

Article

Evaluation of Teacher Support Materials (TSM) in Teaching Titration in the Senior High Schools in Ghana

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Abstract: A qualitatively, interpretative design was adopted to evaluate type of laboratory practical Teacher Support Materials that could be used to teach practical skills of observation, listening and communication and manipulation of apparatus in titration. The population of the study consisted of three public Senior High Schools (SHS) in Komenda Edina Eguafo Abirem (KEEA) municipality of the Central Region of Ghana. Each school offers chemistry as a subject to students. Convenient, purposive and simple random sampling techniques were used to sample schools, teachers and students for the study. Six (6) teachers were purposively sampled out of a total of 8 chemistry teachers because they had qualification in Science Education in Chemistry. Five (5) students from each school were randomly selected from each of the three SHS for focal group discussion. The main instrument used for data collection were semi structured interview guide and Observation Checklist (OC). Teachers interview schedule was used to solicit information from the chemistry teachers on how they perceived the use of Practical Skills- based TSMs for teaching practical process skills in titration at the SHS levels. The curriculum profile was used to collect data to answer the research question. For each of the four Lesson Profiles (lesson introduction, skill development, application and closure) of the lesson plan, the total number of scores was divided by the maximum possible scores for the profile and expressed as percentage and qualitatively describing the trends of emerging themes. The study concluded that there has been some improvement in the cognitive experience and pedagogical content knowledge of the teachers as well as the students in the use of the PS-based teacher support material in the laboratory. It is recommended that teachers and educators should thoroughly read and assimilate the contents and the processes described in the PS-based TSMs before they are used in teaching titration so as to develop practical process skills of the students.

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1. Introduction

Models of teaching provide a basis upon which coherent instructional practices can be based. Instructional models help practitioners understand the importance of and relationships between various activities associated with teaching. Instructional models also provide the framework for interactions between teachers and students [1]. For instance, in a teacher-centred instructional model the focus is placed more on the teacher transmitting information, whereas in a student-centred instructional model the focus is placed more on students constructing knowledge from experiences. In both formal experiments and classroom settings, the use of the model has been found to increase students' learning and interest in science concepts [2]. Models appear as drawings on whiteboards in laboratory, as diagrams in research articles, and even as sketches on napkins. Wherever they

appear, they are, or will be, an object that reflects changes in thinking about some set of ideas. Models don't just reflect reasoning; they also stimulate new ideas. Science instruction should be active, experiential, constructive, address prior knowledge, and include cooperative and collaborative works [3]. This implies that Knowledge can easily be constructed through constructivist approach.

Constructivism approach corresponds to learning by doing an activity assuming that the more repeatedly one does something the more he/she becomes good at it. It consists of different forms and activities including co-operative learning, experiential learning, problem-based learning and enquiry learning [4]. However, it is based on active involvement of learners and their interactions for creation of new knowledge. Critical thinking, problem solving approach and analytical skills are assumed to be the essential constructs of higher education graduates. When students in high schools are equipped with such faculties and skills, they construct new knowledge based on their previous experiences and an involvement in other learning processes [5]. In the same way, a researcher opined that knowledge is constructed through observation, reflection and interaction with the surrounding environment such as their peers, teachers or technology [6]. It is the strategies of effective learning that students learn to construct new knowledge by interpreting it in a particular situation. In a constructivist classroom, the teacher is a facilitator, to help students acquire knowledge through activities [7]. It is the involvement of the students that would results in effective learning. Effective learning takes place through one's involvement personally in learning experiences. It requires students to work in groups and interact in social setting based on principles of Vygostky's social constructivism which says that social interaction among learners spurred the construction of new ideas and enhanced their intellectual development [8]. In an environment such as that, the teacher's role is to offer guidance to facilitate the process.

It could also be said that the intellectual development and creation of ideas is associated with Bruner's pedagogies. Bruner's pedagogies include activity based and hands on activities wherein students were expected to make use of their own direct experiences and observation to acquire information and to solve problem scientifically [9]. A researcher puts the use of practical work into three domains. These include Cognitive domain, Affective and Skill domain. He explains the cognitive domain that practical work can improve pupils' understanding of science and promote their conceptual development by allowing them to 'visualise' the laws and theories of science. It can illustrate, verify or affirm 'theory work'. With Affective use, he explained that practical work is motivating and exciting – it generates interest and enthusiasm. It helps learners to remember what is learnt. It helps to 'make it stick'.

For Skills domain, it is argued that practical work develops not only manipulative or manual dexterity skills, but also promotes higher-level, transferable skills such as observation, measurement, prediction and inference. These transferable skills are said not only to be valuable to future scientists but also to possess general utility and vocational value [10]. But what really is practical work? There are at least six types of activities that take place in school science that would probably be described as practical work; teacher demonstrations, class practical with all learners on similar tasks, working in small groups on a circus of 'experiments' whereby small groups engaged in different activities, rotating in a carousel, investigations organised in one of the above two ways and problem-solving activities [10] This clearly suggests that what is called practical work will mean different things to different people hence different definitions [11]. Because of some of these reasons, a study concluded that:

I use the term '*practical work*' in preference to '*laboratory work*' because location is not a critical feature in characterising this kind of activity. The observation or manipulation of objects might take place in a school laboratory, but could also occur in an out-of-school setting, such as the student's home or in

the field (e.g. when studying aspects of biology or Earth science). I also prefer not to use the term ‘*experiment*’ (or ‘*experimental work*’) as a general label, as this is often used to mean the testing of a prior hypothesis. Whilst some practical work is of this form, other examples are not [12].

Commenting on the ambiguity of the expression ‘practical work’ another scientific study indicated that:

Surprisingly, the lack of a clear and commonly held definition of inquiry in the classroom, the ambiguity in terms of the kind of knowledge it is to engender, and even nagging questions regarding its effectiveness as a pedagogic tool have not stopped the push by those involved in science education reform to integrate inquiry into... classrooms. This widespread acceptance by the research and teacher education community in the face of such uncertainty leaves classroom teachers the burden of crafting their own definitions of inquiry in the classroom, selecting their own approach to this method and determining its strengths and weaknesses for their particular students, context and content [13].

A research done by Dollin again asserts that the term practical science, though widely used, is unhelpful and imprecise. ‘*More practical work*’ is a slogan without agreed meaning. It would help science teachers and those who work with them if there could be better agreement on what kind of science activities are effective. A more sophisticated vocabulary of science teaching might help science teachers and focus the efforts of those who promote the cause of science education. However, the term practical is so embedded into the discourse of science education that promoting its demise might be a forlorn endeavour [11].

In responding to a recommendation in the of Lords, Science and Technology Committee report into Science Teaching in Schools of United Kingdom, a study noted that:

The importance of practical work in school science is widely accepted but it is important we ensure that such practical work genuinely supports learning and teaching, and that flexibility is given to the teacher to do this in relation to their pupils’ needs and the courses they are studying [12, 14].

Strategies for improving the effectiveness of practical work have been identified by many authors. Millar, noting that students need to think as well as act, pointed out that ‘effective tasks are those where students are not only ‘*hands on*’ but also ‘*minds on*’ [12]. In Millar’s opinion, improving the quality of practical activities requires first that teachers become more aware that making links between the domain of objects and observables and the domain of ideas is demanding, and then helping them to design practical tasks which take this demand more explicitly and fully into account – tasks which ‘scaffold’ students’ efforts to make these links. This in turn requires that teachers analyse more carefully the objectives of the practical tasks they undertake, and become more aware of the cognitive challenge for their students. The starting point for improving practical work is therefore to help teachers become much clearer than many are at present about the learning objectives of the practical tasks they use. Despite a succession of reforms, the predominant pattern of science teaching visible in schools through the turn of the twenty-first century has omitted the story of science. On the contrary, they noted that ‘the science visible in schools has focused on “covering” knowledge of science topics and limited problem-solving skills.’ Worse still, ‘laboratory activities have engaged students principally in following ritualistic procedures to verify conclusions previously presented by textbooks and teachers [14]. After extensive review of literature on the effectiveness of practical work a study concluded among other things that:

- Although practical activities appear to be popular with most teachers and many students, there are some caveats. The quality of practical work varies considerably around the world
- There is confusion about the definition of ‘practical work’. This confusion makes discussions about the value of ‘practical work’ difficult. A variety of terms exist to describe practical work many of which are frequently used with little clarification.
- There are many espoused purposes for doing practical work in school science. Some of the most frequently stated are: to encourage accurate observation and description; to make phenomena more real; to arouse and maintain interest; to promote a logical and reasoning method of thought [11].

There is a clear need for the broader science education community to agree, more than is now the case, on the value and purpose of ‘practical work’ in school science. Without an agreement about the purpose of science education and shared understandings about what kind of activities we want students to engaged in, we are in danger of not getting what is needed from practical work. He also agrees with Osborne’s provocative challenge that what happens under the guise of practical work is frequently a relatively ineffective use of teaching time and has repeatedly failed to train students in the science skills needed for the 21st century and has failed to provide learners with an adequate understanding of scientific theories or of how science works [11]. The fundamental purpose of much practical work is to help students to make links between two domains: the domain of objects and observables (things we can see and handle) and the domain of ideas (which we cannot observe directly)

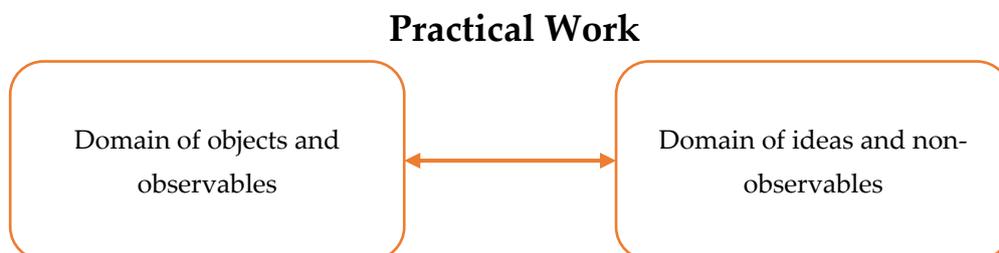


Figure 1. Domain of object and domain of ideas [15]

In some practical activities, the domain of ideas plays a relatively minor role. For example, we may simply want students to observe an object, or a material, or an event, and notice and remember some things about it. In other practical activities, however, we want students to develop their understanding of specific scientific ideas that are relevant for describing or explaining the observations made. In these activities, thinking is at least as important as doing and seeing; students learn only when the activity is not only ‘hands on’ but also ‘minds on’. To assess the effectiveness of activities of this sort, we need to think about both domains. We need to look at what students ‘do’ with ideas, as well as what they do with objects and materials and we need to look at how well the activity supports their learning of ideas and not merely their ability to recall observable events [12]. There are no Teacher Support Materials (TSM) for practical teaching model that may serve as a guide to the teaching of practical skills for example in titration. As a result, science teachers are burdened with additional responsibility of creating and trying different approaches on their own, a possible reason for little practical work and poor performance of students in SHSs in the sciences. In trying to bridge the gap between the two domains, the use of teacher support materials has been found to be very helpful. There is therefore the need to conduct a study into practical teaching in TSM in a simple titration.

The study was guided by this research question - How is this practical teaching TSM going to be used by teachers in teaching simple titration?

2. Materials and Methods

A qualitatively, interpretative design was adopted to evaluate type of laboratory practical Teacher Support Materials that could be used to teach practical skill of observation, listening and communication and manipulation of apparatus in titration. The population of the study consisted of three public Senior High Schools (SHS) in Komenda Edina Eguafo Abirem (KEEA) municipality of the Central Region of Ghana. Each school offers chemistry as a subject to students. The targeted population for the study were teachers and students in all these SHSs. There are total of eight (8) chemistry teachers in all these three SHS, all of them were males. All had graduated from the university with a first degree in science, except two (2). had B.Sc. in Environmental Science. Convenient, purposive and simple random techniques were used for the study. The (six) 6 teachers were purposively sampled out of the total of 8 chemistry teachers because they had qualification in Science Education in Chemistry. Five (5) students each were randomly selected from every SHS in the municipality for focal group discussion. The main instrument used for data collection were semi structured interview guide and Observation Checklist (OC). Teacher interview schedule was used to solicit information from the chemistry teachers on how they perceived the use of Practical Skills- based TSMs for teaching practical process skills in titration at the SHS levels. The OC for was also made up of 15 statements divided into four sections namely Lesson introduction, Skill development, Assessing learning effects and others. The third stair had 10 statements while the fourth and the fifth had 18 and 6 respectively all divided in the four sections of lesson introduction, skill development, assessing learning effect and others. The OC Vo was made up of five columns with the headings; Activity, Tally (with subdivisions Yes or No), time and remarks. After every round of trial, the OC was also modified in accordance with the modifications made in the PS-based TSMs.

The curriculum profile was used to collect data to answer research question, how is the practical teaching TSMs going to be used by teachers to teach simple titration. Each item on the profile represented an action that was to be performed by the teacher in the course of using the support material. The scores were processed by expressing the responses in percentages. For each of the four Lesson Profiles (lesson introduction, skill development, application and closure) of the lesson plan, the total number of scores was divided by the maximum possible scores for the profile and expressed as percentage and qualitatively describing the trends of emerging themes.

3. Results and Discussions

Teachers were observed without interference in teaching using the PS-based TSMs. The lessons were observed using observation checklist which had been developed based on the order of information in the TSMs. These statements are called curriculum profile - "a set of statements about activities of both teachers and students during an observed lesson." A set of statements at each stage of a lesson was quantified to make computation easy to determining how the PS-based TSMs were used by teachers in teaching titration [16, 17]. This implies that, the PS-based teacher support materials designed for use in teaching fundamental skills of observation, listening communication and manipulation of equipment in titration was a way of showing teachers how to develop these essential science process skills in teaching titration in Chemistry [18].

A total of 30 lessons were observed between 10th- 31st March, 2014 using observation checklists in three round successions in three different schools. That is in each school, five lessons (which completes one cycle of trial of the PS-based model) were taught by each of the two selected teachers. It is worth mentioning that the observation checklists (OC) were

also modified after each cycle of trial according to the modifications made in the model. For example, the OC for lesson 1 used in trial school 3 (TS3) was the modified version of that of lesson 1 used in trial school 2 (TS2) which in turn was the modified version of that of lesson 1 used in trial school 1 (TS1). The OC were divided into the following sections; Lesson introduction, skills development, assessing learning effect and others. The total checked behaviour exhibited out of the total behaviours for a section of the OC amounted to the curriculum profile expressed as percentages and accordingly presented.

Tables 1 to Table 5 are summaries of the curriculum profile scores for lessons 1Vo to 5Vo (trial one). Tables 6 to Table 10 summarise that of lesson 1V1 to 5V1 which covers the 2nd trial as it took place in TS2. Tables 11 to Table 15 are summaries of lesson 1V2 to lesson 5V2 which covers the lessons for 3rd round of trials in TS3. Lesson 1Vo sought to develop the skill of observation in students. It was expected that it would enable the teachers help students develop the skills of critical observation especially in relation with colours, the correct way of handling titration apparatus, correct method of reading the volume of solution in the burette and step by step process of performing simple titration. In the lessons, teachers were observed to see how they used the TSM to introduce the lesson by first identifying titration apparatus. The observation continued and the teacher is observed on how he uses the TSMs to develop the skill of critical observation by getting the students to closely observe all that he was doing without allowing any comment or question. Students were however asked to write all questions that they had down and look up for answers themselves for the next lesson. However, the teacher was observed on how the TSM was used to bring out questions to assess how closely students observed. For example, were the students able to observe that the addition of the solution from burette to that in the conical flask changed the colour not just from yellow to pink but from yellow through orange to pink?

Table 1. Curriculum Profile Scores for Lesson 1Vo

Profile	S1T1		S1T2	
	No	%	No	%
Lesson introduction (LI)	2	66.7	2	66.7
Skill development (SD)	6	75.0	7	87.5
Assessing learning effect (LE)	1	50.0	2	100.0
Conclusion (C)	2	66.7	2	66.7

Note: The maximum possible scores for the profiles; LI-3, SD-8, LE-2, and C- 3.

From Table 1, it is seen that S1T1 scored above 60% in all the four stages of the lesson except in LE which the score was 50.0%. It means that the teacher followed the instructions of the TSM to raise appropriate questions about science equipment and to identify titration apparatus among these. A score of 60% of the profile for lesson introduction mean that the lesson was well introduced. Scoring 75% in skill development profile meant that the teacher was able to use the TSM to attract and hold the attention of the students that they may do critical observation of the reagent, apparatus and the process for titration. He basically was able to stimulate the students' interest to observe, did not allow questions or explain any procedure but displayed the well labelled reagents and the apparatus and carry out the very skill of titration. A score of 50% for assessment of lesson effect meant that the teacher followed halfway, the instructions of the TSMs in assessing learning effect. The teachers asked questions to find out how well the students observed. He also gave a take-home assignment which was based on the lesson to ensure that the students continue with practice even after the lesson and also put them in shape for the next lesson.

Other things that were observed were sufficiency of time, easiness to use the model and how the TSM generally helped the teacher to achieve the set objectives. For the Conclusion (C), the score 66.7% means it was generally impressive. For teacher 2, the scores

for lesson introduction (LI), skill development, (SD) assessment of Lesson Effect (LE) and others were 66.7%, 87.5%, 100.0% and 66.7% respectively. The higher score simply means that the lesson was generally good. Compared with the S1T1, the lesson for S1T2 was better than that of the S1T1. A score of 66.7% in lesson introduction meant that the lesson introduction was good. The teacher used questions to help students identify titration apparatus and to direct their minds towards titration. For skill development, S1T2 was able to use the TSM to make the students do critical observation while demonstrating the skills of assembly of equipment, correct handling of these equipment and how simple titration is done step by step. The teacher also demonstrated the correct method of taking readings of solution in a burette, how to enter the readings values on a table of results and how to pipette solution. A 100% score for assessing learning effects by S1T2 is an indication that the teacher could use the TSM to find out from the students how well they observed. He used questions that enabled students describe what they saw. On the last part of the curriculum profile, Conclusion, the score of 66.7% means that the entire approach as well as the general impression for the use of the TSM was good. However, there was a little challenge with sufficiency of time, the reason why the score was not 100%.

The curriculum profile score for both S1T1 and S1T2 which range from 50% - 100% is indicative of the fact that both teachers followed direction as given by the TSM and did well in lesson delivery.

Table 2. Curriculum Profile Scores for Lesson 2Vo

Profile	S1T1		S1T2	
	No	%	No	%
Lesson introduction (LI)	2	66.7	3	100.0
Skill development (SD)	6	75.0	5	62.5
Assessing learning effect (LE)	2	100.0	2	100.0
Conclusion (C)	1	50.0	1	50.0

Note: Maximum possible scores for profiles are LI-3, SD-8, LE-2, and C- 2.

Lesson 2 was designed to help students develop the skill of doing quality listening. The TSM was to guide the teacher to help the students appreciate why some apparatus are used, why some equipment are handled the way they are handled, and why some reagents are kept in certain wares and not others during titration. They were also to listen to and be able to explain the process of simple titration. A curriculum profile score of 66.7%, 75.0%, and 100.0% for LI, SD and LE respectively for S1T1 shows a very good use of the TSMs and lesson delivery. The score of 66.7% for lesson introduction shows that S1T1 was able to review previous lesson on observation and linked it up with the objectives of the lesson stating clearly to the hearing of the whole class exactly what is expected of them. A score of 75.0% for skill development also shows that S1T2 was able to use the TSM to make students do good listening. The teacher verbally explained the observation that the students made but did not understand in the previous lesson. S1T2 was able to use the TSM to have a good interaction as he took questions from the students and addresses them. S1T2 also took time to repeat the process of simple titration and explained at every step what was happening to the students. For example, he explained why the use of white tile, why acid and not the base is kept in the burette, why the use of indicator and why burette readings must be taken from the bottom of the meniscus at the eye level. Curriculum profile score for assessing learning effect (LE) was 100%. This means that guided by the TSM, S1T2 was able to use questions to find out how well students listened. Other things that were observed include how S1T2 put students into small groups to discuss what they saw the teacher do and say. For this part, S1T2 scored 50% indicating that it was OK.

The scores for S1T2 ranging from 50 to 100% means T2 did a good job in using the TSM to help students do good listening. The profile score for lesson introduction and assessing learning effect (LE) was 100.0% which means that S1T2 was excellent at using the TSM to introduce the lesson for listening using simple titration as the topic. He was able to connect very well the previous lesson on observation skills to the present lesson by asking the student some of the observations they made in the previous lesson that they did not understand. The students were made to write these down based on which he invited them to listen attentively as they observed a repetition of the process of simple titration using acid and base. The score for skill development was above sixty which also means that S1T2 performed well in helping the students develop the skill of listening using the TSM. He first aroused the interest of students to listen and went through the process of simple titration step by step pausing at every step to explain what he was doing as instructed by the TSM. Again, following the directives of the TSM, S1T2 was able to use leading questions to tease students to come out with other observations that they might not enquire about. S1T2 was also able to explain to the students why burette readings must be entered immediately after reading and why values are entered the way they are done following the direction of the TSM. The profile score of 100% for assessing learning effect indicate very good performance by S1T2 in following the directives of the TSM to assess the students on acquiring the skill of listening. S1T2 used more 'why' questions in assessing how well the students listened. In the last part of the curriculum profile, the Conclusion (C), per the direction of the TSM, S1T2 put the students into groups to discuss what they saw the teacher (demonstrator) do and say to score a good mark of 50%. The profile scores for the two teachers (S1T1 and S1T2) for lesson 2 show that although both teachers adhered to the instructions given by the TSM, S1T2 did quite better than S1T1. In lesson introduction for example, S1T2 scored 100% while S1T1 managed with 66.7%.

Table 3. Curriculum Profile Scores for Lesson 3Vo

Profile	S1T1		S1T2	
	No	%	No	%
Lesson introduction (LI)	2	100.0	2	100.0
Skill development (SD)	5	83.3	6	100.0
Assessing learning effect (LE)	2	100.0	2	100.0
Conclusion (C)	1	100.0	0	0.0

Note: The maximum possible scores for profiles are L1-2, SD-6, LE-2, and C- 1.

The third (3rd) lesson was aimed at helping the students acquire the skills of communicating verbally, what is being learnt. Students were therefore engaged in activities that involved lots of talking. As shown in [Table 3](#), the scores for both S1T1 and S1T2 for lesson introduction were 100%. This means that teachers were able to use questions based on the students' relevant previous knowledge as directed by the TSM to enable students pronounce as they identify names of at least 10 pieces of apparatus used in simple acid-base titration. They were very clear in making known to the students, the objectives of the lesson. [Table 3](#) again shows that except skill development where S1T1 score 83.3%, 100% scores were recorded in all the sections. That is an indication of excellent adherence to the direction of the TSM. In the skill development students were made to verbally describe the process of the simple acid-base titration step by step for the teacher to perform the skill. Still following the instructions given by TSM, both S1TI and S1T2 made students explain what happens when entering values of burette readings on the table of results, why cancellation of values is not accepted on the table and the need for consistency of the values. Still following the TSM, S1T2 was able to help the students communicate some measures to be employed to ensure good titration something that S1T1 missed.

The profile score for assessing learning effect for both S1T1 and S1T2 were the same (100%). It means that they both assessed the acquisition of the skill based on the ability to explain at least verbally, what titration is all about and how it is carried out. They both (S1T1 and S1T2) following the TSM, organized a debate in the class on the topic “Practical titration in WASSCE examination for the regular schools is a waste of time and resource”. The teacher took a seat among the students as two representatives of each of the two group debated on the topic. The score for the last section of curriculum profile labelled Conclusion for S1T1 was 100%. It means that S1T1 followed the guidelines of the TSM and gave take home assignment to the students. Students were to go and find out and list at least 6 institutions where titration is carried out in the country. On the part of S1T2, he did not follow the TSM to give any take home assignment. He therefore scored 0% for the section the Conclusion as shown in Table 3. The reason (which was found later) was that the section assessing learning effect took lots of time. Students got excited with the debate such that it took more time than necessary hence S1T2 lost sight over the very last item on the TSM. I learnt from this observation that estimated time at each section of the TSM had to be stated to provide enough guide to the users of the TSM.

Table 4. Curriculum Profile Scores for Lesson 4Vo

Profile	S1T1		S1T2	
	No	%	No	%
Lesson introduction (LI)	2	100.0	2	100.0
Skill development (SD)	10	76.9	8	62.3
Assessing learning effect (LE)	2	100.0	2	100.0
Conclusion (C)	1	100.0	0	0.0

Note: The maximum possible scores for profiles are LI-2, SD-13, LE-2, and C-1.

This lesson followed the first three on the fundamental skills of observation, listening and communication. It was intended to bridge the gap between understanding how a skill is done and doing it. It is called the stage of imitation. It is based on Vycosky’s theory of scaffolding. It is expected of the learner to observe what the teacher does and do the same. From Table 4, it is seen that both teachers S1T1 and S1T2 have the same score at LI and LE. At lesson introduction for example, both S1T1 and S1T2 scored 100% which means that they both referred to directives provided in the TSM and asked students to do it. The activity was based on the knowledge the students had acquired in the previously done lessons. Students were asked to check the apparatus displayed on each bench to find out whether it was set for simple titration. Each one of them was asked to lift up one apparatus at the mention of its name by the teacher. This introductory activity intended to give the students some level of confidence in holding the titration apparatus was excellently executed by both S1T1 and S2T2. As shown in Table 4, The Profile score for the skill development for teacher (S1T1) is approximately 77%, which is a good score. It means S1T1 again followed the TSM in helping the students use apparatus to imitate the teacher as the skill is demonstrated. The teacher demonstrated how to assemble the titration apparatus; fixing the burette, adjusting it to the eye level, checking for leakage of the tap and placing the white tile and conical flasks in position. The teacher then paused, went round to ensure that all the students had done same as directed by the TSM. The teacher followed the TSM in helping the students imitate how to fill the burette with solutions, checking for air space at the tip of the burette, pipetting the unknown solution into the conical flasks, doing the actual titration, correct volume reading, drawing of table of results and entering of the volume of the acid that neutralised the base. At every stage of the process, the teacher demonstrator (S1TI) would pause; go round to ensure that students were able to do exactly what he did. Assistance was offered to those students who were facing difficulty.

Example; adding just 2 drops of the indicator, checking air space at the tip of the burette and how to swirl the conical flask. He also stressed how to release the acid on drawing closer to the endpoint. However, both S1T1 and S1T2 performed better in following the TSM to assess the learning effect of the students. As shown by the profile score of 100% for both S1T1 and S1T2. Both S1T1 and S1T2 wrote their average titre values as well as that of the students on the board and discussed the causes of the difference in their values. They were both able to use leading questions to help the students come out with the precautions to be observed in simple titration in order to obtain consistent titre values. In the last section of the observation checklist, S1T1 scored 100% but S1T2 did not get anything because S1T1 gave the students take home assignment something that S1T2 did not do. During the interview, it became clear that S1T2 did not read thoroughly the model in advance before starting the lesson. It was strongly recommended therefore that the model be read through in advance before the start of each lesson.

Table 5. Curriculum Profile Scores for Lesson 5Vo

Profile	S1T1		S1T2	
	No	%	No	%
Lesson introduction (LI)	2	100.0	2	100.0
Skill development (SD)	3	100.0	2	66.7
Assessing learning effect (LE)	2	100.0	2	50.0
Conclusion (C)	0	0.0	1	100.0

Note: The maximum possible scores for profiles are LI-2, SD-3, LE-2 and C-1

Table 5 shows the profile scores of lesson 5Vo, the last stair of the first trial of the 5 stair PS-based TSM. The lesson was intended to improve the skill of students to manipulate the apparatus in addition to all the other skills learnt so far. The teacher was expected to play strictly the supervisory role but offer assistance when is requested for by a student. Lesson 5 was full of hands-on in-laboratory activity where the students were engaged on rinsing of titration apparatus, assembling, pipetting, actual titration, identifying colour change at endpoint and reading the volume of the acid that neutralises the base. Students were also engaged in recording of the reading on a table and calculating of the average volume of the acid that neutralised the base. **Table 5** shows that the profile score for lesson introduction is 100% for both S1T1 and S1T2 meaning they both did well to set-up the laboratory ready for the lesson as directed by the TSM. Both teachers introduced the lesson by asking some students to come forward and demonstrate how to perform some major skills; correct way of handling the conical flask, how to pipette solution (using water), take the reading of volume of solution in a burette and some other skills for the rest to see. Furthermore, they used the TSM as a guide to ask the students to write down on a fresh page the steps for performing simple titration. With regards to skill development, while S1T1 scored 100%, S1T2 scored 66.6%. This is explained that S1T1 was able to help the students carry out activity as described in the TSM to develop the skill of manipulation of apparatus better than did S1T2. Both S1T1 and S1T2 asked the students to follow the steps written down to perform the single titration activity using the apparatus set before them. Each of them following the guidance of the TSM went round to supervise and assist students where necessary while encouraging them to try to make use of all the skills learnt so far. However, before asking them to start work, S1T1 used questions to ensure that the steps for simple titration as written by each student were correct. S1T1 asked one of the students to read out what she had written down and through discussion ensured that the rest of the students corrected what they had written down on their own where necessary. This however was something that S1T2 did not do. The third and last section of the observation checklist as shown by **Table 5Vo** is the assessment of learning effect. S1T1 scored

100% and S1T2 scored 50% meaning both teachers assessed the performance of the students based on how or degree to which they were exhibiting the skills that they were taught. Both teachers went round and awarded marks to the students still performing the titration. However, S1T1 did better than S1T2 because S1T1 followed all the 2-step guidelines given for assessing learning effect in the TSMs but S1T2 did only one. Following the guidance of the TSM, S1T2 saw to it that the students washed their apparatus, cleaned the benches and helped the laboratory assistant to return the wares before ending the lesson but S1T1 on the other hand did not follow all the two guidelines as directed by the TSM hence the average score of 50%.

Table 6. Curriculum Profile Scores for Lesson 1V1

Profile	S2T1		S2T2	
	No	%	No	%
Lesson introduction (LI)	2	66.7	3	100.0
Skill development (SD)	7	70.0	6	60.0
Assessing learning effect (LE)	2	100.0	2	100.0
Conclusion (C)	1	33.3	2	66.6

Note: Maximum possible scores for profiles are LI-3, SD-10, LE-2, and LC-3.

Table 6 shows the curriculum profile scores for the 1st lesson taught in trial school two. The lesson 1V1 is an improved version of lesson 1Vo taught at trial school one (TS1). Two major areas that called for modification in the lesson 1V1;

- (i) The speed for the demonstration of the simple titration
- (ii) What to do when approaching the endpoint to ensure accurate results all under skill development.

The lesson itself was aimed at helping the students improve upon the ability to do critical observation using simple acid base titration. The curriculum profile scores for the 1st teacher of the second school (S2T1) were all above 65% except that of close of lesson which was 33.3%. A score of 66.6% for lesson introduction for S2T1 means that the guidance of the model was well followed to the students to mention names of any of the science apparatus they may know. Out of the long list of the apparatus mentioned, the teacher then asked that students identify the apparatus displayed (titration apparatus) by names. The teacher then went further to introduce the lesson based on the response. The profile score for LI for second teacher (S2T2) was 100%. Compared to S2T1, S2T2 was able to follow the guidance of the TSM to introduce the lesson. Under the section skill development, however, S2T1 scored 70% compare S2T2 who scored 60%. The scores mean that both teachers (S2T1 and S2T2) followed the guideline given by the TSM to develop the skill of observation but S2T1 was able to do it better that S2T2did. It means that S2T1 invited the students to observe closely without asking any question or interrupting in any way while the titration apparatus are inside and assembled, base pipetted into clean conical flask, indicator introduced and table of results drawn to get set for the titration as directed by the TSM. The initial volume of the solution in the burette is then taken from the eye-level and the value immediately entered on the table of results.

The teacher then slowly and systematically demonstrated the process of simple titration. Approaching the endpoint S2T2 was guided by the TSM to release the acid from the burette drop by drop and after each drop, swirl the conical flask for the new colour to disappear until a permanent colour change is obtained (endpoint). The endpoint is then read and immediately entered on the table of results. Occasionally, the teacher would pause and look round to see whether the attention of all the students is drawn toward the demonstration. A good profile score of 70% also means guided by the TSM, the entire process of titration was repeated using another portion of 25cm³ NaOH solution pipetted

into a new clean conical flask. The endpoint value is entered on the table of results and then the titration repeated the third time. The difference between the scores of S2T1 and S2T2 came about because while S2T1 obeyed the directives of the TSM to repeat the titration the second time, S2T2 repeated it only once. Both of them however calculated the average titre value.

Under the third section of the observation checklist, assessment of learning effect, both S2T1 and S2T2 scored 100%, meaning both teachers followed the guide of the TSM and ask questions to find out how well the students observed. Furthermore, both teachers gave take home assignments to ensure that the lesson continues even outside the laboratory. Table 6 also shows that, the profile score for the close of the lesson for S2T2 was 66.6% while that of S2T1 was 33.3%. This means that ending the lesson, S2T2 guided the students to wash clean the apparatus used for the demonstration, returned them to their appropriate places as directed by the laboratory assistant and cleaned the room and the benches before leaving the laboratory. S2T1 however did not guide the student to clean up the apparatus and the laboratory as required by the TSM.

Table 7. Curriculum Profile Scores for Lesson 2V1

Profile	S2T1		S2T2	
	No	%	No	%
Lesson introduction (LI)	3	100.0	2	66.7
Skill development (SD)	8	88.9	7	77.9
Assessing learning effect (LE)	4	100.0	3	75.0
Conclusion (C)	3	100.0	3	100.0

Note: Maximum possible scores for profiles are LI-3, SD-9, LE- 4, and LC-3.

Table 7 shows the curriculum profile score of the second lesson by two teachers (S2T1 and S2T2) in trial school 2 (TS2). The lesson was a revised version of lesson 2Vo (results shown in Table 2Vo above) taught in trial school (TS1). The objective of the lesson was to primarily help students develop good listening skills in studying simple titration. Table 7 shows that for lesson introduction, S2T1 scored 100% meaning the teacher strictly followed the guidelines provided by the TSM in introducing the lesson by using questions to help the students come out with the importance of listening and how to do good listening. The teacher continued by asking students to recall and tell some of the things that they saw during the previous lesson. Based on these, the teacher then introduced the lesson inviting students to observe closely and listen attentively. In the case of S2T2, the teacher missed one of the three stages under introduction stated by the TSM hence the score 66.6%. Under the section skill development, S2T1 missed 1 out of the 9 guideline sequentially presented hence the score 88.9% as compared to S2T2 who scored 77.8% for missing two of the guidelines.

Both S2T1 and S2T2 displayed the titration apparatus again and with a clear and loud voice explains why the use of each apparatus as directed by the TSM. Further, the students were invited to ask questions on all that they heard. The apparatus were assembled (as did in the previous lesson) and the titration process slowly and systematically carried out with an explanation on why it had to be done that way at each stage of the process. The teachers occasionally asked a student to repeat a word, phrase or sentence of the explanation given in other to ensure that the students were continuously focused on the demonstration. The titration process was repeated. From the Table 7, it is observed that S2T1 did better at this section than S2T2. The reason was that S2T2 did not repeat the titration as directed by the TSM and done by S2T1. However, both S2T1 and S2T2 went further to explain the process of recording burette readings on the table of results. S2T1 also went further to explain some of the things that are not supposed to be done on the table of results. For the assessment of learning effect, according to the Table 2V1, S2T1 scored 100%

meaning the teacher followed all guidelines of the TSM to use questions to find out how well students listened. He asked the students more of why questions. The teacher then went ahead to put the students into groups and ask each group to write down at least 5 observations and explain why those things are done. S2T1 finally gave take-home assignment. S2T2 on the other hand scored 75% meaning the teacher did well in following the guidelines as shown by the TSM. However, S2T2 did not give take home assignment. In closing the lesson, both teachers (S2T1 and S2T2) did excellent in following the guidance of the TSM hence the score of 100% for each of them. They both guided the students to clean apparatus, return them to where they were and clean the benches. Generally, the scores as shown in Table 7 indicate that S2T1 did better than S2T2 in following the TSMs. During the interview, it was found out that S2T1 read the model a number of times than did S2T2 before the lesson.

Table 8. Curriculum Profile Scores for Lesson 3V1

Profile	S2T1		S2T2	
	No	%	No	%
Lesson introduction (LI)	2	100.0	2	100.0
Skill development (SD)	8	88.9	7	77.0
Assessing learning effect (LE)	3	100.0	2	66.7
Conclusion (C)	2	100.0	2	100.0

Note: Maximum possible scores for the profiles are LI-2, SD-9, LE-3, and LC- 2.

Lesson 3V1 is the revised version of lesson 3V0 which was taught in trial school 1 (TS1). It follows directly lesson 2V1. After the lesson 3V0 and interview that followed, it was realized that the introduction of the lesson could be improved to make it more interactive and more activity oriented. Besides, the information could be enriched to include barriers of communication in science. In the lesson, students were engaged in activities that will improve their communicative skill with regards to simple titration. Table 8 shows that both teachers (S2T1 and S2T2) have the same score of 100% at the lesson introduction level. This means that they both referred to the guidelines provided in the TSM to carry out the activities stated. Seven students were selected and the teacher gave information on simple titration to one of them in private to be passed on to the next person and to the next till it got to the last person. The 7th student then told the whole class what was received but the message was distorted from the original. The teachers then lead the class to discuss the causes of the distortions and the need to communicate effectively. Based on the discussion, the lesson was introduced. The table again shows that for the 2nd section of the profile (skill development), S2T1 scored 88.9% while S2T2 scored 77.8% meaning S2T1 followed 8 of the 9 guidelines provided in the TSM while S2T2 followed 7 of the 9.

S2T1 asked the students to mention the names of the pieces of apparatus expected to be found on titration bench. A student was then asked to stand up and describe the process of simple titration step by step for the teacher to demonstrate the skill. At some point, the teacher would ask another student to continue the description so as to engage as many students as possible until the titration was done. S2T2 on the other hand did all that was done by S2T1 except that no student was made to explain how to enter values on the table of results as directed by the TSM, and as was done by S2T1. Table 8 also shows that S2T1 scored 100% for assessing learning effect meaning the guidelines shown by TSM was followed by S2T1 to organise a debate for the class. The class was put into two groups and was made to discuss points for and against the motion “practical titration examination in West Africa School Certificate Examinations is a waste of time and resources”. The two groups then appointed two people to represent them in 10-minute debate contest. Following the debate, a take home assignment was given to ensure that the students continued with the lesson even after school. Table 8 shows that S2T2 scored 66.7% for LE meaning

the guidelines of the TSM followed. S2T2 also organised the debate as stipulated by the TSM to assess the ability of the students to communicate the essence of titration as a practical subject in SHS. Further, a take home assignment was given to encourage continuous talk about the skill that was learnt. The students were to write down five ways by which scientist all over the world communicate to each other. Following the assignment was the last section of the observation checklist termed lesson closer. Both S2T1 and S2T2 according to [Table 8](#) scored 100% meaning they both followed very closely the guidelines provided by the TSM to ask the student to wash the apparatus, clean the bench and return the apparatus to its original place as directed by the laboratory assistant. Generally, both S2T1 and S2T2 performed remarkably well in following the TSM.

Table 9. Curriculum Profile Scores for Lesson 4V1

Profile	S2T1		S2T2	
	No	%	No	%
Lesson introduction (LI)	3	100.0	3	100.0
Skill development (SD)	13	100.0	13	100.0
Assessing learning effect (LE)	3	100.0	3	100.0
Conclusion (C)	3	100.0	2	66.6

Note: The maximum possible score for profiles are LI-3, SD-13, LE-3, and LC-3

Lesson 4V1 was purely hand-on laboratory activity where the students demonstrated how well they had observed and listen to all that had gone on in the previous lessons. There were not many changes to lesson 4V0 except that the model was modified to direct the teacher to explicitly state the objectives of the lesson just after the introduction to the students and exactly what he expects them to do or be doing. [Table 9](#) shows the profile scores of the lesson for teacher 1 (S2T1) and teacher 2(S2T2). As shown by the profile score of the two teachers, the lesson was excellently delivered. S2T2 for example scored 100% in all the sections of the profile meaning the teacher was able to follow the directives of the TSM to the letter to introduce the lesson, develop the skill, assess the learning effect and close the lesson. S2T1 directed all the students to check from their benches to see whether all pieces of apparatus needed for the titration including the reagents (Acid and Base) were available. The teacher then asked each student to assemble the apparatus for titration in the introduction as directed by the TSM. The teacher concluded the introduction by inviting the student to imitate what he was going to do and do same. The objective of the lesson was also made known to the students as directed by the TSM. A curriculum profile score of 100% for skill development means that the teacher followed all the 13- step guidelines provided by the TSM to make the students imitate the skill for performing titration by going through the process of simple titration. The steps included rinsing of apparatus, filling the burette with acid and pipetting of the base into the conical flask. As directed by the TSM, the teacher allowed time to practice how to pipette solution using water. S2T1 continued the process with the drawing of table of results, introducing acid-base indicator into the solution in the conical flask and releasing of the solution from the burette to the conical flask. Occasionally, the teacher would stop and go round to check whether the students were doing the right thing or would attend to the call for help of a student. The process continued through till the end point was reached. It was read and entered on the table of results. The students were then allowed to repeat the process on their own for the 1st and 2nd time as directed by the TSM. The impressive score of 100% for S2T1 for assessing learning effect means that the teacher followed the directive of the TSM to compare the titre value that was obtained by the teacher (S2T1) and that of the students. Furthermore, there was a discussion on the causes of the differences in their titre values (volume of acid that neutralised the base). T2S1 closed the lesson excellently as shown by the score of 100% on [Table 9](#). Just like S2T1, S2T2 also put up an impressive performance

as shown by the curriculum profile scores on the Table 4V1. According to Table 9, the scores were 100%, 100%, 100% and 66.7% for LI, SD, LE and LC respectively. An impressive score of 100% each for LI, SD, LE means that T2S2 followed all the guidelines provided by the TLM to introduce the lesson, lead the student to imitate the skills for performing simple titration and assess the learning effect of the students. He however scored 66.7% for the section called lesson closer. It means that S2T2 obeyed 2 out of 3 guidelines provided by the TSM. Generally, the table shows that the two teachers stayed with the TSM in lesson 4V1 and that was highly impressive.

Table 10. Curriculum Profile Scores for Lesson 5V1

Profile	S2T1		S2T2	
	No	%	No	%
Lesson introduction (LI)	3	100.0	3	100.0
Skill development (SD)	2	100.0	2	100.0
Assessing learning effect (LE)	1	100.0	0	0.0
Conclusion (C)	3	100.0	3	100.0

Note: Maximum possible scores for the profiles are LI-3, SD-2, LE-1, and LC-3.

Table 10 shows the curriculum profile score for the lesson 5V1, the last of the five lessons conducted at the trial school 2 (TS2). The lesson also happened to be the revised form for lesson 5V0 which was held at the trial school 1. The lesson was intended to improve the manipulative skills of the students with regards to the handling and the use of titration apparatus by rinsing apparatus for titration, assembling, pipetting, and adding indicator and carry out the actual titration. It was expected of the teachers to strictly play the role of a facilitator and assessor. Table 10 shows that the profile score for lesson introduction is 100% for both S2T1 and S2T2 meaning that both teachers followed all the 3-step guidelines provided by the TSM to introduce the lesson. They both asked each student to write down from memory the processes for performing simple titration. The students were then made to identify some precautions that must be followed to ensure accurate results after which they were allowed some time to practice how to pipette solution using ordinary water. Table 10 again shows that both S2T1 and S2T2 got the maximum scores of 100% for the profile Skill Development. The results as recorded in Table 10 are very impressive. A profile score of 100% shows that both teachers followed the TSM to offer the 2-step guidance for skill development. Students were directed to use the steps for performing simple titration that they had written to carry out titration using a question written on the board. They were then encouraged to employ all the skills learnt in the four previous lessons to perform a good titration. The teacher went round to observe the activity and offered assistance only when a student called for it. With regards to the profile assessing learning effects, S2T1 had an impressive mark of 100%, S2T2 however had a sorry mark of 0%. A score of 100% means that S2T1 followed the only guideline stated in the TSM for assessing learning effect while S2T2 missed that step hence the score of 0%. It was realised later on that S2T2 did not understand that guideline of the TSM which required of him to go round the students with score sheet to assess them while they performed the titration. It was evident that thorough orientation was very necessary for the successful use of the TSMs.

The performance of the two teachers was excellent for the profile lesson closure. The possible maximum score was 3 and both teachers had 100% as shown in Table 10. This means that both teachers followed the 3-step guidelines stated in the TSM to conclude the lesson. Teachers ensured that students cleaned or washed the apparatus, returned them to the laboratory assistant and cleaned the laboratory as well as their hands before leaving the science laboratory. Generally, the performance of the teachers in lesson 5V1 on the use

of the TSM as shown on [Table 10](#) was very impressive. It shows that the two teachers generally followed strictly the guidelines of the TSM in the lesson delivery.

Table 11. Curriculum Profile Scores for Lesson 1V2

Profile	S3T1		S3T2	
	No	%	No	%
Lesson introduction (LI)	3	100.0	3	100.0
Skill development (SD)	9	90.0	9	90.0
Assessing learning effect (LE)	3	100.0	3	100.0
Conclusion (C)	3	100.0	3	100.0

Note: Maximum possible scores for the profiles are LI-3, SD-10, LE-3, and LC-3.

[Table 11](#) shows the profile scores for lesson 1V2, the first of the five lessons marking the third and the final round of the trials. The lesson was aimed at helping the students improve upon their ability to do critical observation using simple acid-base titration. Lesson 1V2 happens to be the improved form of lesson 1V1 taught in trial school 2. Discussions and interviews after the previous lessons suggested that students' participation in the lesson be improved. In addition, students had difficulty easily identifying colour-change at the end point. Lesson 1V1 was therefore revised to include a short activity at the introductory part that help student in identification of colours of solution. The results according to [Table 11](#) show an impressive performance for both S3T1 and S3T2. For lesson introduction, both S3T1 and S3T2 had the excellent mark of 100% meaning that both followed the guidelines of the TSM and asked the students to mention the names of some science apparatus. The responses were written on the board as they mentioned them. Further, the students were asked to identify the apparatus that the teacher had placed on the demonstration table as directed by the TSM. 100% score for lesson introduction also shows that students carried out an activity to identify some colours of solutions displayed. 5 conical flasks each containing solution of different colours was displayed. The beakers were labelled A to E. Students were asked one after another to come closer to identify the colours of the solution and write it down without showing it to anybody. These were then collected by the teacher and the differences in identification of the colour discussed. Each of the teachers based on the discussion to mention to the students the objectives of the lesson to conclude the lesson introduction.

The profile score for both S3T1 and S3T2 was a very good mark of 90% meaning each of them skipped only 1 of the 10 guidelines provided by the TSM to develop the skill in the lesson. These steps include the assembling of the apparatus for titration, clear drawing of the table of results, pipetting of the solution into a conical flask, introduction of acid-base indicator into the base and slowly releasing the solution from the burette into that of the conical flask. Both teachers obeyed the guidelines of the TSM to occasionally pause to find out how closely students were watching and did not interrupt the process with either asking or answering questions from students. Again, as directed by the TSM, closing up on the endpoint, solution was delivered from the burette drop by drop till the endpoint was reached. The volume of acid that neutralized the base was read and recorded. Both teachers exhibited 90% skill development according to [Table 11](#). None of the two scored 100% because each of them repeated the process once instead of repeating twice as directed by the TSM. The section was concluded with the calculation of the average titre as required by the TSM. The profile score for the two remaining sections is all 100% for both S3T1 and S3T2. This means that each teacher fully obeyed the guidelines of the TSM in both assessing learning effects and lesson closure. This was done through questions based on how the titration was carried out as they observed and homework given. Furthermore, the lesson was closed with cleaning of the apparatus by the teacher for the students to see. The apparatus was then handed over to the laboratory assistance. Scores as shown by

Table 11 reveals that generally, both S3T1 and S3T2 had excellent lesson. It came up during the interview session that they both read the TSM many times ahead of the lesson. That probably accounted for the excellent performance.

Table 12. Curriculum Profile Scores for Lesson 2V2

Profile	S3T1		S3T2	
	No	%	No	%
Lesson introduction (LI)	3	100.0	3	100.0
Skill development (SD)	8	88.9	8	88.9
Assessing learning effect (LE)	4	100.0	3	75.0
Conclusion (C)	1	100.0	1	100.0

Note: Maximum possible scores for the profiles are LI-3, SD-9, LE-4, and LC-1.

Table 12 shows the curriculum profile score for lesson 2V2, the second of the five lessons marking the third and the final round of the trials. The lesson which follows immediately, the lesson on observation but before communication is aimed at developing the skills of quality listening among science students using the topic simple acid-base titration. After the second trial, it was observed that the part of the introduction of the TSM that asked teachers to discuss the importance of good listening was a little open which made it difficult for the teacher to kick start the discussion. In revising the TSM therefore, some specifics were introduced to direct the teacher on exactly what could be done to kick start the discussion. The results as shown by Table 12 show an impressive performance for both S3T1 and S3T2. For example, S3T1 had 88.9% as the least score. On the part of the S3T2, the least score was 75%. The results show high degree of compliance by both teachers towards the directives given by the TSM. Table 12 shows that S3T1 scored 100% for lesson introduction meaning the guidelines given by the TSM excellently followed in introducing the lesson. S3T1 then went ahead to discuss the importance of quality listening in science. The score for S3T2 for lesson introduction was also 100% meaning S3T2 also followed closely the directives of the TSM to introduce the lesson as directed by the TSMs. Table 12 also shows that each of the two teachers had a score of approximately 89% for skill development section of the curriculum profile, meaning that the teachers followed the guidelines of the TSM to verbally explain the observations that was made by the students during the previous lesson by repeating the process of simple titration and verbally explaining at each step what was being done to the listening of all students. Each teacher began by verbally explaining the use of each apparatus in titration and went ahead to clamp the burette, rinse apparatus, draw the table of results and start the titration explaining each step on the way. Unlike the previous lesson (lesson 1V2), students are occasionally asked to repeat what was said to ensure their attention is continuously held. Both teachers repeated the process of the titration and went ahead to calculate the average volume of the acid that neutralize the base. In the assessment of learning effect section, S3T2 scored 75% while S3T1 scored 100% meaning although both teachers did well in following the guidelines S3T1 did better than S3T2. S3T1 followed all the four steps given by TSM to assess the learning effects by asking the students questions that required explanations.

Table 13. Curriculum Profile Scores for Lesson 3V2

Profile	S3T1		S3T2	
	No	%	No	%
Lesson introduction (LI)	3	75.0	4	100.0
Skill development (SD)	6	75.0	7	87.5
Assessing learning effect (LE)	2	100.0	2	100.0
Conclusion (C)	1	100.0	1	0.0

Note: Maximum possible scores for the profiles are LI-4, SD-8, LE-2, and LC-1.

Table 13 shows the curriculum profile scores for the third pair of lessons taught at trial school 3. The lesson was the revised form of lesson 3V1 results shown by Table 13 which was also the developed version of 3V0 (results shown by Table 3V0). Just like lesson 3V0 and 3V1, 3V2 is designed to help students develop some communicative skills even as they study the topic simple titration. After observing the teacher demonstrate the skill (lesson 1V2) listening to the reasons behind the demonstration (3V2), the students will then verbally describe the process for the teacher to demonstrate. After the interview that follows the second round at trial school 2, lesson 3V1 was revised to make it more informative and easy to understand. According to Table 13, none of the two teachers scored any mark below 75% meaning the teachers did follow the directives of the TSM very closely in their lesson delivery. Table 13 again shows that, the scores for the lesson introduction for S3T1 was 75% meaning to a greater extent S3T1 followed the guideline given in the TSM to introduce the lesson by first helping the students to define what is meant by communication and then involving the students in an activity which demonstrate how information is transmitted hence some of the barriers in communication. With this background, the students were then helped to pronounce correctly some keywords in titration which had then been written on the board before the objectives of the lesson were clearly communicated to the students, to complete the introductory session. Table 13 also shows that the profile score for skill development for S3T1 is also 75% while that for assessing learning effect and the lesson closure are 100%, 100% respectively. The impressive mark of 100% for assessing learning effect means the teacher (S3T1) obeyed all the directives given in the TSM to assess the lesson by organizing a debate on the topic "Practical titration in senior high school WASSCE is a waste of time and resources" The debate which gave the students opportunities to work in groups, prepared for presentation and present their views was followed by a take-home assignment as stated by the TSM. S3T1 again followed the guidelines of the TSM to close the lesson by asking one of the students to come up and rinse the apparatus as had been done by the teacher in the two previous lessons. That explains why 100% profile score for lesson closure. Generally, the profile score as shown by Table 13 shows a certain high degree of adherence to the directives of the TSM by both S3T1 and S3T2.

Table 14. Curriculum Profile Scores for Lesson 4V2

Profile	S3T1		S3T2	
	No	%	No	%
Lesson introduction (LI)	2	100.0	2	100.0
Skill development (SD)	10	71.4	12	85.7
Assessing learning effect (LE)	3	100.0	3	100.0
Conclusion (C)	2	100.0	2	100.0

Note: Maximum possible scores for the profiles are LI-2, SD-14, LE-3, and LC-2.

From Table 14, it is seen that S3T1 scored above 70% in all the 4 steps of the lesson 4V2. It means that the teacher followed the instructions of the TSM to demonstrate the

skills and ensured that students imitated accordingly. The teacher performed the titration simultaneously with the students. A score of more than 70% of the profile for lesson introduction means that the lesson introduction was done as required by the TSM. 71% of the skill development means that the teacher made sure that the students perform the skill that he demonstrated at one stage before going to the next. The teacher (S3T1) rinsed his apparatus and ensured each student does the same; fit the burette to the retort stand and ensured each student does the same; pipette 25cm³ of the base (sodium hydroxide) into the rinsed conical flask and ensured that each student does the same and continue till the whole titration is completed. The marks were clearly recorded. 71% score also means that the teacher (S3T1) made the students repeat the entire process of the titration on their own as he went round to assist students who needed help. A score of 100% for assessing learning effect means that S3T1 compared his own average value for volume of acid that neutralised the base with that of the students. He then went further to discuss the causes of the differences in the values (precautions). It also means that the teacher asked the student to write down at least four things they would have to do to ensure that accurate results are obtained in simple acid base titration. For the lesson closure an excellent score of 100% also means that the teacher followed the directives of the TSM to summarise to the students all that they did. The teacher also ensured that the apparatus that were used were left as clean as they came to meet it.

The scores for Lesson introduction, Skill development, assessing learning effect and lesson closure according to the table were 100%, 85.7%, 100% and 100% respectively for S3T2. This means that for lesson introduction for instance, S3T2 was able to arouse and direct the interest of the student towards the lesson for the day as expected by the PS-based TSMs. It means students were made to check if the apparatus before them were set for simple acid base titration. For the skill development a high score of 85.7% means that the teacher ensured that students performed the titration same way as he did it as directed by the TSM. S3T2 performed one step and allowed the students to do it before going on to the next step. That continued till the whole process was done. The high score also means that after the imitation process, the students were allowed to repeat the process from the start to the end while the teacher went round to offer assistant where needed. Using discussion as prescribed by the TSM, the teacher sought the students' difficulties with the performance of the simple titration. He then asked students to list five things that need to be done to obtain accurate results in simple titration (precautions). S3T2 followed the TSM to closed the lesson by making the students wash clean the apparatus used and given take home assignments as directed by the TSM hence an excellent score of 100%.

Generally, the profile score for both S3T1 and S3T2 as shown in [Table 14](#) indicates that both teachers referred closely to the TSM in the lesson delivery.

Table 15. Curriculum Profile Scores for Lesson 5V2

Profile	S3T1		S3T2	
	No	%	No	%
Lesson introduction (LI)	3	75.0	2	50.0
Skill development (SD)	2	100.0	2	100.0
Assessing learning effect (LE)	1	100.0	0	0.0
Conclusion (C)	1	100.0	1	100.0

Note: Maximum possible scores for the profiles are LI-4, SD-2, LE-1 and LC- 1.

Like lesson 5V0 and 5V1, lesson 5V2 was purely laboratory practical activity aimed at developing the manipulative skills of the students. The lesson also required that the students employed all the skills learnt from lesson 1 (1V2) through to lesson 4 (4V2). The profile for S3T1 as shown in [Table 15](#) is quite impressive. With the exception of the Lesson introduction where the score was 75.0%, the score was 100% for all three sections left. A

good score of 75.0% for Lesson introduction means that the teacher followed the directives of the TSM to allow the students time (20 minutes) to play around with the apparatus anyhow they wanted. Teacher then asked each student to write down the steps for performing simple titration as they had observed repeatedly in the previous lessons. It also means that the teacher concluded the introduction by asking each student to write down at least four precautions to be observed to ensure accurate results in titration. What S3T1 should have done to score 100% for lesson introduction was that the teacher should have clearly told the students the lesson objectives at this point. The score of 100.0% for skill development means that the teacher (S3T1) obeyed the guidelines given by the TSM to instruct the students to follow the steps that they had written down to carry out the titration exercise. As directed by the TSM, S3T1 went round the students to observe and offer assistance where necessary, playing the role of a facilitator. For assessment of learning effect, S3T1 scored 100.0% as shown by Table 5V2 meaning the students were made to repeat the process. As students were still titrating, the teacher (S3T1) went round with his score sheet to award marks based on the performance of each student. The score sheet shown by the TSM is designed to measure the degree of the acquisition of the skills.

On the part of the S3T2, the profile score was an average mark of 50.0% for lesson introduction, excellent score of 100% for skill development, an unfortunate 0% for assessing learning effect and another 100.0% for lesson closure. 50% for lesson introduction means that the teacher partly obeyed the directives of the TSM, to prepare the students for the titration exercise. S3T2 didn't allow the students time enough as stated in the TSM to play with the apparatus before asking them to write down the steps for performing the simple titration. It was therefore not surprising when two incidences of breakages were recorded during the titration. However, there was an excellent score of 100.0% meaning the teacher did well in instructing the students to follow the steps for the titration as written down to answer the titration exercise written on the marker board. 100% also meant that S3T2 played the supervisory role of a facilitator and assisted students only when they called for help as directed by the TSM. The score of 0% for assessing learning effect means that the teacher (S3T2) did not obey the directives of the TSM to assess the students while performing the exercise. During the interview, it came to light that the teacher did not understand that part of the TSM during the orientation but unfortunately did not ask. It was therefore noted that that part needs proper explanation anytime the TSM is to be used. Table 15 also shows that S3T2 scored 100% for lesson closure meaning students were made to wash clean all the apparatus after lesson as directed by the TSM. Generally, the two teachers, S3T1 and S3T2, obeyed the directives of the TSM closely for the lesson except that S3T2 could not use the only directive of the TSM at the assessing learning effect stage.

4. Conclusions and Recommendations

The study indicated that support material was intended to help teachers implement aspect of the Senior High School integrated science as well as Chemistry syllabus which require the development of practical process skills of the science students, but to which no proper or adequate method is given. The teacher support overcomes the difficulty of how to build these essential skills among the students' scientist. The excitement of the teachers as well as the learners who used the material shows that the support material was of great help and yielded appreciable learning effect. The spiral approach in the process of developing the PS-based teacher support material has shown a practical way of developing any kind of skill among students. The study also concluded that there has also been some improvement in the cognitive experience and pedagogical content knowledge of the teachers in the use of the PS-based teacher support material in the laboratory. It is recommended that Ministry of Education and Ghana education service should stock the science laboratories in the various senior high schools in the country with modern science equipment for practical skill lessons. It is also recommended that teachers and educators

should thoroughly read and assimilate the contents and the processes described in the PS-based TSMs before they are used to teach titration.

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