggested that they cannot calculate for the end point. The last question posed on the students' ability to calculate the concept of mole, concentration and molar mass. 13(42.9%) of the students accepted that, they can calculate for concept of mole, concentration and molar mass, none of the students chose not sure and 17(56.1%) of the students disagreed to the question.

Unstructured Interview Was Also Conducted Among Some Students and These Are Some Of Their Responses.

Student A: *Acid- base titration involves a lot of linked concepts in chemistry so if you are not introduced early, it will be difficult for you to get a better grade in the exams.*

Student B: *I have difficulty applying the mole concept in solving acid-base titration questions. Am not good in mathematics.*

Student C: *We don't go to laboratory to do enough practical. We do some of the practical when we reached final.*

VIII. Discussion of the Results

The study basically focused on the use of appropriate instructional approaches (proportional reasoning and algorithm instructional approaches) in the teaching of titrimetric analyses in Presbyterian Senior High School, Berekum in the Brong Ahafo Region in Ghana. The study was guided by research questions which were analysed in this chapter. This section presents into details the discussions of the analyses of the research questions guiding this study. In the earlier part of this chapter, findings were mainly presented and analysed based on the specific research questions with only brief comments on them. In this part however, the findings have been discussed in detail under the research questions set to guide the study.

Findings with respect to research question, where some of the difficulties encounter by students were elaborated for them answer. Some of the factors included the number of times students go to the chemistry laboratory to do their practical work on titrimetric analysis, also their ability to balance chemical equations, again calculate the end point and last calculate for the mole, molar mass and concentration in titrimetric analysis. The responds showed that in all the questions most the students disagreed with them in the sense that the titrimetric analysis is taught in only form three and that most of them could not recall accurately what they have learnt earlier. Students to not visit the laboratory as often as they should which also contributes to the poor academic performance in titrimetric analysis. Most of the students also find it difficult to comprehend the practical activities involved with titrimetric analysis to the extent that they cannot even calculate for the end point and other major calculations. These factors are confirmed by many researchers around titrimetric analysis.

Many studies show that students have trouble understanding the concept of the mole, concentration, molar mass, the mass of material, chemical equations and the limiting reagent (Chiu, 2001; Dahsah & Coll, 2007; Noraihan, 2008).

Dahsah and Coll (2007) reviewed the achievements of 97 students from three secondary schools in Bangkok, Thailand, through questionnaires. Their study found that only 2% of the total respondents were able to understand all of the concepts tested on the chemical formula, chemical equations, the mole concept, molarity of solution, the limiting reagent, and the mass of the reactants. It is also supported by the findings obtained by Noraihan (2008) in which a study was conducted on 70 form four students in three schools in the district of Mersing. The study which also used questionnaires showed that students experience difficulties in solving problems related to mole concept because they cannot relate the mole to the number of particles, the mass of substance and chemical equations.

IX. Conclusions

The analysis of the students' questionnaire and interviews suggested that students face a number of challenges with the teaching and learning of acid-base titration. Students face challenges with regards to applying the mole concept in solving titration questions. Practical activities should start earlier to enable learners linked the concepts to solve acid-base titration questions.

Acknowledgment

We would like to express our gratitude to ourselves for an effective collaborative research.

Mr Solomon Boachie for traveling across the Bono Region to collect the data for this research.

Mr. Francis Quansah for designing and validating the research instruments for the data collection

Mr. Kennedy Ameyaw Baah for analysing the data and editing the write up.

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