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Article

Teaching and Learning Strategies in Double Indicator Titration: An appraisal of Chemistry Teachers

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Abstract: The purpose of this study was to examine chemistry teachers' teaching and learning strategies in double indicator titration in Senior High Schools in Ghana. Action research design using a quantitative approach was used for the study. Purposive and simple random sampling procedures were employed to select one hundred and seventy-five (175) participants (teachers and students) for the study. The classroom observational checklist and questionnaire were the instruments used to collect data in the study. Descriptive statistics tools (frequency, percentage, mean and standard deviation) were used to analyse the quantitative data. The study revealed that Chemistry teachers in the Kwaebibirim and Denkyembuo Districts of the Eastern Region used the lecture method in teaching double indicator titration lessons instead of practical activities and this had negative effects on their academic performance. The study also indicated that the effective model that can be used to improve teaching and learning of double indicator titration is the developed practical teaching model (DEPTEM) as compared to the teachers' method. It is recommended that in-service training should be organized for chemistry teachers who were already in the field of work to use more of the developed practical model (DEPTEM) in relation to the lecture method. It is also recommended that chemistry teachers should use teaching methods that would allow chemistry students to participate and manipulate equipment/materials using their five senses and other skills instead of teaching in abstract or allowing them to remain less active in their class.

Keywords: Chemistry, Teachers, Strategies, Double Indicator, Titration

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1. Introduction

In all the history of education, science has held its leading position among all school subjects because it is considered as an indispensable tool in the development of the educated person. It is the bedrock of scientific and technological careers and development [1]. Educators give special recognition to chemistry among the sciences because of its educational values, close relation to man as living organism, peculiar field of experimentation and interrelationships with the other sciences [2]. The primary aim of science is to collect data. An ultimate purpose of science is to discern the order that exist between the various data [3]. As a result of this chemistry occupies a relatively pivotal position in the science and it is one of the requirements to professions such as pharmacy, medicine, agriculture and many others.

The importance accorded science, and for that matter chemistry, in the school curriculum from the basic to the senior high level reflects accurately the vital role played by the subject in contemporary society. The importance of the subject is not restricted to the development of individual alone but for the advancement of the social, economic, industrial and political goals of countries all over the world. In Ghana chemistry as a subject is known to have a significant number of student enrolments in recent years in senior high schools. By having knowledge in science education, the economy and sociocultural status will be transformed [4]. This implies that science education and for that matter chemistry is important in producing the required human resources needed for harnessing the natural resources of the country.

The current approach to science teaching and learning in most senior high is most often based on classroom and laboratory works which are intended to meet examination requirements [5]. Unfortunately the examination driven mode of chemistry teaching and learning has limited the chemistry technological scope and perspectives of the students. The approach also tends to make the study of chemistry uninteresting and boring. Students find it difficult to relate the theoretical knowledge with the practical realities of life and the use of manipulative skills. There is also very little orientation for problem solving, inculcation of investigative skills and counseling on chemistry career opportunities. It is therefore necessary that students studying chemistry should understand the subject so that they can apply their knowledge to everyday interactions with people and their ever changing environment.

Teacher is an important determinant of the quality of learning by the learner [6]. The teachers are the pivot of the education system and therefore they are at the center of any reform effort in the system [7]. It is the teacher who organizes the interactions between the learner and the learning materials [8]. All these points to the fact that, the teacher is very significant factor when the learners fail to exhibit the expected mastery in a science subject such as chemistry practical. The chemistry teacher should adopt methods that would enable the student to understand whatever concepts or principles that are being taught. There are various ways of teaching chemistry such as projects, field trips, expositions, experimental and guided discovery strategies. All these methods rely on various forms of teacher- student activities; however, some are more activity oriented than others. The guided discovery has been recommended for teaching the contents of senior high school (SHS) Chemistry Curriculum in Nigeria [9]. This approach is activity oriented for both teacher and student. It applies abundantly the principle of effective questioning, appropriate directives, demonstration by the teacher, high quantity and quality students' activities (laboratory work, field trips, class discussions).

In all these, the students accumulate the products of science by vigorously engaging in various processes of science [10]. Knowledge is constantly extracted from a learning individual's experience and tested. Thus in the guided discovery, the students are active participants in the teaching and learning situation and so they actually do chemistry and not just being taught t chemistry [11]. In view of this and also to make the strategy effective, the Ghana government through the ministry of education in 1997, set up 110 Science Resource Centers (SRC) in all the Districts in Ghana. The SRC have laboratory facilities with modern equipment [12].

1.1. Effective chemistry laboratory

The science laboratory is a setting in which students can work supportively in small groups to investigate scientific occurrences [13]. Laboratory activities have had a distinctive and central role in the chemistry curriculum and chemistry educators have suggested that many benefits accrue from engaging students in laboratory activities [14]. It is in this view that the Ministry of education in 1997 established Science Resource Centres in 110 districts in Ghana. There are still inadequate laboratories due to the growing number of SHS which outnumber the SRCs' available [15]. Infrastructure is often stressed as a result of the insufficient or incomplete laboratory equipment in most of the public primary and senior high schools both in the urban and rural areas. Since chemistry is an experimental branch of science, laboratory is the only place that is capable of developing students' scientific processing skills [16]. An important ingredient for effective science teaching is an appropriate item; laboratory equipment and materials [17]. A standard laboratory should make provisions for the following:

- Staff offices for lab technicians

- Fume chamber for preparation of poisonous gas
- Central storage room; where dangerous chemicals are kept
- Resource room where students carry out their project work

A standard laboratory should also have the necessary glassware and apparatus needed for practical as well as protective wares. Having all the above, effective laboratory should be operational.

1.1.1. In – service training for chemistry teachers

Teacher can be referred to as a catalyst that brings about changes in the behaviour of the student; the teacher plays a central role in the actualization of educational systems [19]. In - service training is a programme that intends to provide update, improvement conversions and support to teaching professionals along their careers. The training actions can be drawn by schools according to the needs of their teachers or it may result from the individual initiative of the teacher [20]. A continuous teacher training is the keystone of improvement and transformation in schools for personal growth and development [21]. The importance of in-service training and professional development of teacher has been given serious thought and effort. With regards to this the Ministry of Education through the Science and Mathematics Education Unit in conjunction with ITEC global organizes workshops yearly for science teachers in Ghana [12]. In the workshops, Teachers from different schools are accommodated at one place and giving four weeks intensive training. The training is based on

- Inculcating effective laboratory activities to classroom activities to enhance learners understanding of scientific concepts.
- Various forms of improvisation for teaching and learning resources in certain concepts
- How to make certain abstract concepts more concrete to the learner.

A study on teacher education, school effectiveness and improvement; and stressed that teachers required professional knowledge and teaching skills to carry out instructional process effectively. He also suggests that teachers should be both academically and professional trained [22]. However, the training venues should be a place of convenience and have all necessary equipment and infrastructure. Training for the teachers should be conducted in a comfortable and relaxed environment that is conducive to change [23]. This is why in Ghana venues such as Opoku ware and Prempeh SHS are used for training of science teachers since these schools have well equipped laboratories and organized environment. It also implies that teachers are more important than the quality and quantity of equipment and material and the extent of financing. A study posit that the importance of teachers in an educational system and emphasized that, no educational system can rise above the quality of its teachers and promised that, the government will continue to give major emphasis to teacher education in all the country's educational planning activities [9].

1.1.2. Methods of teaching practical chemistry

There is increasing concern among practitioners and educational researchers about the effectiveness of teaching. It is surely plausible to suggest that in so far as a teachers' knowledge provides the basis for his/her effectiveness, the most relevant knowledge will be that which concerns the particular topic being taught and the relevant pedagogical skills [24]. To teach successfully, one must know how to facilitate a positive learning experience of students. One of the limitations of learning is the method of instruction which falls short of learners' needs [24]. There are many methods of instruction to practical chemistry but all the methods could be categorized into two. Namely student centered and teacher centered. Science subjects are not being taught to students' maximum benefit, because science instructions are mostly teacher centered [25].

In teacher-centered education, students put all of their focus on the teacher. The teacher talks, while the students exclusively listen. During activities, students work alone, and collaboration is discouraged. When a classroom operates with student-centered instruction, students and instructors share the focus. Instead of listening to the teacher exclusively, students and teachers interact equally. Group work is encouraged, and students learn to collaborate and communicate with one another. In recent years, more teachers have moved toward a student-centered approach. However, some maintain that teacher-centered education is the more effective strategy. In most cases, it is best for teachers to use a combination of approaches to ensure that all student needs are met. When both approaches are used, students can enjoy the positives of both types of education. Instead of getting bored with teacher-centered education or losing sight of their goals in a completely student-centered classroom, pupils can benefit from a well-balanced educational atmosphere [25, 26].

1.2. Double indicator titration involving HCl against Na_2CO_3/NaOH mixture

This is a titration involving the use of two indicators, because the solution pipetted could be alkaline at one stage and at another stage in the titration the product formed could be acidic and vice versa. The common indicators used in the senior high school for this type of titration are phenolphthalein and methyl orange. The two indicators are considered in the determination of the volume of the acid used. Thus two titration tables are required in double indicator titration unlike other titration which requires single indicator. The titration is either continuous or discontinuous.

Double indicator titration is used to determine the purity of samples, estimate quantities of substances and to determine medicinal properties of substances. There are several applications of double indicator titration but this study focuses on the one involving Na_2CO_3/NaOH mixture against HCl. The reactions taking place in this titration are:

- i. $HCl + NaOH \rightarrow NaCl + H_2O$
- ii. $HCl + Na_2CO_3 \rightarrow NaHCO_3 + NaCl + H_2O$
- iii. $HCl + Na_2CO_3 \rightarrow NaCl + CO_2 + H_2O$
- iv. $HCl + NaHCO_3 \rightarrow NaCl + CO_2 + H_2O$

1.2.1. How the concept "double indicator titration" is presented to students

The learner of double indicator titration is taken as an empty vessel in which knowledge is to be poured. Thus the learner only listens to and copy notes from the teacher.

1.2.2. Continuous method

In this method, the first endpoint is indicated by the change in color of phenolphthalein indicator from pink to colorless while methyl orange is used to estimate the second end point and the color changes from yellow to orange.

The letter $X cm^3$ is used to denote the volume of HCl at phenolphthalein end point and $Y cm^3$ for volume of HCl used at methyl orange end point. A series of algorithmic expression is followed to arrive at a final expression:

- Volume of HCl that neutralizes all $Na_2CO_3 = 2Y\ cm^3$
- Volume of HCl that neutralizes all $NaOH = (X – Y)\ cm^3$

1.2.3. Discontinuous method

In this method separate titration of the Na_2CO_3/NaOH mixture against the HCl is done using the indicators separately. With the same representations of the letters X and Y having their meanings as in the continuous method, the volume of HCl used is derived as:

- Volume of HCl that neutralizes all $Na_2CO_3 = 2 (Y - X)\ cm^3$

- Volume of HCl that neutralizes all NaOH = (2X – Y) cm^3

However, learners are supposed to keep these formulas in mind without understanding the main concept. It is important to note that ability to solve numerical problems does not mean an understanding of underlying concepts [27]. The demand of overloaded syllabus and time constraints in senior high schools (SHS) in Ghana, compel teachers to employ mostly the lecture method of teaching where students are giving many rules to learn in order to solve numerical problems [28].

Indeed, some science teachers fail to realize that the nature of science subject is shifting and there is the need for a shift from old methods to routine practical learning. Despite the above methods, students still perform poorly in practical chemistry according to chief exam report [29]. The practical chemistry covers 25% of SHS WASCE. The concept of acid base titration is prominent both conceptually and in the requirement for practical skills. This study focuses on double indicator titration aspect of the acid – base titration. Students are required to determine the volume of acids/base used in the titration. These volumes if determine would be used in subsequent estimation of quantities of substances. Though teachers teach this area well yet students find difficulty in the determination of exact volumes of acids since two indicators are used. Therefore, there is the need to come out with a model which incorporates student centered, teacher entered, inquiry and guided discovery using the constructivist approach. This is the Developed practical teaching method (DEPTEM).

The DEPTEM enables students work in groups thereby providing medium for discussion amongst students. For example, by interacting with others during group discussion or peer collaboration, students share their views, learn from each other, and generate an understanding related to the concept studied [30]. Another exceptionally important assumption in constructivist theory is the zone of proximal development (ZPD), defined by his words as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" [31]. A cognitive change occurs in the ZPD as learners bring their own understandings to social interactions with teachers or more experienced people in the context. This conceptual change leads to learning new knowledge and constructing meanings when it is internalized in the learner [32].

The essence of constructivism is that knowledge is not transmitted among persons but rather is built up "either individually based on what student brings through prior experience or collaboratively by what participants contribute" [30]. Introducing a cognitive conflict dis-equilibrates the new knowledge which in turn produces conceptual change or learning; thus, to promote meaningful learning from a constructivist perspective, it is crucial to stimulate cognitive conflict by employing a student-centered environment that allows interaction of students' beliefs with classroom instructional practices. In a constructivist science classroom, teachers do not stand in front of a group of students lecturing in a traditional way but rather they actively engage students in purposeful, hands-on activities that challenge students' existing conceptions leading them to reconstruct their understanding and personal theories [33].

Basically, informal observations by the researchers for the past eight years on some chemistry teachers in Kwaebibirim and Denkyembuo Districts of the Eastern Region indicated that, most of the teaching skills acquired before certification are not put into practice. The deficiencies in chemistry teaching range from; non-coverage of contents in schemes of work, non-giving and marking of assignments, non-supervision of instruction, non-organization of practical lessons, non-organization of extra lessons to cover lost lessons, non-assessment of learning outcome on regular bases, non-application of improvisation knowledge in instruction to non-taking of students to field experiences. All these tend to suggest that, sometimes teachers are to be blamed for lack of proper exposure of chemistry students which result in poor performance of students in High School chemistry. It is against this background that this study was conducted. The purpose of this study was to examine chemistry teachers teaching and learning strategies in double indicator titration in Senior High Schools in Ghana. The study sought to answer these research questions (1) Which teaching and learning strategies are used by chemistry teachers when teaching double indicator titration at the SHS? (2) In what other ways can the teaching and learning of double indicator titration be done?

2. Materials and Methods

The research design for the was action research. The population for the study was all chemistry teachers and students in four senior high schools with two schools located in the Kwaebibirim District and two senior high schools located in the Denkyembuo District of the Eastern Region of Ghana. Purposive and simple random sampling techniques were used to select chemistry teachers and student for the study. Twenty-five (25) chemistry teachers were purposively selected because of their experience and knowledge in the topic under investigation. One hundred fifty (150) students were randomly sampled for the study. Three main instruments used in this study were classroom observational checklist and questionnaire. The classroom observational checklist of this study was made up of varying number of sets of action statements which was based on the design of each DEPTEM-based lesson plan. The observational checklist was divided into four sections: lesson introduction; lesson development; lesson application; and lesson closure. It contains only two columns: The Yes and No columns. Classroom observational checklist was used as an instrument because it helped the researcher to check the effectiveness of the teaching methods employed by the chemistry teachers in the sampled schools. Semi-structured questionnaire was used to supplement the classroom observational checklist.

Validity and reliability of the instruments in this study was taken through face and content validity techniques. To check the face validity of the instrument, the instruments were given to friends to go through. Afterwards, comments from the friends were used to make the necessary corrections before the instrument was administered. In order to enhance the content validity of the instruments, some colleagues examined them. After the examination of the instruments vis-à-vis the research questions, these colleagues gave their comments and suggested changes, the experts were requested to critically examine and assess all the items of the instrument. A pilot test of the instrument was carried out with fifteen (15) chemistry teachers and seven-five (75) chemistry students in Asaman Senior High School in the Eastern Region of Ghana. Asaman Senior High.

Descriptive statistics (frequency, percentage, mean and standard deviation) were the tools used in analyzing the data gathered. Coding schemes were developed using Statistical Package for Social Sciences (SPSS) (version 21) to organize the data into meaningful and manageable categories. These involve the data obtained from the classroom observational checklist, questionnaires and pre and post – test. The categorized data were converted into frequency counts, simple percentages, means and standard deviations and were used to answer the research questions in this study. School was selected because it is in the same category with the study schools.

3. Results and Discussion

3.1. Teaching and Learning Strategies Used in Teaching Double Indicator Titration

This section presents results and discussion of the study. The study used two research questions and two instruments for data collection. The first research question was: "Which teaching and learning strategies were used by chemistry teachers when teaching double indicator titration at the SHS?" Items 1-5 of the questionnaire for both students and teachers were used to answer this question as shown below in Table 1.

Table 1. Result by students on teaching method used by chemistry teachers

	Strongly Disagree		Disagree		Agree		Strongly Agree	
	f	%	f	%	F	%	f	%
Chemistry teacher serves as a facilitator during chemistry lessons	57	38	40	27	32	21	21	14
Students do not use their own initiative during chemistry lessons	20	13	23	15	38	25	69	46
Teacher first demonstrates and afterwards students follow suit during chemistry lessons	58	38	32	22	31	21	29	19
Teacher dominates throughout the lesson	17	12	29	19	35	23	69	46
Teacher uses practical activities during chemistry lessons	73	49	43	27	33	22	1	1

Source: Field data, 2016. (Total Number of chemistry students=150)

Result from Table 1 indicates that, most of the chemistry students (73, representing 49%) were strongly against the statement that their chemistry teachers use practical activities during chemistry lessons, followed by those who were against the claim that their teachers first demonstrates and afterwards students follow suit during chemistry lessons (58, representing 38%), chemistry teachers did not serve as a facilitators during chemistry lessons (57, representing 38%). The result further shows that, more than one third of the students strongly agree that their chemistry teachers did not allow them to use their own initiative during chemistry lessons (69, representing 46%) and teachers dominated the lesson throughout (69, representing 46%). This result implies that, there is the likelihood that most of the chemistry teachers in the Kwaebibirim District use the lecture (talk-and-chalk) method instead of the inquiry (learner-centered) approach when teaching lessons in chemistry.

Again, items 1-5 of the questionnaire for chemistry teachers were also used to answer research question one and the results are shown in Table 2.

Table 2. Results by teachers on teaching and learning methods used by chemistry teachers

	Strongly Disagree		Disagree		Agree		Strongly Agree	
	f	%	f	%	F	%	f	%
I serve as a facilitator during chemistry lessons	3	12	5	20	10	40	7	28
I don't allow students to use their own initiative during chemistry lessons	6	24	10	40	5	20	4	16
I first demonstrate and afterwards students follow suit during chemistry lessons	9	36	10	40	2	8	4	16
Teacher dominates throughout the lesson	1	4	4	16	3	12	17	68
Teacher uses practical activities during chemistry lessons	5	20	3	12	2	8	15	60

Source: Field data, 2016. (Total Number of chemistry teachers=25)

Result from Table 2 shows that, most of the chemistry teachers (15, representing 60%) were in agreement with the statement that, they use practical activities during practical lessons. Again, Table 2 result indicates that, more than two-thirds of the teachers (9, representing 36%) were against the assertion that, teachers first demonstrate and afterwards students follow suit during chemistry lessons. The result implies that, most of the teachers were of the view that they use the practical activities as compared to the lecture method in teaching chemistry lessons. But, this result contradicted with those of the students. The reason could have been that; some teachers did not want to report their weaknesses in their teaching practice.

It could therefore be concluded that, majority of the teachers sampled do not use practical activities during teaching and learning of chemistry in the Kwaebibirim District. Findings of this study agree with previous study that traditional teacher-centered lecture (chalk and talk) approach, which emphasizes the transfer of knowledge and skills and rewards memorization, is the predominant teaching format used in secondary schools in Tanzania [34]. Their findings further revealed that, in using this approach, teachers talk most of the time, while students jot down notes mainly for the purpose of passing exams. This method does not allow much room for critical analysis of issues but it makes students to duplicate the notes and give back to the teacher during examinations.

Also, findings of this study confirms earlier research that most teachers used transmission (chalk and talk) rather than interactive, learner-centered pedagogy [35]. Likewise, findings of teacher-initiated and dominated teacher - student interaction and lecture method as major methods of teaching agree with Ajaja, who made similar findings in different public schools in Delta State, Nigeria [36].

Furthermore, findings as indicated in Table 2, show that pattern of interaction in most chemistry classrooms is the teacher initiated and dominated teacher-student interaction. This is not in consonant with international standards which recommend that teachers of science plan inquiry-based programme for their students and should also interact with students to focus and support their inquiries, recognize individual differences and provide opportunities for all students to learn [37]. The findings also fall short to the recommendation of teaching for effective learning (learning with understanding) where students take responsibility of their own learning through active construction and reconstruction of their own meanings for concepts and phenomena [38].

3.2. Teaching and Learning of Double Indicator Titration

The second research question: "*In what other ways could the teaching and learning of double indicator titration be done*? An observational checklist was used to answer this research question and the results are shown on Tables 3,4 and 5. Classroom observational checklist was used as an instrument because it helped the researcher to check the effectiveness of the teaching methods employed by the chemistry teachers in the sampled schools.

Table 3. Result on Classroom Observational Checklist for Lesson 1

Category	TALLY		
	YES	NO	REMARKS
Lesson Introduction			
1. Teacher asks students to explain what is an acid – base titration		√	
2. Teacher asks students to provide the names of the two most common indicators used in the laboratory	√		
3. Teacher raises questions about the colour change at the end of titration between HCl & NaOH using methyl orange indicator		√	
4. Teacher raises questions about the colour change at the end of titration between HCl & NaOH using phenolphthalein indicator		√	
5. Teacher observes and listens to students as they express their understanding of acid – base titration	√		
6. Teacher group students together to form five students in a group	√		
7. Teacher insists that students take his suggestions during chemistry lessons		√	
8. Teacher supplies each group the materials needed for the task	√		
9. Teacher writes the instructions clearly on the board for students		√	
Lesson Development			
10. Teacher moves from group to group	√		
11. Teacher asks students to explain what they are doing		√	
12. Teacher makes sure that every student in a group participate fully in the task		√	
13. Teacher moves from group to group the second time to ensure that every equipment has been fixed in its right position		√	
14. Teacher asks leading questions for students to identify the colour change after each titration	√		
Lesson Application			
15. Teacher asks for the average volume obtained by methyl orange group (V0) and that obtained by the phenolphthalein group (V1)	√		
16. Students discusses the average volumes obtained by the two main groups, V0 and V1		√	
17. Students make 1 minute presentation of why V0 = V1		√	
18. Teacher asks questions to summarize the lesson		√	
19. The evaluation questions posed by the teacher cover all the performance based objectives		√	
20. Teacher gives take- home assignment	√		

Source: field data

Table 4. Result on Classroom Observational Checklist for Lesson 2

Category	TALLY		
	YES	NO	REMARKS
Lesson Introduction			
1. Teacher asks students to explain what is an acid – base titration	√		
2. Teacher asks students to provide the names of the two most common indicators used in the laboratory	√		
3. Teacher raises questions about the colour change at the end of titration between HCl & NaOH using methyl orange indicator	√		
4. Teacher raises questions about the colour change at the end of titration between HCl & NaOH using phenolphthalein indicator		√	
5. Teacher observes and listens to students as they express their understanding of acid – base titration		√	
6. Teacher group students together to form five students in a group		√	
7. Teacher insists that students take his suggestions during chemistry lessons		√	
8. Teacher supplies each group the materials needed for the task	√		
9. Teacher writes the instructions clearly on the board for students		√	
Lesson Development			
10. Teacher moves from group to group	√		
11. Teacher asks students to explain what they are doing		√	
12. Teacher makes sure that every student in a group participate fully in the task	√		
13. Teacher moves from group to group the second time to ensure that every equipment has been fixed in its right position		√	
14. Teacher asks leading questions for students to identify the colour change after each titration		√	
Lesson Application			
15. Teacher asks for the average volume obtained by methyl orange group (V0) and that obtained by the phenolphthalein group (V1)	√		
16. Students discusses the average volumes obtained by the two main groups, V0 and V1		√	
17. Students make 1 minute presentation of why V0 = V1		√	
18. Teacher asks questions to summarize the lesson		√	
19. The evaluation questions posed by the teacher cover all the performance based objectives		√	
20. Teacher gives take- home assignment		√	

Source: field data

Table 5. Result on Classroom Observational Checklist for Lesson 3

Category	TALLY		
	YES	NO	REMARKS
Lesson Introduction			
1. Teacher asks students to explain what is an acid – base titration		√	
2. Teacher asks students to provide the names of the two most common indicators used in the laboratory		√	
3. Teacher raises questions about the colour change at the end of titration between HCl & NaOH using methyl orange indicator	√		
4. Teacher raises questions about the colour change at the end of titration between HCl & NaOH using phenolphthalein indicator	√		
5. Teacher observes and listens to students as they express their understanding of acid – base titration		√	
6. Teacher group students together to form five students in a group		√	
7. Teacher insists that students take his suggestions during chemistry lessons	√		
8. Teacher supplies each group the materials needed for the task		√	
9. Teacher writes the instructions clearly on the board for students		√	
Lesson Development			
10. Teacher moves from group to group	√		
11. Teacher asks students to explain what they are doing		√	
12. Teacher makes sure that every student in a group participate fully in the task		√	
13. Teacher moves from group to group the second time to ensure that every equipment has been fixed in its right position		√	
14. Teacher asks leading questions for students to identify the colour change after each titration	√		
Lesson Application			
15. Teacher asks for the average volume obtained by methyl orange group (V0) and that obtained by the phenolphthalein group (V1)	√		
16. Students discusses the average volumes obtained by the two main groups, V0 and V1		√	
17. Students make 1 minute presentation of why V0 = V1		√	
18. Teacher asks questions to summarize the lesson		√	
19. The evaluation questions posed by the teacher cover all the performance based objectives		√	
20. Teacher gives take- home assignment	√		

Source: field data

Table 6. Summary of Table 3, 4 and 5

	1				2				3			
	Yes		No		Yes		No		Yes		No	
Lesson	f	%	f	%	f	%	f	%	f	%	f	%
Introduction	4	44.44	5	55.55	4	44.44	5	55.55	3	33.33	6	66.66
Development	2	40	3	60	2	40	3	60	2	40	3	60
Application & Closure	2	33.33	4	66.66	1	16.66	5	83.33	2	33.33	4	66.66

Result from Table 3, Table 4 and Table 5 as summarised in Table 6 has revealed that, at the introduction stage though the teacher asked students to provide the names of the two most common indicators used in the laboratory. Table 6 shows that both three (3) leesons observed rated 55.55%, 55.55%, and 66.66% for NO revealed that teachers not revising students' previous knowledge on the topic. The teacher observed and listened to students as they expressed their understanding of acid–base titration but failed to write the instructions clearly on the board for students to follow. Result from Table 3, 4 and 5 further shows that, at the lesson development stage, teacher was able to move round the groups to observe how the students were performing the experiment. But, teacher did not ask students to explain what they were doing. Also, teacher did not ensure that every student in a group participated fully in the task. Again, teacher did not ensure that equipment has been fixed in its right position. On the contrary, teacher asked leading questions for students to identify the colour change after each titration. This implies that all the three lessons indicated 60% rating for teachers not using effective strategies in chemistry lessons.

The results further show that, teacher asked for the average volume obtained by methyl orange group and that obtained by the phenolphthalein group at the lesson application stage. The summary results from Table 6 further shows the average rate of 72% indicated that, students were not allowed to discuss the average volumes obtained by the two main groups. More so, evaluation questions posed by the teacher did not cover all the performance based objectives.

From the observational checklist for all the lessons, it was concluded that the lesson was not successful since most of the key factors were not considered by the teacher as shown in Table 6. This was likely to have negative impact on the understanding of students.

Based on these results it was concluded that, chemistry teachers' method of teaching lesson impacted negatively on the understanding of students. Upon these observations came the DEPTEM, to assist the teaching and learning of double indicator titration at SHS level.

4. Conclusions and Recommendations

The study revealed that Chemistry teachers in the Kwaebibirim and Denkyembuo Districts of the Eastern Region used lecture method in teaching double indicator titration lessons instead of practical activities and this had negative effects on their academic performance. The study also indicated that the effective models that can be used to improve teaching and learning of double indicator titration is the developed practical teaching model (DEPTEM) as compared to the teachers' method.

It is recommended that, in-service training should be organized for chemistry teachers who were already on the field of work to use more of the developed practical model (DEPTEM) in relation to the lecture method. Similarly, workshops/seminars/symposiums should be organized for newly recruited teachers on how to use the developed practical model (DEPTEM) since the findings revealed that, it helped in improving the academic performance of chemistry students in the teaching and learning of double indicator titration. It is also recommended that, chemistry teachers should use teaching methods that would allow chemistry students to participate and manipulate equipment/materials using their five senses and other skills instead of teaching in abstract or allowing them to remain less active in their class. Thus, activity-based methods would enhance their understanding of chemistry concepts and increase their abilities to acquire science process skills during teaching and learning of chemistry.

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