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The Status of Fast Feedback Method in Chemistry Classrooms and Its Effect On Students' Learning of Chemical Bonding

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Abstract

This study was designed to find out the types of feedback chemistry teachers give to their students, introduce FAST (frequent, accurate, specific and timely) feedback method by teaching chemical bonding and determine its effect on students learning. A case study design using the action research approach was adopted for the study. A sample of 865 first year chemistry students and 20 chemistry teachers (n=885) selected from senior high schools in the Eastern Region of Ghana responded to the instruments. Out of this, 795 students and 20 teachers were involved in the pre-intervention study and 70 students were involved in the intervention and post-intervention study. At the pre-intervention stage data was collected using questionnaires, interviews, and checklist for the observation of chemistry lessons and students' exercise books. Science educators examined the instruments and modifications were made. The instruments were found to be reliable because alpha values above 0.75 were obtained after the pilot study. At the intervention and post-intervention stage, data was collected with worksheets. The results were analysed using SPSS. Findings from the research revealed that the feedback given by chemistry teachers was neither frequent nor accurate. Additionally, it was found out that the feedback was neither specific nor timely. Path analysis of the correlations of the attributes of FAST feedback method for both teachers and students confirmed this. When FAST feedback method was employed in teaching chemical bonding positive results were obtained. The students became interested and participated actively in the lessons. Students also scored high marks (above 75%) in all the exercises. The FAST feedback method facilitated the diagnoses of the conceptual difficulties of the students with respect to chemical bonding.

Keywords: Fast Feedback Method, Chemistry Classrooms, Chemical Bonding, Students' Learning

1.0 INTRODUCTION

This chapter provides a general insight into the research. It gives reasons why the research was conducted by providing the background, stating the problem associated with the provision of feedback in chemistry classrooms, identifying the purpose of the study, the objectives expected to be achieved at the end of the study as well as the significance of the study. The chapter again provides research questions which directed the study as well as the educational significance of the research. Issues which came up in the course of the research which the researcher could not control have been discussed under limitations and boundaries to the study have been described under delimitations.

1.1 Background to the Study

Teachers have been supported, challenged and encouraged to think critically about their methods of teaching and to build on existing good practices (Alexander, 2009). There has also been a need to align classroom and school-wide assessment with school systems, so that summative pressures do not undermine formative work (Smith & Gorard, 2005; Nicol, 2010). A key component of formative assessment deals with teacher feedback to students and its complexities. Feedback gives specific information about current achievement, the next step (or goal) and how to reach that goal. It then requires thought and some kind of response or action from the student. Feedback is information provided by an agent (e.g., teacher, peer, book, parent, experience) regarding aspects of one's performance or understanding. It occurs after instruction that seeks to provide knowledge and skills or to develop particular attitudes. A teacher has the distinct responsibility to nurture a student's learning and to provide feedback in such a manner that the student does not leave the classroom feeling defeated. Indeed, feedback is an integral part of motivation theory as are needs, goals, and rewards. Students seem to intuitively understand how important it is to receive ongoing performance feedback in order to sustain motivation and attain goals (Stobart, 2008). Teachers routinely and perhaps unconsciously rely on many types of feedback. Teachers give formal feedback when students are given grades and return assignments and examinations. Informal feedback is offered when teachers respond to students' questions and discussions. Teachers also receive formal feedback from students when students complete end-of-term or course evaluations. Informal feedback is obtained from students when teachers detect a look of boredom or confusion from the back of the classroom.

Teachers' reasons for wanting feedback about their teaching performances are usually a mixture of the personal and the professional. Every teacher is likely to be interested to know in a general way, how he or she is doing and how things are going. While some are keen on having details that will help them consolidate good performances or make improvements, others need to be able to document the quality of their teaching skills (Duffield & Spencer, 2011). Although there are various types of feedback available to help facilitate student learning, equally importantly lies in the selection of appropriate type based on students' needs and the instructional activities (Konold, Miller & Konold, 2004). An imperative issue that has constantly been discussed and argued upon is the quality of feedback given to students. MacDonald (1991, p. 1) expounds that teachers' feedback "often lacks thought or depth; students often misunderstand their teachers' feedback…and many students do not attend to teachers' feedback to begin with!" This contention is supported by Weeden and Winter (1999). These results are important as they provide an awareness of the feedback practices employed in the classroom and the significant effects on classroom interaction and student learning.

In Ghana, teachers are not always able to produce frequent, very accurate, specific and timely feedback information as a result of lack of teaching and learning materials and lack of motivation (Personal interaction with some SHS teachers at GAST conference at Koforidua in 2005). The adoption of FAST feedback method by teachers in the classroom could help students in their learning. Van Den Berg and Hoekzema (2006) defines FAST feedback as a whole class teaching method in which the teacher gives a series of short tasks to be done by students individually but at a collective pace. FAST feedback is a straight forward approach designed to teach anyone in a position of supervisory responsibility the key skills and best practices of the most effective teaching style. FAST feedback is a practical method for giving students the kind of feedback they need most. It is based on the formula FAST, an acronym that stands for frequent, accurate, specific and timely. Tulgan (2013) making reference to his earlier work, stated that these four aspects of FAST are also the four elements students most often say they needed but did not get in the feedback they received from their teachers.

Immediate and frequent feedback improves learning (Dihoff, Brosvic, Epstein & Cook, 2010; Dubner & Levitt, 2006; Hattie & Timperley, 2007). Accurate feedback can increase effort, motivation, or engagement to reduce the discrepancy, and/or it increases cue searching and task processes that lead to understanding (thus reducing the discrepancy). Studies related to feedback timing (e.g., timely and delayed feedback) have obtained conflicting outcomes for the effects of feedback on learning (Corbalan, Pass & Cuypers 2010). Although researchers for decades have examined the effects of timely feedback and delayed feedback on learning, study results for feedback timing have always been controversial (Mory, 2003). However, timely feedback has typically proven to have better effects than delayed feedback for a well-structured problem. The concept feedback appears to be complex. It is however, a vital component of formative assessment. It has been suggested that feedback "should be specific and related to the need (Hattie & Timperley, 2007). Simple knowledge of results should be provided consistently (directly or implicitly), with more detailed feedback only when necessary, to help the student work through misconceptions or other weaknesses in performance" (p. 469). Ramaprasad (2007) defined feedback as information about the gap between actual and referenced (predetermined) levels. He adds that this information is considered as feedback only when it is used to alter the gap. He describes these three elements as desired goal, current position, and closing the gap.

Feedback is a reactive form of communication, which is a response to some kind of action or input. For example, an answer to a question, fulfillment of a request for information, reply or rebuttal to a point of discussion, suggestion for work revision or evaluation of a job performance. When operating in a new environment, people rely on feedback to learn what works and does not work. It is an excellent technique to help mankind to improve in any endeavour he or she chooses to undertake. Obviously this is also true in teaching and learning, however it can be difficult to obtain a true measure of performance, and possible areas of improvement. Giving students feedback promotes learning. Instructors in all disciplines spend hours laboriously correcting and explaining errors on quizzes and tests, reports and papers. In addition, a number of studies have found that elaborated feedback, in which students are helped to find the right path, are more effective than situations in which they are simply told whether they are right or wrong (Blair & McGinty, 2013; Nicol, 2010; Hattie & Timperley, 2007).

On the other hand, students may use feedback they receive from their teachers on tasks they perform to distinguish between their misconceptions and scientific concepts. This enables students to change their views about certain concepts they hold about some phenomena and also adopt new ways to solve problems. In a study conducted by Hounsell, McCune, Hounsell and Litjens (2008), it was found out that student's express dissatisfaction with the feedback they receive from their teachers. Students assert a need for meaningful and constructive feedback (Higgins, Hartley & Skelton, 2001) to serve as a guide for their learning. Teachers and students therefore need to think through their own feedback requirements, in the light of their own responsibilities, aims, focus and content of their classes, and the relative merits of a broad overview or some close-grained information (Sadler, 2010). Inevitably, teachers feel that the whole class needs and deserves to know the correct answer or response to a question, and students expect to be told whether their answers are right or wrong, but there are alternatives to traditional whole-class feedback conducted by the teacher or teacher-nomination in a lockstep pattern. Traditional feedback is teacher-led, involves little communication between learners and tends to be contrary to current good classroom practice. The teacher is in control and responsible for important group decisions such as when to move onto the next question.

Considerable teacher talking time may occur, particularly if the teacher reads out the questions in full (often unnecessary as students already have these in front of them) or 'echoes' students' answers for no apparent reason. Whole-class feedback is unlikely to reveal whether all or most of the students know what the correct answer is. Less-able students often become confused the feedback, particularly if they are trying to use strategies for understanding their errors or attempting self-correction. Anxiety may be caused for students who are unsure of the correct response. The correct answer may be established, but understanding is not checked. Despite the interest in assessment and feedback there has been limited research on the process of feedback, its elements and student understanding of it. There has also been a limited amount of research that investigates students' perceptions and views of their learning, and the relationship of their perceptions to the feedback they receive (Duffield & Spencer, 2011). Ampiah, Hart, Nkhata and Nyirend (2003) contend that teachers need to know what students can do or cannot to enable them plan effectively to assist students.

In Ghana, it is known that teachers hardly write feedback on students' tasks and those who do, only give ego-oriented feedback (Amedeker, 2007). The situation in the Ghanaian classrooms concerning feedback to students on their oral responses is even bleaker. Often teachers would only give comments that allude to students' performance for example, good, well done, can do better or poor (Amedeker, 2007). From all indications most Ghanaian teachers would neither indicate what has gone wrong with responses they receive from their students nor tell students how to correct their wrong responses. The study sought to identify the existing types of feedback chemistry teachers employ in their teaching practices and also investigated the effect of FAST feedback as a teaching method on student learning of chemistry.

1.2 Statement of the Problem

Several methods are employed by chemistry teachers in chemistry lessons. These include the inquiry method, the activity method, the demonstration method and several others. During classroom discourse in chemistry classrooms teachers ask questions and students provide answers. The teacher then must also give feedback to enable the students know the accuracy or inaccuracy of their own responses. If teachers give feedback, it should be meaningful and they should deal with the tasks the students did and whether they did well or not. Several studies have found that students may not always understand the feedback comments they receive thereby undermining its learning and achievement potential (Weaver, 2006). The feedback by the teacher may be comments that are too vague, general, ambiguous, abstract, or in unfamiliar disciplinary discourse (Nicol, 2010). The current situation of chemistry teaching and learning in Ghana is a concern to all including government as expressed in the Ministry of Education Science and Technology document (MEST, 2000) and the society at large. Research indicates that many students find chemistry to be difficult, boring and not interesting to them (Yeager, 2014). Large class sizes, inadequate funding, insufficient curriculum resources, poor teaching skills and lack of supports for teaching among other factors further limit the quality of chemistry teaching and learning (Yeager, 2014). It is worthy of note that teacher's feedback in chemistry lessons deal with how the students have performed. Their feedback does not deal directly with what is exactly wrong with the students' responses (Amedeker, 2007).

Although there are strong and consistent findings that feedback improves immediate performance under some circumstance, it is also clear that in some situations, feedback is irrelevant and sometimes even harmful. In a meta-analysis of research in educational, organizational, and laboratory settings, Kluger and DeLisi (2013) found that in one-third of the comparisons, students who received feedback had worse performance than the group who was given no feedback. This is as a result of the poor quality feedback that was given. It has been observed that giving quality feedback in the course of teaching a particular unit is good and enhances student learning (Kluger & DeLisi, 2013).

1.3 Rationale for the Study

Adu-Gyamfi (2013) opined that teaching and learning of chemistry in Ghana is faced with numerous problems that need to be addressed so that the goal of equipping students to live effectively in our modern age of science and technology will not become a daydream as formulated in the Ghanaian Ministry of Education, Science and Technology Policy (MEST, 2000). It is, however, believed that if appropriate steps are not taken to address these lingering barriers to reform, the citizens will not be able to develop chemical literacy useful for coping in the modern scientific and technological world. Efforts at developing scientifically literate citizens by improving the quality of chemistry teaching and learning in schools is a laudable reform that should preoccupy the minds of the policy makers and all the key stakeholders in science education in Ghana.

The issue of giving FAST feedback has been identified as one major factor that can enhance effective teaching and learning (Tulgan, 2013) of chemistry in senior high schools in Ghana. It is imperative for this issue to be examined empirically in the context of science education in Ghana. With the support of students and their respective teachers, the actual and the ideal picture (FAST feedback) giving to students by teachers in chemistry classrooms in Ghanaian senior high schools was explored. It is worthy of note that the research approach for this study is modeled on a study in Australia by Goodrum, Hackling and Rennie (2001) which compared two pictures of science teaching and learning in schools. These are the actual picture, which describes what is actually happening in classrooms and the ideal picture, which defines a realistic ideal (FAST feedback) method in teaching and learning. The study applies this established research approach in developing a better method for giving and receiving feedback in the teaching and learning of chemistry in Ghanaian senior high schools.

1.4 Purpose of the study

The purpose of the study was to determine the types of feedback given by teachers in chemistry classrooms and to provide an intervention through case study action research. The study further investigated the effects of FAST feedback method on students' understanding of chemical bonding.

1.5 Objectives of the Study

The main objectives of the study were to:

1. Find out how often Chemistry teachers gave feedback to their students.
2. Determine whether chemistry teachers' feedback to their students were accurate enough or not.
3. Determine the extent to which feedback given by chemistry teachers could be described as specific.
4. Investigate how timely chemistry teachers' feedback to their students were.
5. Determine the outcome of FAST feedback methods on students' learning of chemical bonding.

1.6 Research Questions

The following research questions were addressed in the study:

1. How often do the chemistry teachers give feedback to their students?
2. How accurate are the feedback giving by chemistry teachers to their students?

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

3. To what extent can the feedback given by chemistry teachers be described as specific?
4. How timely is the chemistry teachers' feedback to their students?
5. What are the outcomes of FAST feedback method on students' learning of chemical bonding?

1.7 Significance of the Study

Providing effective feedback about students' learning is an exceptionally useful teaching tool. That is, giving students frequent, accurate, specific and timely (FAST) feedback on their work allows them to see what they know and what they do not know. Obtaining feedback on student understanding is an essential step in moving students toward full understanding of important concepts and standards. Instruction and feedback are indivisible (Black, Harrison, Lee, Marshall & William, 2004). FAST feedback approach is essential to teaching and learning in classrooms because it helps learners to maximize their potentials at different stages of learning, raise their awareness of strengths and areas for improvement, and identify actions to be taken to improve performance. Researchers have found out that strengthening formative assessment can raise students' achievement and can be very helpful to low-achieving students (Black, Harrison, Lee, Marshall & William, 2004). Teachers can use feedback obtained from their classroom discourse with their students not only to actively and continuously measure a learner's progress but also to acquire useful data to inform their own instructional practice.

FAST feedback is geared toward helping the student to identify mistakes and also making the effort to accept the desired or approved knowledge. FAST feedback method used in teaching enhances the quality of learning and leads to higher-level cognitive development through students' engagement with complex, novel problems (Bateman & Roberts, 2013). FAST feedback methods also help to teach students complex processes and procedures such as planning and communicating (Tulgan, 2013). FAST feedback instruction encourages the development of habits of mind associated with lifelong learning, civic responsibility, and personal or career success. It overcomes the dichotomy between knowledge and thinking; helping students to both "know and do." FAST feedback method of teaching engage, motivate bored and indifferent students to become interested in lessons. The method of FAST feedback support students in learning and practicing skills in problem solving, communication and semi management. The approaches create positive communication and collaborative relationships among diverse groups of students.

At its best FAST feedback methods can help teachers create high-performing classroom in which students form a powerful learning community focused on academic achievement, mastery of the content, and contribution to the community. It allows focus on major themes in the curriculum, creates challenging activities in the classroom, and supports self-directed learning among students. FAST feedback can provide diagnostic evidence for chemistry teachers and also a measure of teaching effectiveness for administrative decision-making. It is becoming increasingly accepted fact that individual teachers refer to students' feedback both to enhance the effectiveness of their teaching and to support applications for appointment, tenure or promotion.

Feedback is the most powerful influence on student achievement as it can enhance students understanding about their learning and work (Brown, 2007; Gibbs & Simpson, 2005). The ultimate goal of feedback is to teach students to monitor their own performance (Gibbs & Simpson, 2005). Engaging with good (FAST) feedback helps students to internalize standards and understand issues of quality in order to independently gauge their own progress (Brown, 2007). Good (FAST) feedback gives students commentary on what they have done and provides suggestions for improvement and what to do next (Brown, 2007). In order for assessment to promote learning, feedback needs to be forward looking so that students can apply it to future work (Carless, 2007). The link between formative feedback and its outcomes needs to be linked and methodically measured or conceptualized to ensure that students have been able to apply and learn from the feedback (Covic & Jones, 2008).

1.8 Limitations

Limitations are matters and occurrences that arise in an experiment that are totally out of the researcher's control. They limit the extensity that a study can go to, sometimes affecting the end result of the investigation (Joynson, 2013). For example, in a school district, a researcher could have restrictions, permitting them to carry out their study. Limitation in social research may include denial of access to the institution or participants for the study, cultural biases or language difficulty. There is nothing that the researcher can do to change this scenario, no matter how problematic it may prove to be in finding out what it is they need to know (Joynson, 2013).

This study was limited to the students' ability to read and understand the questionnaire they had to respond. Some of the participants had poor reading skills and some also were in the low ability group. The study was also limited in terms of getting access to schools in the Eastern Region of Ghana at the time of the study and consequently the students as well as the respective teachers. This was due to some interventions like inter-school's games and athletics', singing competition and shortage of water in some of the schools. Getting access to statistics on schools from the Yilo Municipal Education Office for the case study was also difficult since the officer-in-charge was sick for a long time and no other officer had access to the document.

1.9 Delimitations

Delimitations are defined as the term to identify boundaries. Delimitations in social research refer to the various boundaries used in the study such as the participants, apparatus or instruments used, and the geographical placement (Joynson, 2013). They refer to the number and type of participants used in the study whether they are subjects or observers. They are created before any investigations are carried out, in order to reduce the amount of time spent in certain areas that may be seen to be unnecessary, to the overall study. This is an important boundary because within social research the main objective is to discover various aspects regarding human interactions within certain cultures or areas (Joynson, 2013). A number of tools and instruments are needed to record findings or to generate them and with regards to most forms of research, a particular area will be used for study.

This research is delimited to some selected first year chemistry students and their respective teachers in senior high schools (SHS) in the Eastern Region of Ghana. The study again is delimited to the instruments used, i.e. questionnaire, interview, and observation schedules. The study dwelt mainly on the responses which were given by the students and the respective chemistry teachers. The pre-intervention study again was delimited to twenty schools whilst the intervention exercise was done in one school, Yilo Krobo SHS all within the Eastern Region of Ghana. However, because of the cosmopolitan nature of the region and its environs, spanning over both rural and urban settings, findings to some extent were generalised to students and teachers in the rural and urban settings.

1.10 General Layout of the Report

This thesis had been presented in six chapters. Chapter one discussed the background and stated the problem which called for the study. It also stated the rationale, purpose and objectives of the study. The four research questions which directed the study, the significance, limitations and delimitations to the study were all stated in this chapter. Chapter two reviewed some relevant literature to the research work. This covered types and models of feedback, pedagogical content knowledge as a theory of instruction, relevance of chemistry teaching and learning and conceptual framework among others. Chapter three dealt with information on the research design and the procedure for data collection. It also discussed the characteristics of the participants, sampling and sampling techniques, instrumentation and the method of data analysis.

Chapter four covered the results of the study which emerged out of the responses by the participating teachers and students. Key Findings were also made out of the results. Chapter five also dealt with the discussion of some significant findings identified in the study. This covered responses to the research questions and the discussion of the emerging themes. Finally, chapter six covered a summary of the major research findings, conclusions and recommendations as well as suggestions for future research.

2.0 LITERATURE REVIEW

Literature review is a summary of what is at present known about some issue or field on the basis of a study's evidence, and/or of what lines of argument there are in relation to that issue or field (Babbie, 2005). Simply put, literature review is an explanation of what has been published on a topic or a research area by qualified scholars and researchers. Literature review serves several important functions.

According to Neuman (2007) the goals of literature review is to learn from others and stimulate new ideas, demonstrate a familiarity with a body of knowledge and establish credibility. Again, it shows the path of prior research and how a current project is linked to it by placing the research in a particular context and demonstrating its relevance by making connections to a body of knowledge. It is a way of sorting and assessing what researchers have written on a topic, and organized according to a guiding concept. Literature review thus aims at establishing the academic and research areas that are of interest to the present research (Mensah, 2013).

This chapter brings to bear some of the related literature. It comprises the background for the study, models of giving feedback, FAST feedback methods for teaching and learning, Sources and methods of feedback, classroom interaction and discourse in science, types of teacher feedback to students, constructivists teaching and learning, conceptual change, making chemistry teaching relevant, teaching for conceptual change, pedagogical content knowledge, and conceptual framework for the study.

2.1 Context of the Study

The teacher is but one element in quality education and nevertheless a very crucial one. The Anamuah-Mensah education committee which was tasked to review the existing educational system of Ghana in 2002, among others was charged to ensure the improvement of quality of instruction and making it flexible enough to accommodate diverse student abilities as enshrined in the Ministry of Education policy document (MOE, 2002). The outcome of the new system was supposed to depend to a great extent on the supply of good quality teachers (Eshun, 2013). The teaching profession and all other agents responsible for teacher education have a great task to produce a new type of teacher with the ability to administer qualitative teaching to students. Teachers of quality must be broadly educated, possessing adequate knowledge of an adequate range of subject-matter to give them the confidence to lead their students in learning instead of forcing information on them. They must also have the requisite professional skills to give quality feedback to their students about their learning. Quality teachers and quality teaching together is the single most important determinant of a good science education. The success of students in science education and the progress of Ghana depend on quality science teaching and the ability to let students know their performance level by providing them with the right feedback.

Ghana needs teachers with skills required to teach and give appropriate feedback to students to enable them learn effectively (Ameyaw-Akumfi, 2004). Teachers who care about what students are actually learning have often found informal ways to ask students what they have learned. However, by systematically and thoughtfully asking students about their learning as a normal integrated part of a lesson, teachers can gain valuable feedback about any gaps in their understanding of a particular topic. There is strong evidence that feedback makes a difference to student achievement. Freeman, Amani, Comerton-Forde, Pickering, and Blaynay (2007) analysis reinforces the importance of feedback and the positive benefits for learning and achievement across all levels, knowledge and skill types and content areas. Students should be able to seek feedback if they perceive it as necessary and teachers should offer opportunities for dialogue to students they suspect would benefit from it. The emphasis on feedback for learning has resulted in a range of research projects investigating feedback quality. The goal for teachers is to gain an understanding of what students know (and do not know) in order to make responsive changes in teaching and learning.

Informal classroom assessment that provides constructive feedback to students is "at the heart of effective teaching". One of the key teaching strategies identified as evidence for improved formative assessment was feedback, as shown by Crouch and Mazur (2012). Also, Ajogbeje (2012) opined that formative evaluation process includes the provision of feedback to students on their scores or performance in a given test. There are several key characteristics to bear in mind when thinking about feedback practices. The advice is influenced by the works of Gipps and Simpson (2005), Race and Pickford (2007) and Race (2010). Despite heroic dissemination of the adoption of effective feedback in teaching practices and the documented improvement on student learning Derting and Ebert-May (2010), observed that, teachers have been slow to adopt these practices. In a national survey of new chemistry teachers, 25% reported they had attended teaching workshops (Henderson, 2008) and 87% of these reported knowledge of one or more feedback strategies, yet only 50% of those attending reported adopting feedback practices (Henderson & Dancy, 2009). These teachers identified several impediments to adoption, including inadequate training, misunderstanding of feedback teaching practices, and lack of support for implementation (Henderson & Dancy, 2010). To close the gap needed to provide quality feedback, teachers should be ready to provide feedback as often as required by students, make sure that the feedback they give are devoid of falsehood, point to the exact information students require and timely as well.

2.2 Theoretical Framework

Theories are formulated to explain, predict, and understand phenomena and, in many cases, to challenge and extend existing knowledge within the limits of critical bounding assumptions (Swanson, 2013). The theoretical framework is the structure that can hold or support a theory of a research study. The theoretical framework introduces and describes the theory that explains why the research problem under study exists (Swanson, 2013). A theoretical framework is a collection of interrelated concepts, like a theory but not necessarily so well worked-out. A theoretical framework guides the research, determining what are to be measured, and what statistical relationships are to be looked out for (Swanson, 2013).

A theoretical framework is used to limit the scope of the relevant data by focusing on specific variables and defining the specific viewpoint [framework] that the researcher will take in analyzing and interpreting the data to be gathered. It also facilitates the understanding of concepts and variables according to given definitions and builds new knowledge by validating or challenging theoretical assumptions (Swanson, 2013) . The theoretical framework for this study covers the specificity of feedback and the timing of feedback. It also takes into consideration the learning environment and its effect on students learning. Successful blending of the attributes of feedback in the classroom yields improved students' learning and also increase their interest in learning. The most desirable aspects of face-to-face teaching are the ways in which these aspects can be appropriately integrated to effect learning.

2.3 Feedback Specificity

Feedback specificity is defined as the level of information presented in feedback messages (Goodman, Wood, & Hendrickx, 2004). In other words, specific (or elaborated) feedback provides information about particular responses or behaviours beyond just their accuracy and tends to be more directive than facilitative. A number of researchers have reported that feedback is significantly more effective when it provides details of how to improve the answer, rather than when it just indicates whether the student's work is correct or not (Bangert-Drowns et al., 1991; Pridemore & Klein, 1995). Feedback lacking in specificity may cause students to view it as useless and/or frustrating (Williams, 1997). It can also lead to uncertainty about how to respond to the feedback (Fedor, 1991) and may require greater information processing activity on the part of the learner to understand the intended message (Bangert-Drowns et al., 1991). Uncertainty and cognitive load can lead to lower levels of learning (Kluger & DeNisi, 1996; Sweller et al., 1998), or even reduced motivation to respond to the feedback (Ashford, 1986; Corno & Snow, 1986).

In an experiment that tested feedback specificity and its relationship to learning, Phye and Sanders (1994) tested two types of feedback (i.e., general advice versus specific feedback, the latter providing the learner with the correct answer). Students were assigned to one of the two learning conditions, and they received either general advice or specific feedback as part of a verbal analogy problem-solving task. Phye and Sanders found that the more specific feedback was clearly superior to general advice on a retention task. However, they found no significant differences between feedback types on a transfer task. They cautioned against assuming that procedures that enhance performance during acquisition (e.g., providing specific feedback) will necessarily enhance transfer to new tasks.

2.4 Timing of feedback

The timing of feedback concerns whether feedback should be delivered immediately or delayed. Immediately may be defined as right after a student has responded to an item or problem or, in the case of summative feedback, right after the student has completed a quiz or test. Delayed is usually defined relative to immediate, and such feedback may occur minutes, hours, weeks, or longer after the student completes some task or test.

Regardless of the particular unit of time, the effects of the feedback timing variable are mixed. Again, while there appears to be no consistent main effect of timing, there are interactions involving the timing of feedback and learning. Some researchers have argued for immediate feedback as a way of preventing errors being encoded into memory, while others have argued that delayed feedback reduces proactive interference, thus allowing the initial error to be forgotten and the correct information to be encoded with no interference (Kulhavy & Anderson, 1972). Researchers who support using delayed feedback generally adhere to what is called the interference-perseveration hypothesis proposed by Kulhavy and Anderson (1972). This asserts that initial errors do not compete with to-be-learned correct responses if corrective information is delayed. This is because errors are likely to be forgotten and thus cannot interfere with retention. The superiority of delayed feedback, referred to as the delay-retention effect (DRE), was supported in a series of experiments by Anderson and his colleagues (Kulhavy & Anderson, 1972; Surber & Anderson, 1975) that compared the accuracy of responses on a retention test with the accuracy of responses on an initial test.

Although there are many studies that do not support the delay-retention effect (Kippel, 1974; Newman, Williams, & Hiller, 1974; Phye & Baller, 1970), delayed feedback has often been shown to be as effective as immediate feedback. Schroth (1992) presented the results from an experiment that investigated the effects of delayed feedback and type of verbal feedback on transfer, using a concept formation task. The four conditions of delayed feedback were: 0 seconds, 10 seconds, 20 seconds, and 30 seconds. The verbal feedback conditions were (a) correct-incorrect (verification feedback), (b) correct-nothing (i.e., where nothing means that no feedback was presented if the student solved an item incorrectly), and (c) nothing-incorrect (i.e., no feedback was presented if the student answered correctly). All participants were tested seven days following an initial learning trial. The finding relevant to this paper is that although delayed feedback slowed down the rate of initial learning, it facilitated transfer after the delay.

Supporters of immediate feedback theorise that the earlier corrective information is provided, the more likely it is that efficient retention will result (Phye & Andre, 1989). The superiority of immediate over delayed feedback has been demonstrated for the acquisition of verbal materials, procedural skills, as well as some motor skills (Anderson, Magill, & Sekiya, 2001; Brosvic & Cohen, 1988; Corbett & Anderson, 1989; 2001; Dihoff, Brosvic, Epstein, & Cook, 2003). Corbett and Anderson (2001) have been using immediate feedback successfully in their programming and mathematics tutors for almost two decades (Anderson, Corbett, Koedinger, & Pelletier, 1995). The study involved four feedback conditions, the first three of which offered the student different levels of control over error feedback and correction: (a) immediate feedback and immediate error correction (i.e., the tutor intervened as soon as students made errors and forced them to correct the error before moving on), (b) immediate error-flagging and student control of error correction, (c) feedback on demand and student control of error correction, and (d) no-tutor condition and no step-by-step, problem-solving support (the control condition). The immediate feedback group with greatest tutor control of problem solving yielded the most efficient learning (i.e., condition a). These students completed the tutor problems fastest, and their performance on criterion tests was equivalent to that of the other groups (excluding the control group). Furthermore, questionnaires showed no significant differences in terms of preference among the tutor conditions. This study demonstrated that immediate error feedback helped with immediate learning.

As described by Bangert-Drowns et al. (1991, p. 217), the five states of the learner receiving feedback include: i) *The initial or current state of the learner*. This is characterised by the degree of interest, goal orientation, degree of self-efficacy, and prior relevant knowledge ii) *Search and retrieval strategies*. These cognitive mechanisms are activated by a question. Information stored in the context of elaborations would be easier to locate in memory due to more pathways providing access to the information iii) *The learner makes a response to the question*. In addition, the learner feels some degree of certainty about the response and thus has some expectation about what the feedback will indicate iv) *The learner evaluates the response in light of information from the feedback*.

The nature of the evaluation depends on the learner's expectations about feedback. If the learner was sure of the response and the feedback confirmed its correctness, the retrieval pathway may be strengthened or unaltered. If the learner was sure of the response and feedback indicated its incorrectness, the learner may seek to understand the incongruity. Uncertainty about a response with

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

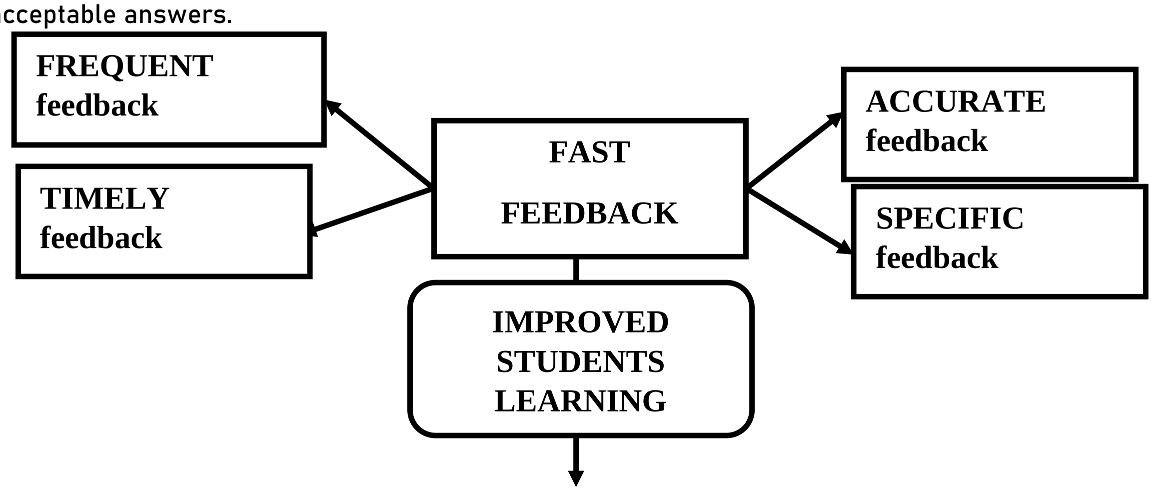
feedback confirmation or disconfirmation is less likely to stimulate deep reflection unless the learner was interested in acquiring the instructional content. Adjustments are made to relevant knowledge, self-efficacy, interests, and goals as a result of the response evaluation. These adjusted states, with subsequent experiences, determine the next current state. Overall, the meta-analysis by Bangert-Drowns et al. (1991) found generally weak effects of feedback on achievement. More specifically (but not surprisingly), the authors found that verification feedback (correct/incorrect) resulted in lower effect sizes compared to correct response feedback (i.e., providing the correct answer). Also, using a pretest within a study significantly lowered effect sizes, as did uncontrolled presearch availability of answers (i.e., ability to locate an answer prior to responding to a question). These last two findings may be because pretests and presearch availability may be seen as advance organizers, which may support short-term retention, but undermine overall feedback effects in studies that employ them.

The main conclusion from the meta-analysis by Bangert-Drowns et al. (1991) and subsequent five-cycle model is that feedback can promote learning if it is received mindfully. Conversely, feedback can inhibit learning if it encourages mindlessness, as when the answers are made available before learners begin their memory search, or if the feedback message does not match students' cognitive needs (e.g., too easy, too complex, too vague)

2.5 Conceptual Framework

A conceptual framework explains either graphically or in narrative form, the main things to be studied, such as, the key factors; constructs or variables of a social research and the presumed relationships among them (Miles & Huberman, 1994). Frameworks can be rudimentary or elaborate and theory-driven or of ordinary description of any event or causes of any event. A conceptual framework specifies who and what will or will not be studied. According to Ravitch and Riggan (2012), a conceptual framework is an argument about why the topic one wishes to study matters, and why the means proposed to study it are appropriate and necessary. A conceptual framework is also an analytical tool that expresses various views about issues within particular contexts. To make distinctions between issues concerning ideas and how to organise them one may require conceptual frameworks to explain the ideas which relate to each other. Often effective conceptual frameworks would portray real situations and show them in such a way as to make them easy to remember and apply (Ravitch & Riggan, 2012). Conceptual frameworks may be abstract representations, connected to a research project's goals that direct the collection and analysis of data. Shields and Rangarajan (2014), defined conceptual framework as the way ideas are organised to achieve a research project's purpose.

A conceptual framework, therefore, keeps the researcher focused so as not to wander from the target being investigated. The conceptual framework works like a map that helps to navigate the path through which the research would go. Thus a conceptual framework may be sketched diagrammatically or set up as a flowchart. In this study, issues concerning feedback that were given by teachers have been investigated. The attribute FAST has been the main focus (Fig. 2). The kinds of feedback given by teachers during classroom discourses are important in guiding students' learning. Thus, frequent feedback (F) is seen as an enabler that propels students to re-organise their thoughts and move towards scientifically acceptable answers.



https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

Figure 2: Diagrammatic representation of the conceptual framework

Figure 2 shows that, during classroom discourse, teachers' give feedback to the responses students give to the questions teachers ask. Teachers' feedback must radiate certain qualities to help students improve upon their learning. These qualities are frequent feedback, accurate feedback, specific feedback and timely feedback (FAST). FAST feedback from a teacher therefore serves as the hob around which students learning can be improved. It is better for a teacher to ensure that all these four attributes are found in the feedback he/she gives to the students. If two or more of these attributes could be identified in the feedback the teacher gives, it is better than one but it is more of quality if all the four attributes could be traced.

A teacher who has been properly trained and possesses high level PCK will be able to give FAST feedback which also brings about improved students' learning. Conversely, a teacher with low level PCK will not be able to give FAST feedback. This obviously will not bring about improved students' learning. In this study, the Researcher used these qualities of feedback as an intervention to help improve students' students learning. It is worthy of note that when FAST feedback is combined with effective instruction in classrooms, it can be very powerful in improving students' learning. Teachers must therefore tap the students' prior knowledge and apply FAST feedback method to close the gap between what students already know and what they are expected to know.

2.6 Students' Evaluations of Teaching (SET)

The practice of obtaining student feedback on individual teachers is widespread. Marsh (2007) identified four purposes for collecting students' evaluations of teaching (SET): Diagnostic feedback to teachers about the effectiveness of their teaching; a measure of teaching effectiveness to be used in administrative decision making; information for students to use in the selection of subjects and teachers; an outcome or process description for use in research on teaching. In completing this questionnaire, students are asked to judge how well each of 35 statements (for instance, 'you found the course intellectually stimulating and challenging') describes their teacher or course unit, using a five-point scale from 'very poor' to 'very good'. The statements are intended to reflect nine aspects of effective teaching: learning/value, enthusiasm, organization, group interaction, individual rapport, and breadth of coverage, examinations/grading, assignments and workload/difficulty.

The test-retest reliability of students' evaluations is high, even when there is an extended period between the two evaluations. The interrater reliability of the average ratings given by groups of students is also high, provided that the average is based on 10 or more students. There is a high correlation between the ratings produced by students taking different course units taught by the same teacher, but little or no relationship between the ratings given by students taking the same course unit taught by different teachers. This suggests that students' evaluations are a function of the person teaching the course unit rather than the particular unit being taught.

Emanuel and Adams (2006) describe their institutions efforts to reframe SET as a way to measure "customer satisfaction" with the service provided by course instructors. Carrell, Scott and James (2010) call into question the value of SET in evaluating student learning. They examined the academic performance of more than 10,000 cadets at the US Air Force Academy taking Calculus 1 from 91 different instructors over a seven-year period. The study found that less experienced and less qualified instructors produced the best student outcomes in their courses and received the highest evaluation scores but that more experienced and qualified professors' students performed better in Calculus 2 courses. Student evaluations may be of questionable value in evaluating student learning, in part, because of problems measuring student learning itself (Algozzine et al., 2010; Pounder, 2008; Stark, Ahlering, & Flannery 2007). Concerns are raised about the various elements included on SET instruments, the fidelity of implementation of the SET process across academic units, and the relative weight of SET in the evaluation of faculty (Harrison, Douglas, Deanna, & Burdsal, 2004; Spooren, Mortelmans, & Denekens, 2007).

Research has looked at a number of factors that are found to bias SET results, for example: the rank, ethnicity, gender, expressiveness, or physical attractiveness of an instructor; the year in institution, personality, gender and ethnicity of the student; the time of day of the course; the length of class meetings, and the number of rows in the classroom. According to Centra (2008) and Remedios and Lieberman

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

(2008), however, such bias can only exist when two conditions are met: the characteristic in question affects the evaluations made and it is unrelated to quality of teaching. The authors claim that established research shows consistently that none of the factors above satisfy both conditions. Many faculty believe that students tend to rate them more highly when they expect to receive good grades (Beran, Violato, Kline, & Frideres, 2005).

2.7 Feedback

The term feedback can apply to a number of classroom situations and procedures, but here it refers to a range of techniques employed by the teacher to facilitate responses from the students to an exercise or task. Quality feedback should provide information to the student relating to the task or process of learning that fills a gap between what is understood and what is aimed to be understood (Hattie & Timperley, 2007). Feedback is essential to learning and to sound assessment practice. Whilst assessment has been described as the engine driving learning, according to Brown (2007), feedback is "…the oil that lubricates the cogs of understanding". Feedback allows students not only to understand how they performed on the assessment task and justification for their grades, but also importantly it provides guidance for students to build their capacity as a learner. As Nicol (2007) sees it, the focus of this self-regulatory or empowerment style of feedback targets "…how students learn to monitor, manage and take responsibility for their own learning".

Feedback is not simply the correction of errors, awarding a mark/grade or the writing of a comment (e.g. "shows promise") or a negative equivalent (e.g. "poor effort"), neither is it editorial or grammatical corrections. In the latter instance students should be informed when the literacy of their submitted work does not meet expected standards; in some case it may need to be returned for attention prior to marking. The academic may choose to make several annotations against substandard practice to serve to illustrate the issue, but are not expected to correct the work. Meaningful feedback is rigorous. Gibbs and Simpson (2005) claim feedback can "correct errors, develop understanding through explanations, generate more learning by suggesting further specific study tasks, promote the development of generic skills by focusing on evidence of the use of skills rather than on the content, promote meta-cognition by encouraging students" reflection and awareness of learning processes involved in the assignment and encourage students to continue studying". The feedback can be either summative, where it provides an explanation for the grades, or formative feed-forward comments to assist students in critiquing their learning to inform subsequent work.

The quality of teacher feedback to students has a considerable impact on student achievement (Knight, 2013). She examined the quality of teacher feedback to students in two New Zealand primary schools selected randomly from those involved in the Numeracy Development Project 11. She gathered 349 examples of oral feedback over six lessons, and collected a total of 62 samples of written feedback from students' mathematics books. Teachers were also asked for their own perceptions of feedback and found that they struggled "to define effective feedback in any detail". Knight found that teachers' feedback was mainly general and tended to reflect effort and attitude of the learner rather than the actual learning that had taken place. All these findings strengthened the view that it is the quality not quantity of feedback that needs closest attention. Some educators use the term 'feed forward' alongside feedback. Feed forward refers to next steps comments.

According to Knight (2003), there are two conditions under which feedback does not perform its facilitative role. One, if the feedback has high availability for the learner before he/she responds and two, if the material studied is very difficult for the learner. In the absence of these conditions, one would conclude that feedback on performance helps to confirm correct responses as well as to identify and correct errors. This correctional function is probably the most important aspect of feedback, and if one was given the choice, feedback following wrong responses probably has the greatest positive effect. Sometimes feedback leads to better performance, but not all the time and not as often as teachers would like, given the time and effort they devote to providing students feedback. It is easy to blame students who seem interested only in the grade and do not even read the feedback. Most students report that they do, but even those who pay attention to the teachers' feedback do not seem able to act on it. They make the same errors in subsequent assignments (Weimer, 2013).

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

Test scores feedback may affect the motivational, self-confidence and anxiety level of a student. Ajogbeje (2010) opined that feedback from tests motivates the students intrinsically and that a person who is informed of his successful performance on a test would begin to develop interest in that subject and may continue to explore means of doing well in subsequent tasks. On the other hand, a negative feedback on performance may produce one of two effects. One, the students may use it for correction purposes and try to do well on later tests. That is, it influences him positively. Two, he/she may choose to be defeated and could begin to develop a feeling of inadequacy in the subject. The consequence is that he/she would continue to perform poorly as well as lose interest in the area of study. The findings of these studies have implication for teaching and learning in secondary schools. They point to the need for effective mounting of formative testing with feedback strategy in the school system. There is the need for effective and proactive dialogue over feedback to help clarify comments and address misperceptions, misconceptions and wrong understandings. Blair and Mc Ginty (2013) described the dialogue over feedback as "collaborative discussion" between teacher and student or between students and student which enables shared understanding and subsequently provides opportunities for further development based on the exchange. By proactive it implies that dialogue must be initiated or caused to happen by any of the concerned parties in a feedback interaction.

Several studies have found that students may not always understand the feedback comments they receive, thereby undermining its learning and achievement potential (Smith & Gorard, 2005; Weaver, 2006; Nicol, 2010). Reasons for this include comments that are too vague, general, ambiguous, abstract or in unfamiliar disciplinary discourse (Nicol, 2010). If feedback comments could adequately support learning and achievement, it should be followed by dialogue that is proactive and effective, initiated by any of the concerned parties in an environment of trust. Despite the importance of feedback, some studies found that feedback did not necessarily support learning (Smith & Gorard, 2005). One of the factors that influence the impact of feedback on learning is the quality of feedback comments (Nicol & Macfarlene-Dick, 2006; Hattie & Timperley, 2007; Stobart, 2008). When students do not understand feedback comments, it is difficult for them to engage with such feedback in ways that will improve their learning and achievement in current and/or future assignments. Hence, there may be need for effective and proactive dialogue over feedback to help clarify comments and address misperceptions, misconceptions and wrong understandings. Blair and McGinty, (2013) described the dialogue over feedback as "a collaborative discussion" between tutor and student or between student and student "which enables shared understandings and subsequently provides opportunities for further development based on the exchange". By proactive, it is implied that dialogue must be initiated or caused to happen by any of the concerned parties in a feedback interaction.

In large class size situations, tutors can facilitate peer dialogue by asking students to share and discuss teacher feedback comments in organised small groups and giving collaborative assignments (Nicol, 2010). On the other hand, teachers should endeavour to give feedback comments that are understandable, specific, timely, non-judgmental, contextualized, balanced, forward looking and transferable (Nicol, 2010). It would however be more proactive to extend invitations for teacher dialogue to students who are still dissatisfied with peer-dialogue. It is a fact that students may choose to either seek teacher-support or peer-support or even work independently (Murtagh & Baker, 2009). However, teachers should endeavour to build an environment of trusting relationships (Carless, 2013) with students, so that they are motivated to proactively seek help and support, if necessary. This can be achieved by reaching out to students who obviously need assistance as inferred from their work and throwing open invitations to students who desire dialogue. In the absence of these, most students will not seek assistance even when needed. Furthermore, there should be opportunities for students to develop their "assessment literacy" through critique of peers' work (Price, Handley, Millar & O'donovan, 2010).

Increasingly, students are becoming dissatisfied with the outcomes of feedback comments and would really like opportunities to clarify their understanding of the feedback received through dialogue with their teacher (Thomas, 2002; Cozier, Reay, Clayton, Colliander, & Grinstead, 2008; Blair & McGinty, 2013). Viewing the giving and receiving of feedback as a communication process, Higgins, Hartley, and Skelton (2001) argue that it occurs within "complex contexts, and so is mediated by power relationships and the nature of the predominant discourse within each setting". Thus, several researchers have advocated the need for feedback dialogue in order to minimise existing dissonance between the intent of teachers' feedback comments and students' understanding of the comments (Higgins, Hartley, & Skelton 2001; Nicol & Macfarlene-Dick, 2006; Hounsell, McCune, Hounsell & Litjens, 2008).

Written feedback is dominantly a one-way communication (Nicol, 2010), with inherent didactic characteristics. Students are expected to engage with the written feedback they receive, rather than negotiate feedback (Blair & McGinty, 2013). When written feedback moves beyond the mere transmission of feedback information where student engagement is limited to using the provided information to make future improvements, to a (social) constructive feedback model which facilitates students' active engagement and reflection while encouraging teacher and peer dialogue around learning, learning and achievement is enhanced (Nicol & Macfarlene-Dick, 2006; Murtagh & Baker, 2009).

Teachers and students have a responsibility to stimulate and facilitate feedback dialogue if there is need for it. However, tutors have a greater responsibility to foster a confident and trusting pedagogic relationship within which students can be confident to seek assistance. It is not uncommon for students to exhibit reluctance in seeking assistance from teachers over feedback comments especially in scenarios where the giving of feedback is inherently transmission. Feedback is not perceived as a "gift" from the expert teacher to the novice student, but as an interaction "constructed through loops of dialogue and information" (Askew & Lodge, 2000). Dialogue is most effective when students feel comfortable enough to be open about their ignorance / partial understandings (Carless, 2013) and to seek assistance when needed. Walker (2009) observed that because comments are expected to convey so much in few words, concepts might be used in ways difficult for students to understand or assumptions made about students' conceptual understanding of the topic. If students do not understand the feedback received, then they will neither be able to effectively engage with it in ways that will enhance learning nor adequately effect the recommendations of the feedback for better achievement.

When there are conceptual mismatches between teachers and students understanding of concepts, students' meaningful interpretation of feedback comments becomes difficult (Hounsell, McCune, Hounsell, & Litjens, 2008). Again, students may understand the feedback comments received and still not know how to achieve its recommendations. It therefore appears necessary for students to have interactive engagement and dialogue over the feedback they receive, in order to achieve relevant understandings, make meaningful connections and gain new insights (Askew & Lodge, 2000). All these can happen through the teacher's ingenuity to provide feedback frequently as required by students, and that the feedback they give must be devoid of falsehood. Also the feedback must point to the exact information students require and finally must not be delayed.

2.7.1 Feedback as a Social Constructive Process

Central to Vygotsky's theory was the presence of a more skilled partner, be it a peer or an adult in the learning process, whose responsibility it was to guide the learner towards taking control of their learning (Wood & Wood, 2013). According to Rogoff (2013), social interaction facilitated cognitive development of the individual through "joint problem solving with guidance by a person who is more skilled". The role of the more skilled has been variously described as "guided participation" (Rogoff, 2013) and "scaffolding". To conceptualise feedback as a two-way social constructive process, it has to incorporate effective dialogue, which enables the teacher who is supposedly "more skilled", to provide appropriate guidance to the student. Essentially, effective dialogue should be adaptive, discursive, interactive and reflective (Laurillard, 2002). By adaptive, dialogue should suit the needs of the individual student. Usually, feedback is tailored to the needs of each student as perceived by the teacher, and so must effective dialogue. By being discursive, dialogue should be contingent on the feedback tasks or actions, drawing mutual conclusions through reasoning and engagement. As interactive, dialogue should be a two-way communication process.

A dialogue should be reflective by motivating the parties involved in the feedback process to reflect on the tasks, actions and goals of the feedback. Carless (2013) argue that such effective dialogue provides adequate opportunities for the clarification of expectations, sharing of interpretations and negotiations of meanings. In the absence of dialogue over written feedback, feedback processes align itself to a didactic pedagogy that promotes a transmission view of teaching and learning. Didactic pedagogy sees the mind of learners as a 'tabula rasa', that is, a blank slate, and imposes a view of pedagogic activities directed at filling up the slate of the learner's mind. This form of pedagogy is

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

essentially a one-way communication and offers an unequal power relation that stifles students control over their learning, by constraining them to unquestioningly accept the teachers view (Rogoff, 2013). The teacher is seen as an authority/expert in particular field(s) of knowledge and is responsible for preparing the knowledge to be transmitted, and in motivating the learner (either by incentives or by punishment) to be receptive to what is being transmitted (Rogoff, 2013). However, the inequality lay in "skills and understanding rather than in power" (Rogoff, 2013). Such ineffective dialogue has been branded "monologue disguised as dialogue" or might merely be a "technical dialogue" which is just concerned with the exchange of feedback information (Backhouse, 2011). Carless' (2006) description of feedback as the "written annotations and comments on drafts or on finalized assignments, in addition to verbal dialogues prior to or after submission" is adopted.

2.7.2 Classification of Feedback Comments

Several authors have classified feedback comments in a number of ways (Hyatt, 2005; Hattie & Timperley, 2007; Brown & Glover, 2006). For example, analyzing 60 feedback commentaries of Masters level assignments in Educational Studies, Hyatt (2005) suggested seven types of feedback comments (each with sub categories) based on their purpose: Phatic, developmental, structural, stylistic, content-related, methodological and administrative comments. Phatic comments establish and maintain teacher student academic relationship. Developmental comments aid students with subsequent assignments. Structural comments address how an assignment is structured. Stylistic comments deal with the language and presentation style. Content-related comments, as the name implies, evaluate the appropriateness/accuracy of content. Based on function, Brown and Glover (2006) identified comments that are mere indications of the actual level of a student's understanding or performance on an assignment, comments that provide corrections and those that provide explanations. On the other hand, Hattie and Timperley (2007) distinguished feedback comments based on four levels at which they can be directed at. Comments directed at the task level are focused on how well a task has been performed or achieved in relation to established criteria or standards. At the process level, comments go beyond giving periphery information about a task, to providing strategies for students to construct their own understanding and establish meanings for themselves.

Comments directed at the self-regulation/metacognition level focus on the task in relation to the way students regulate their actions toward learning goals. At the self/personal level, comments contain little or no information relating to the task, rather, focusing on the self/person in terms of ability, self-esteem etc. These classifications do not exhaust the potential general categories of feedback comments, but they offer a framework for understanding the nature of common feedback comments. In co-constructivist pedagogy, feedback is viewed as a dialogic relationship, which enable learners reflect on learning and meta-learning in its appropriate context, and in relation to previous and intended learning (Askew & Lodge, 2000). The learner is viewed as active and capable of independent thought and reasoning, which can be "moved toward some shared frame of reference" (Bruner 1999). Through enquiry, discovery learning, open-ended questioning, negotiation, discussion, collaboration and interaction, the learner assumes an active role by constructing knowledge for him/herself (Askew & Lodge, 2000). Teacher-led feedback, usually involving only one student at a time, can be predictable monotonous and time-consuming. It may also be unnecessary for abler learners and potentially demotivating or embarrassing for the less-able. However, some form of feedback is required for a variety of reasons: Feedback on an activity satisfies students' expectations and needs, both as a measure of success or failure and as reassurance that they have at least completed the task properly.

2.7.3 Feedback during Classroom Discourse

Within the context of the classroom, feedback exists in multitude of forms: written comments, grades, marks, oral responses and non-verbal gestures. The notion of feedback as a one-way communicative activity, where the source of information is external to the learner, has been criticised due to its dependency-creating effect on learners (Sadler, 2010). Recognising the pivotal role that learners play in learning and assessment, the most valuable form of feedback is now commonly considered to be that which is constructed jointly by teachers and students and framed as a dialogue (Nicol & Mcfarlane-Dick, 2006). As tasks, in particular the practice exercise type during classroom discourse is in effect a form of test and the feedback which is given indicates a degree of success that can be motivating. Often an element of competitiveness enters into feedback which encourages learners to participate in the lesson. The negative aspects of competition, together with the risk of demotivating some learners, can be reduced by the judicious use of nomination and sensitive management of feedback by the teacher. Feedback acts as an effective signpost, signaling the end of a task or stage of a lesson. A variety of analytical skills can be fostered through the way that feedback is conducted. Learners not only need to know if their answers are correct, but also why they are correct or why they are making errors.

Useful correction or reteaching may take place during feedback on exercises, while reading skills may be enhanced by identifying clues in a text or checking a listening task by referring to the tapescript. Students may also provide useful information by indicating which questions they found most difficult and why. Learners' performance in tasks performs an important diagnostic function. Errors may indicate the need for clarification, reteaching or repair work, while successful completion of a task may indicate that learning has taken place and that the teacher is free to move on. However, repair is rarely accomplished by setting a similar task, while accurate conclusions can only be drawn from tasks that are manageable but achievable rather than too easy or too difficult.

The need for time-consuming whole-class feedback can be minimised by effective teaching and classroom management, not only during the activity but also in the earlier stages of the lesson. Clearly, feedback is more speedily conducted when the majority of student responses are correct. Feedback is an ongoing process, and a good number of correction may take place while the teacher is monitoring, thus ensuring a minimum of feedback at the end of the task. The teacher may also notice specific difficulties and choose to conduct feedback on problematic questions. Anticipating problems, grading tasks so that they are manageable and designating time for feedback rather than leaving it open-ended are all prerequisites for efficient feedback. There is an element of security in both teacher and learners knowing that an exercise has been completed satisfactorily. Where exercises are completed individually and the focus \is predominantly on accuracy, the teacher may opt to take control of the feedback process. Even, control can be partially relinquished, and there are alternatives to the teacher either reading out answers or nominating students in turn.

2..7.4 Types of Feedback

Teachers' feedback to students could be descriptive or evaluative. Descriptive Feedback is specific information in the form of written comments or conversations that help the learner understand what is needed to improve. Evaluative Feedback is a summary for the learner of how well he or she has performed on a particular task. This feedback is often in the form of letter grades, numbers, check marks, symbols and/or general comments such as "good," "excellent," or "needs help."

2.7.5 Evaluative and descriptive feedback

Evaluative feedback is subdivided as positive or negative feedback whilst descriptive feedback is also categorized as either specifying feedback or constructing feedback. Also positive feedback is subdivided into rewarding feedback or approving feedback whilst negative feedback is classified as either punishing or disapproving. On the other hand, specifying feedback under descriptive feedback is categorized as specifying attainment or specifying improvement whilst constructing feedback is subdivided into constructing achievement or constructing the way forward (Table 1).

Table 1 - Tunstall and Gipps' (1996b) Feedback Typology

EVALUATIVE FEEDBACK				DESCRIPTIVE FEEDBACK			
Positive Feedback		*Negative Feedback*		*Specifying Feedback*		*Constructing Feedback*	
Rewarding	Approving	Punishing	Disapproving	Specifying attainment	Specifying improvement	Constructing Achievements	Constructing the way forward
A1 Reward	B1 Positive expressions	A2 Punish-ments	B2 Negative expressions	C1 Mastery-oriented approach	D1 Mastery-oriented approach	C2 Constructive approach	D2 Constructive approach
	Warm expression of feeling		Reprimand	Specific acknowledgement of attainment	Correction of errors	Mutual articulation of achievement	Mutual critical appraisal
	General praise		Negative Non-verbal feedback	Use of predetermined criteria (often mastery)	More practice given; training in self checking	Illustrates Teachers use of sharp contextualized fuzzy criteria	Provision of strategies forself regulation
	Positive Non-verbal feedback			Checking and correcting procedures		Teacher-child assessment	

The same categorizations were used as a framework by Hargreaves, McCallum and Gipps' (2000) in a more recent research where they looked in detail at teachers' teaching, assessment and feedback strategies in primary classrooms. The research took place in twenty schools with eleven teachers for year 2 and twelve teachers for year 6. In mid-1997, the researchers interviewed head-teachers and observed lessons. They observed up to five lessons in each of the twenty-three classrooms. They held post observation interviews and involved teachers in discussion about theories of learning. In early 1998 there was a further visit to ten case study teachers. Two lessons were observed in each classroom and the teachers took part in a 'Quote Sort' activity. Teachers sorted fourteen quotes, which focused on teaching, assessment and feedback strategies, on pupil learning. In mid-1998 the 'Quote Sort' activity was undertaken with the non-case study teachers and towards late 1998 there were focus group interviews. What they found was that, depending on how teachers perceived learning to come about, and what sort of learning they hoped to encourage, teachers used a repertoire of feedback strategies in order to bring about transformation in learning. This work confirmed that teachers use a repertoire of feedback strategies that are easily placed on the Tunstall and Gipps' (1996b) typology. They concluded that, in part, choice of feedback strategies depends on teachers' beliefs about how children learn.

The difference between evaluative and descriptive feedback is also the focus of a study by Davies (2013). She argues that descriptive feedback supports learning because it reduces the uncertainty by telling students what is working and what is not. In contrast, she suggests, evaluative feedback, which is usually encoded (letters, numbers, other symbols) and includes praise, punishments and rewards, does not give enough information for students to understand what they need to do in order to improve. Kohn (2013) referred to this as "the praise problem" and states that while some approving comments are not only acceptable (but positively desirable) some are neither. He suggests that the difficulty could be because different people mean different things by 'praise' or 'reward' or 'positive feedback'. He argues that: "young children don't need to be rewarded to learn; at any age, rewards are less effective than intrinsic motivation for promoting effective learning; rewards for learning undermine intrinsic motivation"'. Crooks (2010) agrees that praise should be used sparingly and where used should be task specific whereas criticism (other than simply identifying deficiencies) is usually counterproductive. He argues that feedback should be specific and related to the need.

2.7.6 Written feedback

Ronayne's (2013) research focused on written feedback and teachers were asked to give a particular type of feedback. He investigated eight separate occasions, across a range of subject and secondary school age groups (11-13 years), on which teachers marked their pupils work and gave written feedback. Each case study followed the same procedure. When the task was completed, the teacher marked the work with formative feedback (no grades) and then the comments were analysed. After the students received the written feedback, they were questioned about the feedback they received. The categories Ronayne identified and used were 'organizational', 'encouraging/supportive', constructive', 'think', and 'challenging'. While these appear to be different, there are elements which are very similar to evaluative and descriptive feedback. He describes 'organizational' as dealing with such things as date, title and correction of spelling, with praise and ticks, and 'think' when the answer is not corrected nor is there any direct teaching, such as 'unnecessary'. These have clear similarities to evaluative feedback in that there is no focus on quality. He explained 'constructive' comments as showing how something could be done or built on, and 'challenging' as taking a task from explanation to evaluation. These categories are work focused and similar to descriptive feedback.

2.7.7 Positive feedback

In a similar way, Hattie and Timperly (2007) talk about forms of feedback that are positive, such as reinforcement, corrective feedback, remediation and feedback, diagnoses and feedback and mastery learning. They also discuss immediate (often verbal) versus delayed (often written) and less effective forms of feedback such as extrinsic rewards, and punishment. The effectiveness of these forms of feedback was also a discussion point for Gibbs and Simpson (2005).

2.7.8 Informal and formal feedback

Several methods of giving feedback to students can be identified in the teaching and learning in classrooms. These range from *informal* conversation with students to the use of some more *formal* types of feedback. Informal samplings of students' comprehension of the subject matter help one to gauge how and what students are learning. Informal request for constructive criticism also help one identify which teaching methods best contribute to students' understanding of the material. Feedback can be seen as informal (for example, in day to day encounters between teachers and students or trainees, between peers or colleagues) or formal (for example as part of written or clinical assessment). However, "there is no sharp dividing line between assessment and teaching in the area of giving feedback on learning" (Rowe & Wood, 2008). Feedback is part of the overall dialogue or interaction between teacher and learner, not a one-way communication. If feedback is not given, students may think that everything taught is alright and that there are no areas for improvement. Learners value feedback, especially when it is given by someone credible who they respect as a role model or for their knowledge, attitudes or clinical competence. Failing to give feedback sends a non-verbal communication in itself and can lead to mixed messages and false assessment by the learner of their own abilities, as well as a lack of trust in the teacher.

2.7.9 Models of Giving Feedback

Pendleton's model for giving feedback in science education setting, cited by Carless, Salter, Yang and Lam, (2010), outlines a series of rules to be followed by the teacher. The rules according to Pendleton, include the following; (1) Check what the learner wants and the learner's readiness for feedback, (2) Let the learner give comments or background to the material that is being assessed, (3) Let the learner states what was done well, (4) Let the observer(s) state(s) what was done well, (5) Let the learner states what could be improved, (6) Let the observer(s) state(s) how it could be improved, and (7) Make an action plan for improvement. Although this model provides useful framework, there have been some criticisms of its rigid and formulaic nature and a number of different models have been developed for giving feedback in a structured and positive way. These include reflecting observations in a chronological fashion, replaying the events that occurred during the session back to the learner.

This can be helpful for short feedback sessions, but one can become bogged down in detail during long sessions and no progress can be made. Another model is the 'feedback sandwich', which starts and ends with positive feedback. When giving feedback to individuals or groups, an interactive approach is deemed to be the most helpful. This helps to develop a dialogue between the students and the teacher giving the feedback and builds on the students own self-assessment. It is collaborative and helps students take responsibility for their own learning. A structured approach ensures that both trainees and trainers know what is expected of them during the feedback sessions. Walsh (2005) summarized the key points for problem-based analysis in giving feedback to groups as follows; (1) start with the trainees agenda, (2) look at the outcomes that the interview is trying to achieve, (3) encourage self-assessment and self-problem solving first (4) involve the whole group in problem solving, (5) use descriptive feedback, (6) feedback should be balanced (what worked and what could be done differently), (7) suggest alternatives, (8) rehearse suggestions through role-play, (9) be supportive, (10) The interview is a valuable tool for the whole group, (11) introduce concepts, principles and research evidence as opportunities arise, and (12) at the end, structure and summarise what has been learnt.

Vassillas and Ho (2000) identified that science educationists claim that using this method for groups and individuals is more likely to motivate adults, in particular, to learn. Initially, grasping this different way of working can be more difficult for trainers than using the traditional didactic approach, but research into using this method supports its effectiveness. The widely used Calgary-Cambridge approach to communication skills teaching is referred to by Walsh (2005) in his summary to 'agenda-led, outcome based analysis': 'Teachers start with the learners' agenda and ask them what problems they experienced and what help they would like. The teacher then looks at the outcomes to be achieved and encourages them to solve the problems.

2.7.10 FAST Feedback Method for Teaching and Learning

The term FAST feedback is derived from management practices but can be applied to instruction (Bateman & Roberts, 2013). Classroom feedback given by teachers must be frequent, accurate, specific, and timely (FAST). Fast feedback is a 'whole class' teaching method in which the teacher gives a series of short tasks to be done by students individually but at a collective pace (Van den Berg & Hoekzema, 2006). The tasks can be answered in the form of a diagram, a sketch, a drawing or a few words.

2.7.11 Frequent feedback

Frequency of feedback refers to the information giving by teachers to their students or is given to students to enable them learn better. The teacher should not wait for an annual performance or review of students' achievements at the end of the course. Outstanding performers become frustrated by the lack of recognition, while weak performers interpret the teacher's silence as approval (Bateman & Roberts, 2013). Feedback must therefore be an on-going process as the lesson proceeds. Sufficient quantity of feedback is necessary to guide students to improve their learning practices. As Gibbs and Simpson (2005) found, one piece of feedback provided three quarters of the way through a unit of study is hardly likely to influence student's learning and subsequent performance on tasks. It was far better to structure assessments tasks so feedback can be provided earlier in the course of study allowing students the opportunity to improve on their performance. The teacher can incorporate feedback in group discussions, laboratory work, and oral response by students to questions posed by their teachers, e-mails, and notes. Ideally, time should be set aside each day just for giving and receiving feedback. Whilst this may seem like a huge investment of time, it will pay back well in increased morale, motivation, and productivity.

2.7.12 Accurate feedback

Accurate feedback is based on expectations that have been agreed upon and communicated upfront, rather than personal opinion. Before delivering feedback, the teacher must do his or her homework by observing, organizing his or her thoughts and being sure that his or her assessment is based on facts, and not hearsay. The teacher must avoid exaggeration and always focus on the behaviour, not the person. As teachers' assess their students, they are assessing their judgment, professionalism, and integrity (Bateman & Roberts, 2013). Providing accurate feedback means giving students an explanation of what they are doing correctly and incorrectly. However, the focus of the feedback should be based essentially on what the students are doing right. It is most productive to a student's learning when they are provided with an explanation and example as to what is accurate and inaccurate about their work.

2.7.13 Specific feedback

Students will improve in their learning if they know specifically what they did right or wrong. If it is the latter, they also need to know specifically what the "new and improved" behaviour looks like. The teacher needs to describe what he or she observed and heard, explain how students' behaviour (good or bad) affects the classroom discourse (Bateman & Roberts, 2013) and support it with specific examples and relevant facts. Avoid vague descriptions, for instance, 'this lacks focus'. The distribution of generic feedback on feedback sheets, via chalkboard discussion or emails is very useful but depersonalised. Teachers must plan to supplement this with individualised feedback to make explicit the ownership of the feedback and to assist students to reflect on how they are learning and how they can make improvements.

2.7.14 Timely feedback

Timely feedback is necessary for students to learn well. A behaviour rewarded is likely to be repeated. The teacher rewards and recognizes desirable behaviours quickly and often. If the feedback is especially important or serious, the teacher must schedule an appropriate time and place (Bateman & Roberts, 2013). There is a strong evidence base for providing feedback as soon as possible whilst the task is still fresh in the student's mind. Some marking approaches can give relatively instantaneous feedback. For example computerised objective testing can reveal the correct option and supply built in feedback comments as to why distracters are not suitable responses. However, most other forms of assessments cannot be so speedily attended to. Prompt provision of feedback is challenging in a climate of rising student numbers and shortened study periods (Gibbs & Simpson, 2005).

2.7.15 Steps in FAST feedback Methods

FAST feedback methods used during instructions are based on six steps (Van Den Berg, & Hoekzema, 2006) enumerated as follows: (1) Teacher poses a problem (on chalk board). Students start to respond by drawing or writing (2) Teacher checks whether everybody is at work and acts if not (3) Teacher goes around and sees some solutions Teacher asks a student with an unexpected answer to explain (individually). Meanwhile other students will spontaneously start to compare answers (Peer Teaching) (4) Teacher presents briefly one or two frequently occurring errors and explains (Plenary on the board) (5) Teacher presents the next problem (6) Teacher goes round. The challenge to teachers in the provision of FAST feedback is to ensure that students can access, understand and use it to inform their studies and future performances. To achieve this Boud (2010) claim that feedback should be: *Informative and supportive* to encourage positivity towards learning; *timely*, allowing feedback to be used to inform other learning and work; *Frequent*, *accurate* and *specific* enough to guide students learning and work.

2.7.16 Types of Teacher Feedback to Students' Responses

In response to a teacher's question that solicits factual information or what taps into conceptual understanding or reasoning, a student's answer could be either scientifically correct or incorrect. After evaluating the student's answer mentally, the teacher could verbalize this evaluation publicly to the class by providing a comment. Alternatively, he/she may not articulate this overtly but keep this evaluation silently to himself/herself, thus remaining neutral in his/her response (Chin, 2006). In the case of a correct answer, this evaluation could be in the form of a praise or acknowledgement; whereas for a wrong answer, the teacher might either issue a put-down or remain neutral.

Thus, as a follow-up to a student's correct answer, a teacher could proceed in either two ways; (a) affirm the answer, reinforce it, and then move on to further expository talk via direct instruction, or (b) accept the answer and then ask another related question or series of questions that build on the previous ones to extend the line of conceptual thought. On the other hand, in response to a student's answer that is incorrect or that deviates from the scientific norm, corrective feedback could be via (c) explicit correction followed by further expounding of the normative ideas, or (d) evaluative or neutral comments followed by reformulation of the question or challenge via another question (Chin, 2006). Unlike feedback types (a) and (c), which does not encourage student input beyond the initial solicited answers, feedback types (b) and (d) further elicit students' responses, stimulate productive thinking and extend lines of conceptual thought in students. The different types of teacher feedback are referred to as Affirmation-cum-Direct Instruction, Focusing and Zooming, Explicit Correction-Direct Instruction and Constructive Challenge. These different types of feedback are summarized in Table 2.

Table 2 - Types of Teacher Feedback to Students' Responses (Chin, 2006)

Nature of students' Responses	*Type of feedback*	*Description*
Correct	Affirmation-Direct Instruction	Affirm and reinforce response followed by further exposition and direct instruction.
Mixture of correct and incorrect	Extension by responsive questioning: Focusing & Zooming	Accept response followed by a series of related questions that build on previous ones to probe or extend conceptual thinking
Incorrect	Explicit correction-Direct instruction	Explicit correction followed by further expounding of the normative ideas.
	Constructive challenge	Evaluative or neutral comment followed by question reformation.

2.7.17 Affirmation-cum-direct instruction

In this type of feedback, the teacher affirms and reinforces students' correct answers and then move on to expound further scientific information via direct instruction. While the discourse is dialogic in nature, during the initial stage, the teacher talk is authoritative and has transmissive function during the latter expository phase. During the conversation, the teacher encourages the students' thinking by accepting responses in a neutral manner, affirming the responses with a comment or restating students' responses (Chin, 2006). The teacher consolidates the key points embedded in the students' responses by introducing the appropriate scientific vocabulary.

2.7.18 Focusing and zooming

In this type, the teacher remains neutral in evaluating students' responses (even when the responses are inconsistent with the scientific norm). The teacher asks series of further related questions that extend students' thinking (feedback type (b)). These questions are used to elicit, probe, extend, and elaborate students' thinking, with a view to helping students construct conceptual knowledge (Chin, 2006). The teacher can pose "responsive questioning". This can be done by adjusting the questions to students' responses, with each subsequent question building on to the previous one(s) to help students progressively construct related and integrated framework of ideas. The teacher also invites other students to respond to a given answer. Discourse can be dialogic and occasionally authoritative, and has a facilitative function (Chin, 2006). This approach to questioning is termed "Focusing and Zooming" as the questions zoomed "in and out" – alternating between a big, broad question and more specifically focused, narrow, and subordinate questions. The teacher uses his/her skills to adjust and refocus the nature of his/her questions, as appropriate. Through a series of responsive "focusing and zooming" questions, the teacher guides students to generate their own inferences and conclusions, where they can give positive responses.

2.7.19 Explicit correction-direct instruction

In this type of feedback, the teacher elicits students' ideas on a particular situation. A student then proposes an answer and the teacher calls for peer evaluation from the class. After explicitly pointing out the student's mistake, the teacher proceeds to give the correct answer and then carry on with telling students more information (Chin, 2006).

2.7.20 Constructive challenge

Here, the teacher does not articulate the student's mistake in the form of an evaluative comment. Instead, the teacher remains neutral but challenges the student by posing another question, thereby throwing the responsibility of thinking back to the student in the form of a reflective toss (Chin, 2006). The teacher does this by further elicitation as well as reformulating the question in the form of a recast which forces the student to reflect on and reconsider his/her answer. The teacher does not explicitly tell the student of the mistake made. Instead, the teacher poses a series of questions, articulating them in several different ways, with each question cast in a slightly different wording. These questions provide the student with cues to draw on her own conceptual resources. They prompted the student to self-evaluate his/her own thinking, reflect on his/her incorrect assumption made earlier, discover the fallacy in his/her reasoning, and to rectify his/her mistake (Chin, 2006). Subsequently, the teacher also stimulates the student to evaluate his/her proposed method to see whether there are possible sources of error.

2.7.21 Sources and Methods of Feedback

In the minds of students and their teachers, feedback is often very firmly linked to the use of questionnaires. In fact, there are many different methods that can be used, although each method is usually associated with a particular source of feedback, whether it is self, students or teachers. A wide range of methods and sources of feedback can be deployed.

2.7.22 Feedback from teachers

One method of encouraging self-reflection in a productively focused way is to use a *checklist* which calls for self-rating of performance on a number of key dimensions. Checklist is a series of questions that helps a person by reminding him or her of the things that need to be done to achieve a particular activity. If the teaching or practical concerned is likely to be repeated at some future date, teachers can supplement the completed checklist of additional background information about what they did or did not do, together with any ideas on what to try next time around (Gomally, Evans & Brickman, 2013). Another method under feedback obtained from self is the *pro forma.* The pro forma is more general but so explicitly forward-looking in focus, and can be a useful spur to noting down thoughts generated at a time. Since teaching is fitted in alongside other commitments, it is not surprising that ideas and insights which strike teachers in the course of carrying out their teaching tend to fade unless captured whilst still relatively fresh and clear (Race & Pickford, 2007). Teachers can carry out similar logging functions in lots of different ways, including: keeping a regular teaching diary; maintaining loose-leaf collection of reflections, jotted down as and when this seems worthwhile; embellishing preparation notes with post-its, recording thoughts and ideas immediately after the class concerned (Gibbs, 2006).

According to Gipps (2013), feedback from the teacher to the student, a key link between assessment and learning, can be analyzed in terms of the power relationship between teacher and student. She describes traditional assessment as the hierarchical relationship between teacher and student where the teacher sets the task and determines how performance should be evaluated. The student's role is to be the object of this activity and, through the completion of tasks and tests, to be graded. Gipps argues that these traditional assumptions about assessment should be challenged. Perhaps some of the difficulty with assessment could have been avoided had it been realized that, as Black and William (2003) suggest, "it has been clear from their earliest use the terms 'formative' and 'summative' applied to the functions they serve rather than the actual assessments" (p.624). The purpose for giving any classroom feedback should surely be to have an impact on teaching, learning and achievement. Feedback to any student should be about the particular qualities of his or her work, with advice on what he or she can do to improve, and should avoid comparisons with other students.

Gipps (2013) says that ideally, there should be opportunities for tasks and criteria to be discussed, clarified, and even negotiated with the student, so that feedback becomes a more collaborative enterprise in which the students have some input. An example is highlighted in research about feedback and marking which shows that, even if marking is understood, it has more impact on students' progress if it is focused on the learning intention and suggests explicit strategies for improvement (Gipps, 2013). Feedback focused on learning intentions will involve shared expectations for the learning or the task. If these expectations are not clear and have not been discussed, what do students use for self-assessment, or assessment of their peers? Gipps (2013) argues that constructive feedback in classrooms can be a valuable impetus for learning and explains that in 'constructing' the teacher shares power and responsibility with the student. Such a situation would allow more opportunities for establishing a teacher/student relationship based on power with the student as opposed to power over the student. He also found that, "this type of feedback encouraged students to assess their own work and provided them with strategies that they could adopt to develop their work" (p.6). Bishop, Berrymann, Tiakiwai and Richardson (2003) also discuss the importance of relationships, the sharing of roles and power between the teacher and student, and an academic focus for feedback.

2.7.23 Feedback from academic staff to teachers

Previewing and reviewing are techniques for engaging in dialogue, either before or after a tutorial or practical session, with someone who has an informed understanding of the course and its students (Race, Brown & Smith, 2005). The academic colleague's role is to assist the teacher in anticipating and forestalling any problems which might arise in connection with his/her plans and ideas for a forthcoming class. In reviewing, sometimes called debriefing, the teacher shares with his/her colleagues, impression of how the class has gone, whatever its peaks and troughs, and together he/she explores *why* as well as *what* happened in the course of the session, and *how* he/she might most benefit from the experience (Race, Brown & Smith, 2005).

Openness, sensitivity, and a supportive attitude on the part of colleague teachers are the main requirements for previewing and reviewing to work well, and either can be done at any time. The same applies to the scrutiny of tutorial materials or laboratory worksheets, and is another useful feedback activity, whether associated with previewing or reviewing, and undertaken separately (Race, Brown & Smith, 2005). Needless to say, the existence of a mentoring relationship enlarges the scope for more sustained feedback from and interaction with an experienced academic colleague, and might well benefit from an established pattern of meetings for the regular review of progress. Where there is lack of mentoring relationship, the mentor could adopt FAST feedback teaching method which enhances better interaction between the mentor and the students.

2.7.24 Feedback from students to teachers

Since *group discussion* is a characteristic teaching method, the case for teachers deploring the same approach to obtaining feedback from their students is a compelling one. But it is a useful approach for demonstrators too, since they also have the advantage of working regularly with a group of students they have come to know well (Taber, 2011). As a feedback technique, group discussion has distinctive strengths: it gives opportunities for exploring issues in depth, weighing the significance of points raised and clarifying students' suggestions (Taber, 2011). If it is to work well, however, it needs a clear framework or structure which will both help to ensure that key issues are addressed and encourage everyone to make contributions. One possible starting point is for the teacher to ask the students to identify the main strengths and weaknesses of their tutorials or practical classes or to suggest what changes they think would be helpful. Another is to provide a working agenda, while at the same time encouraging the group to substitute or add other items as they see fit (Daly, Martens, Barnett, Witt, & Olson, 2007). It also helps the teacher appoint one of the students in the group to assist in recording the main discussion points, which can be checked over before a summary note of the findings is produced.

Whilst group discussion does take up valuable time in eliciting views, this is counterbalanced by the effort saved in the painstaking analysis which other methods of feedback would necessitate, since students' views are recorded and collated as an integral part of the process. Should the teacher feel that the students are likely to be too inhibited by the lack of anonymity to voice their opinions, perhaps for fear of causing embarrassment or of being disadvantaged in some way, one feasible solution might be to involve a trusted third party in running the feedback session (Daly, Martens, Barnett, Witt & Olson, 2007).

A refreshingly different way of getting pointers as to how classes are progressing is to give out 'Post-it' slips for students to label with simple headings. The teacher then asks students to write below each heading what they would like him/her to stop, start and continue doing in tutorials or practicals during the next part of course. The 'Post-it' notes can be displayed immediately on a board, wall, or the back of a door, and after they have been collected up the teacher can group similar comments together to identify the main themes. Questionnaires are of course a third option, but a light touch is essential, for two reasons. First, questionnaires may look straight forward, but in reality in designing and processing a good questionnaire calls for considerable effort and expertise. Second, feedback questionnaire is in such widespread use that some students are experiencing "questionnaire fatigue", and there is a growing reluctance to fill them in with careful thought or attention to detail (Ramsden, 2013).

One way of achieving the light touch is to use the one-minute questionnaire. This entails asking the students to jot down their answers to one or two questions, which are handed in as they leave the classroom. The focus could be related to the teaching or practical class. For instance, 'What is the most significant thing that you learned today?' 'What question is uppermost in your mind at the end of this tutorial/practical?' or it might touch on what the group was like: 'How do you feel the class went today?', 'What would have made it better for you?' While students would feel put on the spot if asked directly, their written responses are more likely to give insights into their experiences and what they are taking from them. A similar approach can also be used to get feedback at the end of a course or part-course, asking students to indicate, for example, 'Things they find most valuable, and why?', 'Things they find least valuable and why?', and 'Their ideas for improvements' (Buchanan, 2011).

2.8 Teacher-Student Discourse in Science Classrooms

Teachers and students interact formally in science classrooms via a triadic dialogue (Lemke, 1990, p.127 as cited in Lehesvuori, 2013). It consists of three moves. This comprises initiation by the teacher's question, students' responses and evaluation, (IRE). This triadic dialogue, for the purpose of this study, is referred to as 'IRF', initiation, response and feedback found in the document, European Association for Language Teaching and Assessment (EALTA, 2013) as the third move may not be necessarily explicit. Lemke identified several "thematic development" strategies used by teachers in science classrooms (Lehesvuori, 2013). These include "dialogue and monologue" strategies. Dialogue strategies include the Teacher Question Series (similar to the triadic IRF) selection and modification of students' answers, retroactive recontextualization of students' answers, and joint construction. Monologue strategies include logical exposition, narrative, selective summary, and foregrounding and backgrounding.

Molinari, Mameli and Gnisci (2013) characterized authoritative and dialogic discourse based on the general features of discourse, the nature of teacher utterances, and the nature of student utterances. While authoritative discourse focuses on the "Information transmitting" voice and has a fixed intent of outcome, dialogic discourse involves several voices and has a generative intent. In authoritative discourse, the teacher conveys information and his/her utterances often involve instructional questions, factual statements, and reviews. However, dialogic discourse encourages challenge and debate, and is often based on open or genuine questions. For authoritative discourse, student utterances are often given in response to teacher questions, and consist of single, detached words interspersed in teacher delivery. In contrast, they are often spontaneous, expressed in whole phrases or sentences, and are tentative suggestions in dialogic disclosure.

While dialogic discourse allows students to argue and justify their ideas, the authoritative discourse is observed particularly when the already constructed shared knowledge needs to be emphasized. Indeed, an alternation between these two types of discourse is important for developing conceptual thinking on the intra-psychological plane (Mortimer & Scott, 2003). Smith and Gorard (2005) referred to the alternation between these two types of discourse as "rhythm of discourse", and suggested that learning will be enhanced through a balance between presenting information and allowing exploration of ideas. Thus, for the interactive/authoritative communicative approach, the teacher invites responses from students but discounts their ideas, as he/she focuses solely on the scientific idea. He/she typically leads students through a sequence of questions and answers with the aim of reaching one specific point of view.

In contrast, for the interactive/dialogic approach, the teacher explores students' views and takes account of them, even though they may be quite different from the scientific one. The non-interactive/authoritative approach is best represented by the formal lecture where the teacher presents normative ideas in a monologue. As for the non-interactive/ dialogic approach, the teacher does not invite any turn-taking interaction with students, but makes statements that address other points or view in addition to the formal scientific one. As for patterns of discourse, Mortimer and Scott (2003) expanded on the IRE or IRF structure by identifying the IRERF chain where the elaborative feedback from teacher is followed by a further response from a student. This form is typical of discourse that supports a dialogic interaction. As part of the feedback, the teacher could repeat a student's comment to encourage the student to continue, elaborate on the comment, or ask for elaboration. By establishing this pattern of discourse, the teacher is able to explore students' ideas.

2.8.1 Involving Students in the Feedback process

Involving students in the feedback process can take various forms. Texas education agency research indicates that students can effectively self-monitor their own progress (TEA, 2008). Practical examples of student self-monitoring include having students keep track of their progress during learning or self-evaluate their performance. Student-led feedback can also produce desirable results. While teachers must formally evaluate student work, students can effectively peer evaluate projects using the same specifically-defined criteria employed by teachers during grading (TEA, 2008). Peer-evaluation reinforces learning and provides students with a variety of perspectives on work during the feedback process. Examples of peer-evaluation include having students edit rough drafts of work in progress and participate in formal critiques of visual work or presentations. Timperley and Alton-Lee (2008) and Timperley, Parr and Bertanees (2009) all support the claim that "feedback should not be regarded as merely a one-way flow of information from the teacher to the student". The dialogue should also contain relevant feedback from the student to the teacher. In other words, the student must be empowered by being taught how to provide the teacher with relevant information.

2.8.2 Perception of Teachers Feedback by Students

The social context can be critical when students interpret feedback (Cowie 2005; Hattie & Timperley, 2007; Waldrip, Fisher, & Dorman, 2009; Hattie & Gan, 2011), but most importantly, the power of feedback does not only lie in when and how it is given, but more in when and how it is received (King, Schrodt, & Weisel, 2009; Andrade 2010; Hattie & Gan 2011). These studies have thus contributed to the expansive view of feedback that exists today. Feedback is regarded as part of the crucial interaction between teacher and student(s) carried out for the purpose of furthering learning (Black, Harrison, Lee, Marshall, & William, 2004; Smith & Higgins, 2006; Hattie & Timperley, 2007; Brookhart, 2008; Hawe, Dixon, & Watson, 2008). In classrooms, there may be a need to move away from seeing the teacher as giver and the learner as receiver of feedback toward accounting for the social context of learning – and the ways students provide feedback to teachers as well as to their peers (Hattie & Gan, 2011). Finally, students need to understand that the feedback they receive from teachers' peers or through self-assessment can improve the quality of learning (Black & William, 2009; Andrade, 2010).

2.9 Relevance of Chemistry Teaching and Learning

Unfortunately, science and especially chemistry courses are often felt to be irrelevant to students' everyday life (Aikenhead, 2006; Bennett, Gräsel, Parchmann, & Waddington, 2005; Bulte, Westbroek, de Jong, & Pilot, 2006; Gilbert, 2006; Hofstein & Kesner, 2006; Millar, 2006; van Aalsvoort, 2004a, 2004b). Aikenhead (2006) argues that science content included in school courses seldom is applicable in everyday life, and most students have problems finding the science content meaningful even though the context in itself might be relevant.

The lack of relevance in chemistry has been studied from many different starting points and van Aalsvoort (2004a; 2004b) has analysed chemistry education from two different theoretical perspectives, activity theory and logical positivism, and shows that the former has a potential to connect knowledge with practice which makes chemistry more functional, multi-perspective and situated. From these results it has been recorded that chemical education textbook with the activity theory as starting point and claims that it solves the problem of lack of relevance. In another effort to make chemistry studies more relevant, context-based chemistry courses have been developed (Bennett & Lubben, 2006; Bulte, Westbroek, de Jong, & Pilot 2006; Gilbert, 2006; Hofstein & Kesner, 2006; Parchmann et al., 2006). Besides the problem of relevance, there is a belief that science is very difficult to study (Bennett, Gräsel, Parchmann, & Waddington, 2005; Bulte, Westbroek, de Jong, & Pilot, 2006), and there is also an apparent curriculum overload in science courses (Bennett et al., 2005; Gilbert, 2006). The overload problem seems to be an issue for both conventional and more context-based courses (Bennett, Gräsel, Parchmann, & Waddington, 2005). In order to understand why students, find science difficult, research projects have tried to reveal the main obstacles.

Misconceptions and problems with models and modelling are often mentioned as important impediments for students (de Jong & Taber, 2007; Gilbert & Treagust, 2009). Teachers therefore have to identify effective means of providing students with the necessary feedback to enable them identify their misconceptions and help them to close the gap between their current knowledge and the desired knowledge. Most teachers of chemistry have been found to use the old didactic way of lecture in teaching. This does not help learners to learn better. Teachers of chemistry forget that the learners have prior conceptions about whatever topic they have to teach and that tapping from them and moderating these conceptions will help them learn better. The neglect of these prior conceptions in the teaching of particulate nature of matter, solutions, and acid-base titration, can discourage students' learning. Within the students' ambience, certain concepts about the particulate theory of matter can be identified. For instance, evaporation of water into the atmosphere, melting of ice, boiling of water meant for bathing or cooking and condensation of water vapour, can all be seen happening and therefore the teacher is supposed to utilize these in the teaching and learning of particulate nature of matter. As students move about daily, they come across situations where concepts associated with solutions are being used; for instance, dilute and concentrated solutions, solvents, solutes, and measurement of exact volumes of solutions. Students are already familiar with these concepts and the science teacher is supposed to tap these conceptions and use them in helping the students to learn better.

Acid-base titration is one of the major laboratory works that science students have to study and know very well before they complete their course of study in a senior high school. Unfortunately, most science students in senior high schools in Ghana enter their final year of education without any knowledge in acid-base titration. In most of the schools visited by the Researcher, it was ascertained that it is only when students were just about to write their final examinations that chemistry teachers quickly take them through some aspects of laboratory work especially acid-base titration. This does not auger well for us as teachers in science education and for the students as well. The students may go through their course of study without having learnt the concepts and theory behind it very well. Most teachers of chemistry are not very conversant with the teaching of acid-base titration and so their concentration has been in the teaching of the theory aspect contained in the syllabus. Even those who find themselves teaching the practical aspect of acid-base titration do so neglecting the constructivists' approach. When this happens students only receive the body of knowledge as packaged by the scientific community and students do not learn well. Most students also complained that they do not understand certain concepts like equivalence point, endpoint, etc. that are associated with acid-base titration. Other factors that affect effective teaching of chemistry can be attributed to lack of equipment and materials in the senior high schools, science teachers' failure to explore what students already know about the topic, and teachers' inability to apply what students have learnt in their daily life situations.

2.10 Conceptual Change

Conceptual change involves the rejection of a prior understanding in favour of a new one. This view of conceptual change as a rejection of one idea in light of another is a radical reorganization of knowledge structure (Chi, 2005). This is not to suggest that in conceptual change one idea is merely replaced by another and the original premise is banished from one's thinking. The old idea often remains, and indeed, may need to be intentionally inhibited. What changes is the level of belief that is placed in the idea. In practice, individuals are certainly capable of holding several competing ideas at the same time. Since science concepts are not presented with any ontological differentiation such as between process and material, the desired changes to students' ontologies are not generally succeeded in schools with traditional instruction (Treagust & Duit, 2008). To promote conceptual understanding and eliminate learners' misconceptions, various conceptual change views of teaching and learning approaches were suggested (Treagust & Duit, 2008; Vosniadou, 2007). These models and strategies were derived from Kuhn's philosophy of science and Piaget's cognitive developmental theory (Zhou, 2010). Treagust and Duit (2008) recount the approach by Posner, George, Strike, Hewson, and Gertzog, (1982) to help learners in transforming preconceptions into scientific conceptions. It involves teacher making students' preconceptions explicit before designing a teaching approach which includes ideas that are inconsistent with students' existing conceptions.

According to Posner, George, Strike, Hewson, and Gertzog, (1982), there are four conditions for conceptual change: 1) dissatisfaction of learner, 2) intelligibility, 3) plausibility, and 4) fruitfulness of new conception must be satisfied for the conceptual change. Learners must first encounter with pre-existing conception to consider a new one. If the new conception does not produce dissatisfaction, then it may be assimilated alongside the old one. If new and old conceptions reveal their incompatibility, then two outcomes may happen; if new one succeeds higher status than the previous one, then accommodation or conceptual exchange may occur, otherwise no conceptual exchange proceeds (Treagust & Duit, 2008). Intelligibility requires constructing a coherent representation of a theory and understanding of the meaning of conception.

A plausible conception must be believable in addition to the learners' knowing what it means. Fruitfulness is the capacity of the conception to help learners in solving other problems or to suggest new research directions (Treagust & Duit, 2008). Treagust and Duit (2008) reported that embedding conceptual change strategies in conceptual change supporting learning environments would result in efficient conceptual understanding. Carey (2009) presents six educational implications as far as defining concepts as "units of mental representation" (pp. 17) and Vosniadou (2007) provides us with the "Mechanisms of Conceptual Change" as a mode of viewing the discussion of knowledge transfer in conceptual change. Chi (2005) suggests that concepts are more difficult to learn when: 1) they are not directly observable, and 2) when a macroscopic pattern emerges from observable microscopic phenomena (direct versus emergent concepts). Therefore, context affects students' conceptual understanding. It is the notion of many people that 1) conceptual change is a difficult and herculean task, 2) conceptual change is organized in such a way that in order to change, the sub-categories must be changed in order to change the over-arching category, and 3) the barriers to conceptual change outnumber the strategies to perform conceptual change properly.

Slotta and Chi (2006) stated that concepts are ontological in nature. Chi, Roscoe, Slotta, Roy, and Chase (2012) presents the element of emergent vs. sequential processes. This idea displays conceptual change as a process instead of a concept itself. Chinn and Brewer, (1998) address the issue: How do students respond when they encounter scientific information that is different from their own theory about the world? They offered seven responses as to why conceptual change may not even work. Responses include: ignoring anomalous data, rejecting it, and incorrect interpretation. The conceptual change as knowledge acquisition versus participatory learning debate is one in which the lines between the two ideas are seemingly blurred. On the knowledge acquisition side the argument is tied to how people acquire knowledge by changing their underlying framework or overall approach to learning new material. Conceptual change as knowledge acquisition sits in the realm of paradigm shifts as discussed by Zirbel (2006). Theorists such as Piaget, Kuhn and Vygotsky have discussed that through the process of gaining new knowledge, whether through experimentation or having it being presented, one can either assimilate new information to the old ideas or completely reject their pre-conceptions in lieu of the new idea being

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

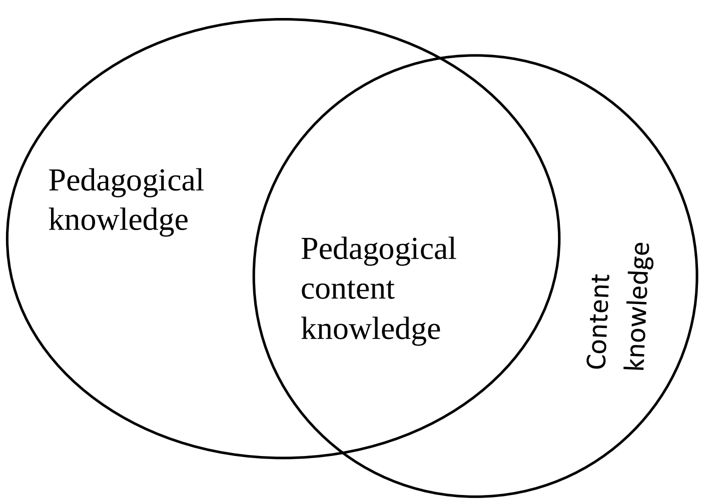
presented (Vosniadou, Vamvakoussi, & Skopeliti, 2008). The approach to conceptual change in this domain is such that if the learning environment and instructional strategy by extension, appeals to the students' own conceptual framework then they will experience dissatisfaction when presented with new information that challenges their existing beliefs.

Many well established theories of conceptual change hold to the knowledge acquisition framework. Chi (2008), for example, discusses conceptual change as ontological category shifts such as reclassifying concepts like *current* as processes rather than materials. Instructors also seem to favour knowledge acquisition over participatory learning (Duit, Treagust, & Widodo, 2008). This is based on the view that scientific knowledge is "authoritative in nature" and the teacher is best positioned to determine what knowledge is correct and valuable (Leach & Scott, 2008). Knowledge, in some settings, is socially constructed rather than determined by some external body. Thus, students are able to determine what is important to know, and develop a better understanding of the process of constructing knowledge. Duit, Treagust, and Widodo (2008) favour the participatory view of conceptual change and suggest that treating conceptual change as knowledge acquisition view neglects considerations of individual motivation and social structure.

While these two perspectives on conceptual change seem diametrically opposed, some suggest that they may simply be points on a continuum (Sinatra & Pintrich, 2013). Individual learning environments may contain elements of both and differ only in how much knowledge or processes are favoured and the amount of control students have over their own learning. For example, an instructor might teach science through inquiry-based lab assignments but provide some guidelines or scaffolds, or even model appropriate processes. Research findings in conceptual change have started using instructional practice but there is a vast gap between our theoretical and empirical knowledge and classroom practices. Teachers are not well informed about conceptual issues and do not use the recommended instructional strategies for promoting conceptual change in the classroom (Duit, Treagust, & Widodo, 2008). Pedagogical decisions should be made at three levels while planning for conceptual change teaching. Firstly, teacher needs to foster a learning environment that will support conceptual change learning. This can be via providing opportunities for discussion and consideration of alternative viewpoints and arguments. A second level of decision-making involves the selection of teaching strategies. Lastly, consideration must be given to the choice of specific learning tasks (Duit, Treagust, & Widodo, 2008)). The learning task must address the demand of the particular science domain under consideration.

2.11 Pedagogical Content Knowledge as a Theory of Instruction

In any profession there is a specialised professional knowledge that makes it unique and distinct from other professions. This also applies to the teaching profession. One of the characteristics of good teachers is that they possess a substantial amount of specialised knowledge for teachers known as *pedagogical content knowledge* (PCK), which is the intersection between *pedagogy* and *content* (Shulman, 1986) as shown in Figure 3.



https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

Figure 3: Knowledge base of the Teaching Profession

Teachers of chemistry need to develop scientific reasoning, insight, understanding, and skills that are to teach the subject. Many have worked to develop theoretical models and measures to address this question, most notably Ball and colleagues (Ball, Thames, & Phelps, 2008; Hill et al, 2008). Pedagogical content knowledge is more than an overlap of content knowledge and pedagogical knowledge. It is an inextricable blending that is "predicated on coherent and generative understandings of the big scientific ideas that make up the curriculum." (Silverman & Thompson, 2008, p.502). PCK is about how understanding of concepts, informs thinking and knowledge building about content and students, about content and teaching implementations, and about content of the curriculum. PCK grows when a teacher gets better at the transformation of personal and intimate forms of scientific knowing into ways of understanding that include how to orchestrate purposeful exploration of that scientific knowledge among others. In investigating correlation between K-8 teachers' mathematical knowledge for teaching and quality of instruction, Hill et al. (2008) concluded the existence of powerful relationships among what and how teachers know about mathematics and what occurs during instruction. In addition to the categories in Figure 1, the authors identified (1) beliefs about mathematics, (2) perceptions of mathematics learning and teaching, and (3) decision-making around adoption of teaching material, as significant factors in mediating teachers' instructional performance.

Existing work on science PCK has long included a component of "orientation" or "disposition" (Park & Chen, 2012). That is, science PCK models include a melding of knowledge and beliefs about the teaching and learning of the discipline itself, a teacher's personal conceptual map about what is valuable in science as well as in its learning and teaching. Researchers have investigated the vocabulary, discourse practices, gestures and setting of norms for talking about the discipline (Alibali et al., 2013; Moschkovich, 2007; Race, 2010 & Ryve, 2011). If pedagogical content knowledge is the reshaping and melding of knowledge and beliefs about mathematics and pedagogy into instructional realizations in the classroom, then certainly the aspects of communication just listed are part of PCK. Teachers should be given experience with teaching approaches that are similar to those being used in classrooms. If, for example, teachers are expected to teach in a learner-centered way, then they should be exposed to this approach of FAST feedback methods of teaching.

2.12 Review of Related Empirical Studies

The intent of feedback is to improve performance. The way in which students receive feedback from others, however, is critical to positively impacting student learning and improving performance (Marzano, Pickering, & Pollock, 2005). Research indicates a wide-range of results on the general effects of feedback; certain strategies produce better results than others. Some types of feedback can produce negative results (Marzano, Pickering, & Pollock, 2005). It is important, therefore, for teachers to understand and use the most effective, research-based strategies when providing feedback to students. Bruce Tulgan in his book FAST feedback for managers of organisations declared that FAST feedback is a straightforward workplace communication system designed to generate brief, results-oriented information exchanged between employees and their managers. The system produces immediate results in the workplace (Tulgan, 2013). FAST Feedback transforms the role of managers and dramatically improves the relationships between managers and their direct reports. Once a critical mass of managers begins practicing FAST Feedback, behaviour change is created which produces dynamic environment of ongoing results-oriented dialogue (Tulgan, 2013). By turning managers into coaches, there will be increase in productivity, accelerated turnaround time, and corporate culture will be invigorated (Tulgan, 2013).

In this research managers refer to teachers and the employees also refer to students. Tulgan (2013) posited that if the only feedback employees get from managers is in the form of a 6-12-month performance review, then it is time to change this approach of feedback. Tulgan (2013) prescribed the FAST feedback method for giving feedback in business organizations and this has been adopted and adapted in this study which focuses on classroom discourse. Frequent feedback (F) must be given by teachers to ensure effective learning. Teachers must give feedback regularly so that the students could get accurate, up-to-date understanding of their performance strengths and areas for development or improvement. The feedback teachers give must also be accurate (A) to ensure that students get the correct information about their responses to teachers' questions. Teachers' feedback must be specific (S) to the task or as exactly as students' responses. Teachers must describe and focus on the actions or behaviours that the students did (or did not do).

2.13 Chapter Summary

This chapter looked at the background of feedback given in classrooms as obtained from some research studies and described feedback identifying some types of feedback. Sources and methods of giving feedback were also described and this led to the description of FAST feedback. Pedagogical Content Knowledge, a theory of instruction, teacher-student discourse in science classrooms and teacher questioning and feedback were also discussed. The chapter again described feedback and instruction, conceptual change and making chemistry teaching relevant. Meaningful versus rote learning, teaching for conceptual change, pedagogical content knowledge and finally, the conceptual framework for the study were all described.

3.0 RESEARCH METHODOLOGY

In this chapter the research design is described as well as the procedures that were used to investigate and describe the status of feedback given by chemistry teachers in senior high schools. The procedures for intervention and how data collected were treated have all been described.

3.1 The Research Design

A research design describes how the study would be conducted. It identifies the method suitable for the study and explains the rationale for the method chosen. It also points to the stages for which the researcher would follow (Gerald, 2014). Early consideration of design in relation to research questions leads to the elimination or diminution of threats to eventual research claims, by encouraging internal validity and substantially reducing the number of alternative explanations for any finite number of research 'observations' (Gerald, 2014). A case study action research design was adopted for the study. A case study is a "published report about a person, group, or situation that has been studied over time. If the case study is about a group, it describes the behavior of the group as a whole, not behavior of each individual in the group. Case studies can be produced by following a formal research method. The resulting body of 'case study research' has long had a prominent place in many disciplines and professions, ranging from psychology, anthropology, sociology, and political science to education, clinical science, social work, and administrative science. In doing case study research, the "case" being studied may be an individual, organization, event, or action, existing in a specific time and place. Thomas (2011) offers the following definition of case study: "Case studies are analyses of persons, events, decisions, periods, projects, policies, institutions, or other systems that are studied holistically by one or more method. The case that is the subject of the inquiry will be an instance of a class of phenomena that provides an analytical frame, an object within which the study is conducted and which the case illuminates and explicates."

According to Creswell (2009), data collection in a case study occurs over a "sustained period of time." One approach sees the case study defined as a research strategy, an empirical inquiry that investigates a phenomenon within its real-life context. Case-study research can mean single and multiple case studies, can include quantitative evidence, relies on multiple sources of evidence, and benefits from the prior development of theoretical propositions. Yin (2014) posits that a case study research should not be confused with qualitative research, as case studies can be based on any mix of quantitative and qualitative data. Similarly, single-subject research might be taken as case studies of a sort, except that the repeated trials in single-subject research permit the use of experimental designs that would not be possible in typical case studies. At the same time, the repeated trials can provide a statistical framework for making inferences from quantitative data. One of the areas in which case studies have been gaining popularity is education and in particular educational evaluation (Stake, 1995). Case studies have also been used as a teaching method and as part of professional development, especially in business and legal education. The problem-based learning (PBL) movement is such an example. When used in (non-business) education and professional development, case studies are often referred to as critical incidents (Macdonalds & Walker, 1975)

This research was designed to describe the actual feedback that teachers' give to their respective students in chemistry classrooms. It also sought to find out the effect of FAST feedback as an ideal method of giving feedback by teachers in chemistry classrooms in Ghanaian senior high schools. Data for the actual picture was generated through survey of questionnaires for chemistry teachers and students, teacher interviews, observation of chemistry lessons and students' exercise books. Data for the ideal feedback was generated through classroom discourse with the students by the researcher where the FAST feedback method was adopted in the teaching of chemical bonding.

Analysis of the responses from students was done immediately after every lesson. The purpose of collecting data related to actual and FAST feedback by teachers in chemistry classrooms in Ghanaian senior high schools was to compare the actual (what exists in chemistry classrooms) with the FAST feedback and then to validly develop recommendations for closing the gap between the actual and FAST feedback. A mixed method approach (triangulation) involving a combination of both qualitative and quantitative data from different sources was used to corroborate findings in this study. As a methodology, it involves philosophical assumptions that guide the direction of the collection and analysis of data and the mixture of qualitative and quantitative approaches in many phases in the research process (Creswell, 2012). As a method, it focuses on collecting, analyzing, and comparing both quantitative and qualitative data in a single study or series of studies. Its central premise is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than either approach alone (Creswell, 2012). Quantitative research is a more logical and data-led approach which provides a measure of what people think from a statistical and numerical point of view. Quantitative research can gather a large amount of data that can be easily organised and manipulated into reports for analysis (Bouma et al, 2007). The quantitative approach involved the use of questionnaires to survey both chemistry teachers and students. It also involved scores obtained by students from the worksheets during and after lessons.

The teachers' survey helped to identify typical feedback given to students during classroom discourse with associated factors limiting quality and acting as barriers to conceptual change. The students' survey further helped to gather students' views about how their chemistry teachers give feedback, and the effect of the feedback on their learning. Quantitative methods essentially help to identify and assess the bounds of knowledgeability of the respondents and to assess the respondent's attitudes, values, believes or opinions (Bouma, et al, 2007). It indicates that questionnaires in quantitative research give more precise, explicit, and predetermined measure and identification of relevant variables in advance. Hackling (2006) further claims that questionnaires are economical and very simple to administer to sample large groups of respondents; give better potentials to generalize findings because samples are larger; ensure efficient gathering of large quantities of baseline data; and also the responses gathered can usually be transformed easily by coding into data files that are ready for statistical analysis. However, questionnaires are very complex to construct and the success of using questionnaires depends on the honesty of the respondents (Bouma et al, 2007).

The qualitative approach on the other hand involved interview protocol, examination of students' exercise books, observation of chemistry lessons as well as probe into the classroom discourses. Thus qualitative method is necessary for the support or proof that it provides to make the outcome of the quantitative method true or even to disprove it. The qualitative approach explains, describes the programme, constructs a narrative history, presents data collection procedures, and summarizes and allows the researcher to have more continuous reflection of the research in progress, more interaction with the participants in the research and more room for ongoing alteration as the research proceeds (Bouma et al, 2007). Some of the major setbacks of qualitative methods are that, they tend to produce large amount of information that can only be focused after data collection, less focused at the outset that is, assume less in advance which variables are relevant, more open-ended and are sensitive to context that are likely to be focused on in the intentions, explanations and judgments of the participants, since it aims at providing the maximum opportunity for the researcher to learn from the subject, or participants in the research (Bouma et al, 2007). Despite the complex nature of the quantitative methods, they are more quickly accomplished, produce conclusions and help provide reportable findings involving percentages of variable occurrences (Berg, 2007). Therefore, quantitative methods are essential in educational research (Patton, 2002). While quantitative and qualitative methods each gather valuable

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

information on their own, findings from qualitative and quantitative methods are distinct and they complement one another in the content (Berg, 2007). No single approach either qualitative or quantitative methods can be perfectly effective (Berg, 2007) and so each method can be improved significantly through triangulation of data from various sources (Yin, 2013). This approach is relevant to this study to triangulate and corroborate findings from the respondents.

3.2 Population

The study was conducted in the Eastern Region of Ghana. Students representing a cross section of mainstream public and private senior high schools in Ghana were included in the sample, which was believed to be representative of the target population, typical of senior high schools located in the Eastern Region of Ghana. The pre-intervention study aimed at identifying the actual (existing) types of feedback giving in chemistry classrooms which covered the senior high schools in the Eastern Region of Ghana. Thus the population consisted of chemistry teachers and their respective students from senior high schools in the Eastern Region of Ghana. After the preliminary study, the first year chemistry class from Yilo Krobo SHS in the Yilo Krobo Municipal Directorate of Education in the Eastern Region of Ghana was selected for the intervention.

During the intervention, the researcher selected chemical bonding and taught it to the students incorporating FAST feedback which yielded positive results. Two prominent senior high schools in the municipality are the Yilo Krobo senior high school, a public institution, and Somanya senior high and Technical school, which is a private institution. There are a number of Junior High Schools in this traditional area (Table 3). Yilo Krobo district started operating the ongoing educational reform as a district since 1987. Educationally, the district is divided into 8 circuits of which 6 are rural. The district has 38 highly deprived school communities out of which only Somanya North and South are urban.

Table 3: Public and Private Schools in Yilo Krobo Municipal Educational Directorate.

Level	*Public*	*Private*	*Total*
Kindergarten	79	30	109
Primary	79	30	109
Junior High School	42	4	46
Senior High School	2	1	3
Total	202	65	267

A letter (Appendix A) describing the study rationale and procedure was sent to the headmasters of the respective senior high schools. Following this, a similar letter was sent to the heads of the science departments in these participating schools (Appendix A). Data was collected in April, 2014.

3.3 Sample and Sample Size

Purposive sampling approach was used to select student participants for the study (Oliver, 2013). A form of non-probability sampling in which decisions concerning the individuals to be included in the sample are taken by the researcher, based upon a variety of criteria which may include specialist knowledge of the research issue, or capacity and willingness to participate in the research (Oliver, 2013). In purposive sampling, participants are handpicked and in this case the chemistry teachers helped the researcher to do the sampling since the teachers were familiar with the students. Student participants were selected from SHS1 in all the participating schools. The basic assumption for selecting schools for the study was that the schools had similar characteristics such as chemistry teachers who had been teaching for at least two years, average age of student participants was 16 years, and same curricula to follow. The region in general is cosmopolitan where the people had almost all social groupings, different ethnic groupings, some children were found in deprived schools whilst others were in endowed schools and came from diverse home backgrounds. Participating schools included schools from both rural and urban areas. Also participants were selected from single sex schools as well as co-educational institutions. The sample size was 885 (*n=885*) comprising 795 students and 20 teachers for the pre-intervention study and 70 students for the post-intervention study. The sampling frame is presented in Table 4.

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

Table 4 The Sampling Frame for the Participants Survey (Pre and Post Intervention)

	School Location				
School Type	Rural		Urban		.
	Males	*Females*	*Males*	*Females*	Total
Co-educational	95	65	185	90	435
Boys Only	-	-	250	-	250
Girls Only	-	-	-	180	180
Teachers	4	1	11	4	20
Total	99	66	446	274	885

Participants as shown in Table 4, indicated their interest by completing and returning the consent form were selected to participate in the survey. Using purposive sampling method helped to obtain a sample of participants who were informed and also provided a range of important perspectives to the research. It is worthy of note that the contribution of the key stakeholders was crucial to this study.

3.4 Instrumentation

Three main instruments were developed for data collection. The first instrument was questionnaire for both teachers and students (Appendices B and C respectively). The second instrument was teachers' *interview protocol* (Appendix D) of twenty (20) items based on the qualities (FAST) of feedback. The third instrument was the *Observation schedules* (Appendices D and E) which were also used to chemistry lessons and from student's exercise books. The combination of these approaches supported and provided triangulation for the study. Triangulation according to Rothbauer (2008) is getting the data through a variety of different strategies so as to strengthen and verify the research findings. These instruments sought to collect base line data on the existing ways by which chemistry teachers give feedback to their students. Both teachers and students participated in this initial data collection which helped to establish a relationship between the responses of the teachers and the responses from their respective students. These were followed by classroom *discourse* using the procedures of FAST feedback methods to help students towards effective learning. The underlying principle of FAST feedback methods is the frequency by which the teacher poses problems for students to respond during the lesson and the immediate feedback that teachers give to students.

After every lesson, the students were given *worksheets* and the outcome of students' performances was used to determine the effect of this method of teaching. Drawing inspiration from the following instruments which have been described under the theoretical framework, the instruments for the study were developed.

3.5 Survey Questionnaires

The purpose of the survey questionnaire was to elicit information about the characteristics or opinions of the respondents. Two forms of survey questionnaire were used for data collection; a teacher survey and a student survey. Both the teacher and student questionnaires were developed by the researcher having taken a cue from the SET. A questionnaire of twenty-two items based on the domains of the qualities (FAST) of feedback was developed to collect data on how chemistry teachers give feedback to their students. The responses were supposed to provide baseline data for the study. Teachers' attitude towards the provision of feedback during classroom discourse and the types of feedback that they give were unearthed by the questionnaires. Table 5 summarizes how the items were distributed over the domains.

Table 5 Distribution of Questionnaire Items over the Domains of FAST Feedback

Domain	*Item number*
Frequent	1, 2, 3, 4, 5, 6, 7 8
Accurate	9, 10, 11 12
Specific	13, 14, 15 16 17
Timely	18, 19, 20, 21 22

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

The Likert-type scale was preferred to other scales such as Thurstone scales, Guttmann scales and Semantic Differential scales. Among these attitudinal scales, Likert-type scales are easy to construct. The Likert scale is the most widely used method of scaling in the social sciences today. Perhaps this is because they are much easier to construct and because they tend to be more reliable than other scales with the same number of items (Page-Bucci, 2003). Likert scales also provide the researcher with opportunity to compute frequencies and percentages, as well as statistics such as the mean and standard deviation of scores. This, in turn, allows for more sophisticated statistical analyses such as Analyses of Variance and factor analyses to be performed on the data. In addition, Likert scales are often found to provide data with relatively high reliability (Page-Bucci, 2003).

3.5.1 Teacher Survey Questionnaire

The teacher questionnaire comprises five sections. The first section elicited information on demographic data regarding the teachers' age, qualification, years of teaching experience, area of teaching specialization, and class size. The other four sections focused on how the teacher provides feedback with reference to the qualities (FAST) of feedback. The scales forming the core around which the Items were developed are Frequent, accurate, specific and timely (FAST) feedback. Thus, Items under each scale aimed at finding out from the chemistry teachers how they give feedback to their students during chemistry class. Each Item had weights for the Likert scale ranging from three (3) to one (1). The respondents were to tick in the box corresponding to how the chemistry teacher provides feedback to students. If the respondents *strongly agree* (3) with the item statement, they will make a tick in the box closer to *very frequent, very accurate, very specific, or very timely* and if they *agree* (2) then a tick will be made in the box corresponding to *frequent, accurate, specific or timely*. On the other hand, if they *disagree* (1) with the Item, they will make a tick in the box closer to *Rarely*.

2.5.2 Student Survey Questionnaire

The purpose of the student survey was to investigate students' perception about how their chemistry teachers give feedback during classroom discourse. The questionnaire comprises five sections. The first section asks for demographic data, including, age, students' school (boys/girls/coeducational), year or level and class size. The other sections inquired from students, how their chemistry teachers give feedback as to whether the feedback given, have the qualities (FAST) feedback. If the respondents *strongly agree* (3) with the item statement, they will make a tick in the box closer to *very frequent, very accurate, very specific, or very timely* and if they *agree* (2) then a tick will be made in the box corresponding to *frequent, accurate, specific or timely.* On the other hand, if they *disagree* (1) with the Item, they will make a tick in the box closer to *Rarely.*

3.6 Interviews

Chemistry teachers were Interviewed using the interview protocol. The teachers responded to semi-structured interview questions that focused on the research questions. The intention here was to allow the respondents to give their own free judgment of the way they give feedback to their students. Structured interviews are easy to replicate as a fixed set of closed items are used, which are easy to quantify. This means it is easy to test for reliability. Unstructured interviews however, have been proposed to be most appropriate for qualitative research because they provide volunteered information as the interviewee is more relaxed. However, it is believed that it is necessary to identify some key issues of the study to guide the interview process, while room is made for the interviewees to respond to questions orally if they wished. The items in the interview protocol were developed by the researcher using the four scales; *frequent, accurate, specific, and timely* means of giving feedback to students. Each of these scales had the same number of interview questions as the number of Items in the questionnaires. This is shown in Table 6.

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

Table 6 - Distribution of Interview Questions over the Domains of FAST Feedback

Domain	*Interview Questions*
Frequent	1, 2, 3, 4, 5, 6, 7 8
Accurate	8, 9, 10, 11, 12
Specific	13, 14, 15, 16 17
Timely	18, 19, 20, 21 22

The interview protocol was used to survey the respective teacher respondents to confirm their responses to the questionnaires. On the day that the structured interviews were administered in each of the participating schools, the researcher read a brief script to the teachers describing the study, and the directions for the response (Appendix D). Participants completed the interview protocol in approximately 30 minutes.

3.7 Observation schedule

Most qualitative research literature emphasizes data collection through observation or making "detailed notions" of behaviour and events. Inter-rater reliability and validity of observation schedules have been found to be good (Bedimo-Rung, Gustat, Tompkins, Rice, & Thomson, 2006). It is necessary to use pre-specific sets of events for the observation of teacher-student interactions for the following reasons: i) a clear focus and reduction in the degree to which the researcher's attitudes and biases might have blurred what was seen ii) to sharpen the researcher's sense of observational skills (Bedimo-Rung, Gustat, Tompkins, Rice, & Thomson, 2006). This feedback observation schedule was aimed at collecting a lot of feedback information from the classroom discourses and students exercise books. The information gathered were analysed, categorized and put into themes.

3.8 Teaching with FAST feedback Method

The intervention activity was the classroom discourse between the researcher and participating chemistry students from Yilo Krobo Senior High School. For all the topics that were taught, the researcher first of all *posed a problem* on the board. The researcher went *round to check* whether everybody was working. The researcher again went round to see some of the students at work. When the researcher found any student with an *unexpected answer*, he *called that person to explain* his or her answer. Other students spontaneously *compared answers*. The researcher presented briefly one or two *frequently occurring errors* and explained. The researcher then presented the *next problem* and that went on and on from the introduction stage to the closure of the lesson. The researcher ensured that throughout the lesson the feedback given to students were frequent, accurate, specific and also timely. At the end of every lesson, the researcher gave some exercises to the students to respond so as to tell how far the approach had helped students to learn. Higher scores indicated that the approach was good and lower scores implied the researcher had to restructure the strategies employed.

3.9 Methodological Framework

The methodological framework that underscores the discourse between the teacher and the students is presented in Appendix J. At the introductory stage of the lessons, when questions are posed by the teacher, the students give their responses. If the responses are not satisfactory, the teacher reframes the question to enable the students give the correct responses. That constitutes a cycle which is aimed at initiating and eliciting responses from the students that led them into the topic under study. The next stage of the lesson was the development stage where the teacher developed the lesson step by step with new concepts and ideas. All along, the teacher posed problems for the students to respond. If students were not able to respond positively, the teacher reframed the question to enable the students provide the appropriate response. This feedback cycle is also aimed at extending the students' level of understanding beyond. The closure stage also had a cycle which solicited feedback from the students. Teachers' asked students to answer questions orally or written to establish their level of understanding or misconception. If the teacher discovers a common problem running through among the students, a plenary session is held for the teacher to explain well for the students to understand. Throughout the lessons, frequent feedback was solicited from the students to find out their level of understanding, interest and misconceptions. This classroom discourses were done bearing in mind the qualities of feedback (frequent, accurate, specific, and timely). Students were asked to do activities in groups and discuss issues concerning them (collaborative learning). Students later reported their findings which provided feedback to the researcher which determined the next steps to take so as to bring about meaningful learning. Series of activities that helped the participating students to understand the lessons better were employed.

3.9.1 Procedure for Data Collection

Data collection for this research study involved seven phases. These are enumerated as follows: Phase 1: Seeking permission to access schools: A letter signed by the Head of Department of Science Education, University of Education, Winneba (Appendix A) was used to obtain permission from heads of the participating senior high schools as well as the heads of science departments. The letter introduced the researcher as a student who was undertaking a research into how chemistry teachers in SHS give feedback during lessons. It further requested the heads of departments to accord the researcher the necessary assistance to go through the exercise. Later, heads of the participating schools and their heads of science departments were approached by the researcher to discuss the purpose of the study to seek their consent for completing the questionnaires and the interview protocols. Participants who indicated their interest in participating in the study and also returned their consent forms were involved in the study.

Phase 2: Pilot testing of the research instruments: The teacher and student survey questionnaire and the teacher interview protocol were pilot tested with the chemistry teachers and students from two schools in the Eastern Region of Ghana which did not form part of the main study. The pilot study was done purposely for both content and construct validity. Also, these instruments were pilot tested with other science educators to determine the level of understanding of the questions raised in the study. Based on the responses in the survey questionnaires and comments from the interviews, appropriate corrections were made by the researcher in agreement with the supervisors. Thereafter the instruments were considered appropriate for the research study.

Phase 3: Distribution and administration of questionnaires: Teacher survey questionnaires were given to the chemistry teachers in all the participating senior high schools in the Eastern Region of Ghana. Also the student survey questionnaires were distributed to the chemistry students in the participating schools. To ensure high return rate of the questionnaires, the researcher personally supervised the distribution and collection from the participating chemistry teachers and their respective students. The administration of the students' questionnaires was personally supervised by the researcher. The questionnaire was administered in April 2014.

Phase 4: Distribution and administration of the interview protocol: Participating chemistry teachers were given the interview protocols to respond to. The interview protocols were responded to on the sheets of papers where the interview questions were written. This lasted for about one hour. The respondents had to write down their responses as they perceived the manner in which they give feedback during classroom discourse. The interview protocol was administered in April 2014 just as the questionnaire.

Phase 5: Observation of lessons and exercise books: The lessons which were observed using the checklist (Appendix D) included the nature of the atom, the periodic table, trends in the periodic table and acids bases and salts. The chemistry exercise books belonging to students who participated in the study were collected and examined using the checklist (Appendix E). The qualities of FAST feedback were noted during the lessons by the chemistry teachers. For instance, if students were not able to answer any question, did the teacher repeat (frequent) or reframe (accurate, specific) the question in another form to enable the students answer the question? Did the teacher give approval or disapproval immediately students provided responses (timely)? In the case of the exercise books, the number of exercises given by the teacher was noted (frequency). The number of marked exercises (frequent) and the type of comments (accurate) written against the items (specific) were all recorded by the researcher. Also did the teachers mark and submit to students on time (timely)? This can be seen by checking the time interval between on exercise and the next.

Phase 6: Teaching with FAST feedback method: The researcher held a meeting with the chemistry teacher of the SHS (Yilo Krobo Senior High School) where the FAST feedback method was used. Chemical bonding which was yet to be taught by the chemistry teacher was selected and the researcher prepared lesson plans for the sub-topics and incorporated FAST feedback methods in the teaching processes (Appendix G-L). In this method, the researcher posed a problem, went round to see if all students were working, tried to identify students with unexpected answers, called the person to explain whilst the other students compared their answers, the researcher presented briefly one or two frequently occurring errors and explained, and then moved on to the next step.

Phase 7: Administration of post intervention tests: In the course of the classroom discourses, and after every lesson, the researcher administered to the student participants some tests (Appendix P) through worksheets. The aim was to find out the performance of students as to whether the approach used (FAST feedback method) in teaching had enhanced their understanding or learning. In addition, a probe into the classroom discourse between the researcher and the students triangulated study.

Summary of Data Sources: In order to generate data to address each of the research questions for the study, various data sources were employed and these are presented in Table 7.

Table 7 Data Sources Related to the Research Questions

Data sources	RQ1	RQ2	RQ3	RQ4	RQ5
Teacher questionnaire	√	√	√	√	
Student questionnaire	√	√	√	√	
Teacher interviews	√	√	√	√	
Observation schedules	√	√	√	√	
Students' worksheets					√
Probe into classroom discourse					√

3.10 Ethical Issues

Teachers and student participants were assured of anonymity and so they were not asked to indicate their names or schools on the questionnaires or the interview protocols. They were also not asked to declare their identity on the worksheets.

3.10.1 Pre-intervention Survey

Permission and interest were sought from the headmaster/headmistress in each of the senior high schools which were sampled. A written guarantee of privacy and confidentiality was provided. Cooperating science teachers were also informed of the nature of the study and the data being sought. Students were told that their perceptions about how their science teachers give feedback were being sought. Teachers were asked to respond to questions similar to that of the students. The surveys were conducted with little disruption to the normal class routine as possible. Data were collected by the researcher only, thus, eliminating access or handling by other parties. Students were assured of anonymity. In this respect codes were assigned to the respondents. Data from the schools were also coded in such a way as to protect each school's anonymity. The chemistry teachers from the participating schools were assured of feedback if they so desired.

3.10.2 The Intervention

The case study involved 70 students of a class, 1G of the science department of Yilo Krobo senior high school who were selected with the assistance of the chemistry teacher in the school. These comprised 27 females and 43 males who offered chemistry, mathematics, physics, biology or agricultural science as their elective subjects and were classified as students offering science programme or agricultural science programme. Student participants were given some worksheets to respond to determine their level of understanding in chemical bonding. In all, five worksheets were given to the students' either during or after every lesson. Students were also given the chance to give verbal responses to questions by the researcher and also to demonstrate on the class white board their understanding of certain concepts. These were used to determine the effects of FAST feedback method on chemistry learning.

3.10.3 Activities before Classroom Discourse

The topic "chemical bonding" was broken down into five subtopics and lesson notes were prepared and used to teach the students. Worksheets were given to students during the classroom discourse or after the classroom discourse to respond to. These were used to collect data. The topic "chemical bonding" was chosen from the WAEC syllabus for senior high schools in Ghana with the assistance of the chemistry teacher who declared it as the topic to be taught in that class. The sub-topics which were used as the main topics for each lesson were, ionic bonding, covalent bonding, metallic bonding, Van der Waals forces and hydrogen bonding. Six worksheets (appendices L-Q) were also prepared alongside and were given to students to respond to during and after classroom interaction. Materials necessary to enhance students understanding were also made available for instance, a chart of the periodic table. Several discussions were held with the chemistry teacher and students before the lessons. The questions posed by the researcher and responses by the students orally during the classroom interaction were recorded verbatim.

3.10.4 Classroom Discourse

Throughout the five lessons, the procedure for FAST feedback method was incorporated to ensure maximum learning of students.

3.10.4.1 Steps of the FAST feedback method

Van Den Berg and Hoekzema (2006) and Ramsden (1992) enumerated the steps of FAST feedback method as follows: Teacher poses a problem on the board. Students start to respond by drawing or writing. Teacher checks whether everybody is at work and acts. If not teacher goes around to see some solutions in say thirty seconds. Teacher asks a student with an unexpected answer to explain (individually). Meanwhile other students will spontaneously start to compare answers (Peer Teaching). Teacher presents briefly one or two frequently occurring errors and explains (Plenary) on the board. Teacher presents the next problem. Teacher goes round.

3.11 Pilot Study

A pilot study was conducted prior to the familiarization visits to test the appropriateness and effectiveness of the instruments. The questionnaire, interview protocol, and observation schedule, were used as the main instruments for data collection. The pilot study was conducted in four senior high schools in the Eastern Region of Ghana. Both teachers and students provided responses to the questionnaire. Chemistry teachers responded to the interview protocol. This took about 20 to 30 minutes. These were followed by the observation schedules thus, exercise books observation and classroom lessons observation.

3.12 Validity and Reliability of the Instruments

In determining the validity of the instruments, the questionnaire, interview protocol and the observation schedule were given to experts in science education, who had undertaken research involving classroom studies to examine them. Modifications were made based on their suggestions before piloting the instruments. The reliability of the instruments was determined after the pilot study. The chronbach alpha values obtained from students' responses to the instruments during the pilot study with respect to the attributes frequent accurate, specific and timely were 0.946, 0.851, 0.902, and 0.949 respectively. Also alpha values obtained from chemistry teachers responses to the questionnaire of their own feedback to their students were, 0.941, 0.980, 0.980 and 0.949 respectively for frequent, accurate, specific and timely feedback. These were all above 0.75 and are therefore reliable. According to Borg, Gall and Gall (1993), Coefficient of reliability values above 0.75 are considered reliable.

3.13 Method of Data Analysis

The instruments used to obtain the quantitative results on the various attributes of FAST feedback were the questionnaires for both teachers' and students'. These questionnaires are presented in Appendices B and C respectively for the pre-intervention survey. Each of the pre-intervention survey questionnaires contained 22 Items tailored to answer research questions one to four. The Items in the questionnaire for teachers were similar to the Items in the questionnaire for the students to allow for comparison of their responses. All the Items in the questionnaires were written based on the attributes of FAST feedback.

Data obtained from the pre-intervention responses from the participants were presented in tabular forms. Respondents were to choose from a Likert type scale of very frequent, frequent and rarely for the attribute, *frequent feedback*; very accurate, accurate and rarely for the attribute *accurate feedback*; very specific, specific and rarely for *specific feedback* and very timely, timely and rarely for the attribute *timely feedback*. In order to compile a table of results, the response categories were assigned values 3, 2 and 1 in the descending order for each of the attributes. Thus for instance, very frequent was assigned the value of 3, frequent, 2 and rarely 1. In order to determine the internal reliability of the instrument, Chronbach's alpha values were calculated for each Item. According to Borg, Gall and Gall (1993), Coefficient of reliability values above 0.75 are considered reliable. All the Items in the research had alpha values above 0.75 and thus the instruments used were considered to have strong internal reliability. The various statistical values of the responses were determined using SPSS.

The data collected were analysed by first determining the frequency of responses to each Item in the questionnaire. The means, standard deviation and cronbach alpha of the Items for each of the attributes were also determined. The correlation coefficient for the attributes were computed and these were used to draw the path analysis model for both teachers and student's responses. The relationship between the students' responses and that of their respective science teachers about the existing styles by which the teachers give feedback to their students were also established. The results of the teachers' interviews and the observation schedules triangulated the quantitative data for the pre-intervention activities. The post-intervention worksheets and the probe into the classroom discourses also provided answer to research question five.

For the sake of anonymity, participating schools were identified by letters and the responses were put together as a representation of the sample population. Responses from teachers from the various schools with respect to the interview protocol and the observation schedules were interpreted qualitatively. The results which were obtained from the classroom discourse between the researcher and the participating students were used to determine the effectiveness of the approach to teaching. Scores of students from the exercises and class tests proved the strength of the FAST feedback methods to teaching.

3.14 Chapter Summary

The study was designed to investigate and describe the status and quality of feedback given by teachers in chemistry classrooms in senior high schools in Ghana. This was done with the view of generating data for actual and ideal pictures of the feedback that chemistry teachers give and to make recommendations for closing the gap between the actual and ideal. The research design was based on that developed by Goodman, Hackling and Rennie (2001) for an Australian study. Data for actual feedback given by teachers in chemistry classrooms were generated using teacher and student survey questionnaires, teacher interviews, and observation schedules. Data for an ideal picture (FAST feedback) in chemistry classrooms were generated using the worksheets, and probe into classroom discourses.

Data generated from the questionnaires and the worksheets were coded and analysed using descriptive statistics while data obtained from, interviews, observation schedules and probe into classroom discourses were analysed qualitatively for emerging themes.

4.0 DATA ANALYSIS

In this chapter, data obtained from the responses of students and teachers are presented and analysed with respect to the attributes of FAST feedback and the research questions. Quantitative data of the responses to the Items in the questionnaires of students and teachers as well as students' worksheets have been presented in tabular forms. Qualitative responses by teachers to the interview questions were presented under emerging themes. Observations made out of students' exercise books and classroom discourses provided triangulation to the study. The results are also presented under pre-intervention data and post-intervention data. Pre-intervention data covered the responses from the teachers and students' questionnaires, the teachers' interview protocols and the observation schedules. The post-intervention data were taken from the responses to the worksheets and probe to the classroom discourses.

4.1 Demographic Data

The pre-intervention investigations were conducted in twenty SHS in the Eastern Region of Ghana which were single-sexed or co-educational; rural or urban. Teachers who teach and students who studied chemistry participated. The data on the categories of schools and participants are shown in terms of frequency in Table 8.

Table 8 - Categories of Schools and Participants. (n=815)

School Type	*School Location*				
	Rural		*Urban*		
	Males	Females	Males	Females	Total
Students Co-educational	85	55	175	80	395
Students Boys Only	-	-	240	-	240
Students Girls Only	-	-	-	160	160
Teachers Co-educational	4	1	9	3	17
Teachers single-sexed	-	-	2	1	3
Total Participants	89	56	426	244	815

From Table 8, students who participated from co-educational institutions were 395 representing 48.5% of the total participants for the study. This was made up of 85 (10.4%) males and 55 (6.7%) females from rural schools and 175 (21.5%) males and 80 (9.8%) females also from urban schools. Single-sexed male schools had 240 (29.45%) students and single-sexed female schools had 160 (19.6%) student-participants. Altogether, the number of student participants in the pre-intervention survey (PIS) was 795 (97.55%). Teachers who participated in the study were 20 (2.45%) out of which 17 (2.08%) came from co-educational institutions and three (0.4%) came from rural schools.

Schools from rural areas which participated in the study were all co-educational. The number of students who took part in the intervention study was 70 comprising 27 females and 43 males drawn from Yilo Krobo SHS in Somanya in the Eastern Region of Ghana which brought the total sample size to 885 *(n = 885).* These students offered chemistry, mathematics, physics, biology or agricultural science as elective subjects and were classified as students offering science programme or agricultural science programme.

Demographic Survey Result (DSR): Key Finding 1

A total of 885 participants took part in the study. Out of this, 815 comprising 795 students and 20 teachers from co-educational, single-sexed as well as rural and urban institutions participated in the pre-intervention study. None of the rural schools was single sexed. Both sexes of teachers were in all the schools that participated. The intervention exercise involved 70 first year chemistry students from Yilo Krobo SHS.

4.2 Personal Details of Teacher Participants

Details of teacher-participants have been analysed in terms of teaching experience, subject specialization and highest qualification and have been presented in Table 9.

Table 9 - Details of Teacher Participants

Teaching Experience(years)	*Subject Specialisation*	*Highest Qualification*
5 and above	Chemistry (12)	BSc; PGDE (Chem) 5 B Ed (Chem) 7
4-5	Physics (2)	B Sc (Phy) 1 B Ed (Phy) 1

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

3-4	Biology (2)	B Sc (Bio) 1 B Ed (Bio) 1
2-3	Agricultural science (4)	BSc (Agric. Sc.) 1 B Ed (Agric) 1
1-2	Mathematics (1)	B Sc (Math) 1
1	Engineering (1)	B Sc (Eng) 1

From Table 9, Out of the 20 teacher participants 12 studied chemistry and eight studied biology, physics, agricultural science, mathematics, or engineering. The first 12 teachers were trained and certified as teachers of chemistry. Five out of these seven teachers, first trained only in Content Knowledge (CK) and later studied for the Post Graduate Diploma in Education (PGDE) which equipped them in the skills of teaching. The other seven studied both Content Knowledge (CK) and Pedagogical Knowledge (PK) alongside (B Ed). Whereas these 12 professional chemistry teachers had taught for a period of five years or more, the eight non-professional chemistry teachers had teaching experiences of between one and five years.

DSR: Key Finding 2

Most of the teachers were professionally trained chemistry teachers who had been teaching for five or more years.

4.2 Pre-intervention Survey Results (PISR)

The pre-intervention results covered the responses by 795 students' and 20 teachers to the questionnaires on FAST feedback. Teachers' responses to the interview questions and the results of observation schedules A and B, provided triangulation to the study.

4.2.1 Research Question 1: How often do the chemistry teachers give feedback to their students?

Students and teacher's responses to the questionnaire, teacher's responses to the interview protocol and the observation schedules with the checklist in respect of frequent feedback provided answers to this research question.

42.1.1 Students' Response to Questionnaire on Frequent feedback

Items F1-F8 of the questionnaire (Appendix C) required students to provide responses to Items on frequent feedback. If students strongly agreed with the Item, they were to tick against *very frequent*, agreed with the Item, *frequent*; and not sure, *rarely*. The responses have been analysed in terms of frequencies, means, SD and Cronbach's alpha and presented as Table 10.

Table 10 - Students' Response to Items on Frequent feedback (n=795)

Items	*Very Freq.*	*Freq.*	*Rarely*	*Mean*	*SD*	*CA*
F4. Teacher often responds to questions students' ask in class	98(12.3)	160(20.1)	537(67.5)	1.50	1.28	0.948
F7. Teacher often ask questions in class	65(8.2)	30(3.8)	700(88.1)	1.50	1.02	0.947
F6. Teacher often give class exercises	55(6.9)	30(3.8)	710(89.3)	1.18	0.93	0.953
F1. Teacher often write comments as he marks	20(2.5)	75(9.4)	700(88.1)	1.15	0.75	0.954

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

F3. Teacher often returns class test weekly	0(0)	50(6.3)	745(93.7)	1.13	0.93	0.936
F2. Rate at which teacher return assignments is once a week	0(0)	85(10.)	710(89.3)	1.12	0.67	0.952
F5. Teacher often discuss exercises after marking.	20(2.5)	15(1.9)	760(95.6)	1.03	0.72	0.941
F8. Teacher often go round to correct what students do wrongly.	20(2.5)	15(1.9)	760(95.6)	1.03	0.92	0.935

Note: Figures in brackets are the respective percentages. The Items are ranked by decreasing order of means. Standard deviation =SD. Chronbach's alpha for the seven Items= 0.941. Overall Mean = 1.30

From Table 10, about two-third (68 %) of the respondents disagreed with Item F4 that their teachers responded to their questions in class. For Item F7 over 88 % of respondents disagreed that their teacher often asked questions in class while for Item F6, over 89 % of respondents disagreed that their teacher often gave class exercises. Similarly, for Item F1, a little over 88% disagreed that the feedback their teachers frequently write comments as they mark their work. Whereas, for Item F3 almost 94% disagreed that their teachers often return class tests weekly, 89% disagreed that the rate at which teacher return assignments to students is once a week in Item F2. Again, for Item F5, 96% disagreed that their teachers discuss their exercises with them after marking and finally, for Item F8, 96% again disagreed that their teachers often go round to correct what students do in class. The overall Cronbach's alpha value for the Items was 0.941, indicating the reliability of the Items for the respondents. Also an overall mean of 1.30 indicates that the respondents did not agree that their chemistry teachers' feedback were frequent.

PISR: Key Finding 3

Majority of the student-respondents indicated that they disagreed with the statement that their teachers gave frequent feedback. (Overall means of the Items was 1.30).

42.1.2 Teachers' Response to Questionnaire on Frequent feedback

Items F1-F8 of the questionnaire (Appendix B) required teachers to provide responses for the attribute frequent feedback. If teachers strongly agreed with the Item, they were to tick against *very frequent*; agreed with the Item, *frequent*; and not sure, *rarely*. Teachers' responses were analysed in terms of frequency, percentages, means, standard deviations and Cronbach's alpha and presented in Table 11.

Table 11 - Teacher self-ratings of Items on Frequent feedback (n=20)

Items	*Very Freq*	*Freq.*	*Rarely*	*Mean*	*SD*	*CA*
F4. I often respond to questions students ask	15(75)	0(0)	5(25)	2.50	1.00	0.945
F5. I often discuss exercises after marking.	15(75)	0(0)	5(25)	2.50	1.00	0.950
F6. I often give class exercises	10(50)	10(50)	0(0)	2.50	0.58	0.953
F7. I often ask questions in class	10(50)	5(25)	5(25)	2.25	0.96	0.946
F1. I often write comments as I mark	5(25)	10(50.0)	5(25)	2.00	0.58	0.941
F2. I return assignments once a week.	0(0)	10(50)	10(50)	1.50	0.96	0.937

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

F3. The rate I return class tests is once a week	1(5)	10(50)	17(45)	1.20	0.44	0.952
F8. I often go round to correct what students do	0(0)	0(0)	20(100)	1.00	0.42	0.948

Note: Figures in brackets are the respective percentages. The Items are ranked by decreasing order of means. Standard Deviation =SD. Cronbach's alpha (CA) for the seven Items= 0.946. Overall Mean = 1.90

From Table 11, majority of the teachers (75%) recorded that they frequently respond to questions asked by students and also discuss exercises with students after marking. Again 60% of them recorded that they frequently give class exercises and 55% recorded that they often write comments on exercises as they mark. Whereas 75% of the teachers recorded that they often give more than four feedbacks in a lesson, 50% recorded that they often give students take-home assignments. Also 55% of the teachers indicated that they often go round to correct what students are doing and finally all the teachers (100%) recorded that they disagree with the statement that, the rate teachers return marked class test is once a week. The overall Cronbach's alpha value for the Items was 0.946, indicating the reliability of the Items for the respondents. Also an overall mean of 1.90 indicates that the teacher-respondents give frequent feedback to their students during classroom discourse.

PISR: Key Finding 4

Most of the teacher-respondents recorded that they gave feedback frequently to their students during classroom discourse (overall mean= 1.90).

4.2.1.3 Teachers' Responses to Interview Protocol on frequent feedback

The views of the teacher-participants across the group with respect to the attribute, frequent feedback (Appendix R) have been synthesised into themes under categories in relation to the questions and have been presented in Table 12.

Table12. - Teachers responses to Interview Questions (1-8;n=20)

Category	*N*	*Percentage of respondent*
Frequency of teachers questions in class		
Ask questions throughout classroom discourse	7	35
Unable to ask a lot of questions in class	13	65
On the average two questions per lesson	9	45
Teacher's responses to students questions		
Immediately students ask questions	9	45
During remediation all questions are answered	12	60
On the average two questions are responded to	14	70
Frequency of class exercises		
In course of the lessons	8	40
At the end of every lesson	12	60
About two in a term	14	70
Going round to correct students' mistakes		
Always go round to see students' work	7	35
Occasionally go round the class	6	30
Correct students' mistakes at plenary so do not go round the class	15	75
Frequency of take-home assignments		
Averagely two take-home assignments per term	14	70
Students study their notes so no home work	9	45
Writing of comments as teacher marks along		

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

Teacher writes no comments	15	75
Teacher writes grade or scores obtained	17	85

Table 12: continued

Category	*N*	*Percentage of respondents*
Discussion of class exercises after marking		
Do not discuss exercises after marking	12	60
Have plenary session to discuss common errors	8	40
Factors inhibiting frequent feedback by teachers		
large class size	20	100
broad nature of the curriculum	7	35
lack of appropriate teaching skills	10	50
lack of in-service training	7	35
out-of-field teachers	8	40
negative attitudes of some teachers	13	65
lack of motivation	12	60

It is clear from Table 12 that majority of the teachers (65%) are not able to ask questions and 45% averagely ask two questions during lessons. Only 35% of the respondents recorded that they ask questions throughout the lesson. Also only 45% of the teachers responded to student's questions immediately and 60% responded to all questions asked by students during remediation (extra lessons for those who need help) whilst 70% averagely responded to two questions per lesson. Whereas only 40% of the teachers give class exercises as lessons progress, 60% give exercises at the end of a lesson and 70% give two exercises every term. Whilst 35% of the teachers go round the class, only 30% occasionally go round to see students work and the majority (75%) do not go round at all because they correct students' misconceptions at plenary session. Again, most of the teachers (70%) recorded that they give on the average two take-home assignments per term to students and 30% do not give any take-home assignments because students have notes to read.

Whereas 75% of the teachers did not write any comments against student's work, 85% wrote scores or grades to indicate students' performance level when they marked. Similarly, a high of 60% do not discuss with students their work after marking but 40% discuss common errors at plenary session. Finally, teachers recorded most of the teachers recorded the following as factors militating against their ability to give frequent feedback: Large class size (100%); broad nature of the curriculum (35%); lack of appropriate teaching skills (50%); lack of in-service training (35%); out-of-field teachers (40%); negative attitudes of some teachers (65%); lack of motivation (60%). The themes that emerged are: immediate feedback and remediation, oral and written feedback, feedback during classroom discourse, after-class feedback and factors militating against frequent feedback.

PISR: Key Finding 5

> Majority of the teacher-participants indicated that their inability to give feedback frequently to their students are due to large class size, broad nature of the curriculum, lack of teaching skills, lack of in-service training, out-of-field teachers, negative attitudes of some teachers (lateness to class, absenteeism) and lack of motivation.

4.2.1.4 Observation of Exercise Books for Frequent Feedback

In support of the teachers' responses to the questionnaire and the interview protocol, students' exercise books were observed. The details of the schools and the number of exercises done and marked have been analysed and presented as Table 13.

Table 13: Schools and the number of exercises done and marked

No. of schools	Number of exercises done	No. of exercises marked
2	6	6
6	5	3
7	3	2
3	2	Nil
1	1	Nil
1	Nil	Nil

Total number of schools = 20: Total number of exercises done = 17; Total number of exercises marked=11; Average number of exercises = 0.85; Average number of exercises marked = 0.55

From Table 13, only two schools did a maximum of six exercises and marked all of them. Thus on the average, students were given two exercises per term. Six schools did five exercises out of which only three were marked and seven schools did three exercises out of which two were marked. Again three schools did two exercises and none of them was marked. Whilst one school did only one exercise which was not marked, another school did no exercise.

PISR: Key Finding 6

> On the average, very few exercises' (0.85, maximum, one) were done for the three terms by the participating schools. The exercises were partly marked (0.55).

4.2.1.5 Observation of Lessons for Frequent Feedback

The observed lessons again confirmed teachers' responses to the interview protocol and partly to the responses to the questionnaire; "that, teachers asked very few questions and responded to only few of the questions asked by students." Also only one teacher out of the 20 teachers gave students exercises to do as the lesson developed. This exercise was however not marked nor seen by the teacher.

PISR: Key Finding 7

> Most of the teachers asked very few questions and responded to few of students questions The only exercise given to students during classroom discourse was also not marked nor seen by the teacher-participants.

4.2 2 Research Question 2: How accurate are the feedbacks giving by chemistry teachers to their students? Students and teacher's responses to the questionnaire, teachers' responses to the interview protocol and the observation schedules with the checklist in respect of accurate feedback provided answers to this research question.

4.2.2.1 Students Response' to questionnaire on Accurate feedback

Item statements A9-A12 from the questionnaire (Appendix C) required students to provide responses in respect of the attribute accurate feedback. If Students strongly agreed with the Item they were to tick against *very accurate* if they agreed, *accurate* and not sure, *rarely*. Students' responses have been analysed in terms of frequency, percentages, means, standard deviations and Chronbach's alpha and presented in Table 14.

Table 14 - Students Ratings of Items to the attribute, Accurate feedback (n=795)

Items	*Very Acc.*	*Accurate*	*Rarely*	*M*	*SD*	*CA*
A10. Teacher gives us exact examples of what is demanded.	55(6.9)	90(11.3)	650(81.8)	1.25	0.96	0.978
A9. Teacher's feedback directs us to do appropriate corrections.	45(5.7)	100(12.5)	650(81.8)	1.24	0.98	0.982
A11. Teacher's feedback describes exact work students present.	45(5.7)	35(4.4)	715(89.9)	1.16	0.92	0.980
A12.Teacher's feedback enable us to understand what went wrong with our work	50(6.3)	20(2.5)	725(91.2)	1.15	0.89	0.980

Note: Figures in brackets are percentages. The Items are ranked by decreasing order of means. Standard Deviation =SD. Cronbach's alpha for the Items= 0.980 Overall mean = 1.20

From Table 14, about 82% of the students disagreed that their teachers give exact examples of what they demand. Also the same number of students (82%) disagreed that their teachers' feedback directs them to do appropriate corrections. Again about 90% of the students disagreed that their teachers' feedback describes exact work students present whilst about 91% of the students also disagreed that their teachers' feedback enable them to understand what went wrong with their work. The overall Chronbach's alpha value for the Items was 0.980, indicating the reliability of the Items for the respondents. Also an overall mean of 1.20 indicates that the respondents did not agree that their chemistry teachers' feedback were accurate

PISR: Key Finding 8

Student-respondents recorded that feedback given to them during classroom discourse are not accurate (overall mean = 1.20).

4.2.2.2 Teachers' Response to Questionnaire on Accurate feedback

Items A9-A12 of the questionnaire (Appendix B) required teachers to provide responses to Items on accurate feedback. If teachers strongly agreed with the Item they were to tick against *very accurate*, agree, *accurate* and not sure, *rarely*. Teachers' responses have been analysed in terms of frequencies, means, and SD and Cronbach's alpha and presented in Table 15.

Table 15 Teachers Self-ratings of the attribute Accurate Feedback (n=20)

Items	*Very Accurate*	*Accu.*	*Rarely*	*Mean*	*SD*	*CA*
A10. I give students exact examples of what is demanded	15(75)	5(25)	0(0)	2.75	0.50	0.851

A9. My feedback direct students to do appropriate corrections	10(50)	10(50)	0(0)	2.50	0.58	0.850
A11.My feedback describes exact work students present.	15(75)	0(0)	5(25)	1.20	1.50	0.851
A12. Feedback I give enable students to understand what went wrong with their work	5(25)	10(50)	5 (25)	1.20	0.82	0.852

Note: Figures in brackets are the respective percentages. The Items are ranked by decreasing order of means. Standard Deviation =SD. Cronbach's alpha (CA) for all the Items= 0.851. Overall Mean = 1.91

From Table 15, majority of the students (75%) recorded that they give students exact examples of what is demanded whilst all the teachers (100%) recorded that their feedback direct students to do appropriate corrections. Again, 75% of the teachers recorded that their feedback describes the exact work students present in their exercise books. Finally, 75% of the teachers indicated that their feedback enables students to understand what went wrong with their work. The overall Cronbach's alpha value for the Items was 0.851 indicating the reliability of the Items for the respondents. Also an overall mean of 1.91 indicates that the teachers' agreed that their feedback were accurate.

PISR: Key Finding 9 - Teachers' Responses to Interview questions (accurate feedback)

> Majority of the teachers recorded that the feedback they gave to students are accurate
>
> (overall mean= 1.91).

42.2.3 Teachers' Responses to Interview Protocol on Accurate Feedback

The views of the teacher-participants across the group with respect to the attribute, accurate feedback (Appendix R) have been synthesized into themes under categories in relation to the questions, have been presented as Table 16.

Table 16 Teachers responses to Interview Questions on Accurate Feedback (9-12; n=20)

Category	*N*	*Percentage of respondent*
Feedback direct students to do corrections		
Accurate feedback helps to identify errors	9	45
Unfair, biased and inaccurate feedback do not help students to do corrections	12	60
Feedback provides exact examples		
Give exact examples to help students	9	45
Reframe questions which are not clear to students	11	55
Feedback presents exact work of students		
Halo effect sometimes limits fairness	10	50
Too much work load hinders teachers fairness	10	50
Common Errors and plenary session		
Occasionally go round the class	8	40
Correct students' mistakes at plenary so do not go round the class	12	60

From Table 16, about 45% of the teachers stated that accurate feedback enables students to correct their mistakes. Also 60% of the teachers recorded that when they give fair, unbiased and accurate feedback students are able to correct their mistakes. Again 45% of the teachers recorded that they give exact examples to help students understand what they teach whilst 55% stated that they reframe their questions to make it clear to their students. Whereas 50% of the teachers recorded that halo effect

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sometimes makes them biased towards some students, 50% also recorded that, too much work load hinders their desire to be fair. Some of the teachers indicated that they occasionally go round the class to inspect students work and 60% recorded that when they discover common errors among students work, they discuss at plenary. The themes that emerged are: fair, unbiased and accurate feedback; ambiguity and reframing of questions; work load and halo effect; common errors and plenary session.

PISR: Key Finding 10

> Most of the teacher-participants indicated that they sometimes give unfair, biased and inaccurate feedback to their students because of too much work or as a result of halo effect. Majority of the teachers also indicated that they discuss common errors observed among students during plenary session.

4.2.2.4 Observation of Exercise Books for Accurate Feedback

Observation of students' exercise books revealed that, ticks (√) or crosses (x) were used to indicate correct or wrong answers and that positive written feedback were seen. Negative comments observed were poor, crazy, why did you do it this way? No general comments were written to indicate students' performance level and no correction of students' errors in previous exercises had been done.

PISR: Key Finding 11

> All books observed revealed, i) no written positive feedback. ii) Few written negative feedbacks e.g. poor, why did you do it this way, crazy! Could have done better, iii) ticks (√) were used to indicate correct answers and crosses (X) for wrong answers.

4.2.2.5 Observation of Lessons for Accurate Feedback

Teachers failed to reframe their questions to enable students provide right responses e.g. "Which element on the periodic table is hard and shiny?" since many elements exhibit these characteristics, teacher could have given options. Few exercises given to students during classroom interactions were not marked nor seen by the teachers so students did not know the accuracy of their responses.

PISR: Key Finding 12

> Teachers failed to reframe their questions to enable students know the exact responses required. Exercises given during lessons were not seen by the teacher for students to know if their answers were accurate or not.

4.2.3 Research Question 3: To what extent can the feedback given by chemistry teachers be described as specific?

Students and teacher's responses to the questionnaire, teachers' responses to the interview protocol and the observation schedules with the checklist in respect of specific feedback provided answers to this research question.

4.2.3.1 Students' Response to Questionnaire on Specific feedback

Items S13-S17 of the questionnaire (Appendix C) required students to provide responses in respect of specific feedback. If students strongly agreed with the Item, they ticked *very specific*, agreed, *specific* and not sure, *rarely*. Students' responses have been analysed in terms of frequencies, means, standard deviation, alpha values and presented in Table17.

Table 17 Students' ratings of the attribute specific feedback (n=795)

Item	*Very Specific*	*Specific*	*Rarely*	*Mean*	*SD*	*CA*
S15. Teacher's feedback is directed to students'responses	40(5.0)	225(32.1)	530(65.4)	1.38	0.58	0.978
S14. Teacher's feedback is directed to what is done correctly	50(6.3)	200(25.2)	545(68.6)	1.37	1.50	0.980
S13.Teacher's feedback is directed to what is not done correctly	95(11.9)	50(6.3)	650(81.8)	1.30	0.50	0.979
S16. Teacher's feedback provide answers to omissions	55(6.9)	35(4.4)	705(88.7)	1.18	0.95	0.982
S17.Teacher's feedback provide correct answers to wrong responses	50 (6.3)	30(3.8)	715(89.9)	1.16	0.97	0.981

Note: Figures in brackets are the respective percentages. The Items are ranked by decreasing order of means. Standard Deviation =SD. Cronbach's alpha for all the Items= 0.980. Mean of means = 1.28

From Table 17, about 65% of the students disagreed that their teachers' feedback is directed toward students' responses and about 69% also disagreed that their teachers' feedback is directed toward what students do correctly. Also about 82% disagreed that their teachers' feedback is directed to what students do not do correctly. Again about 89% of the students disagreed that teacher's feedback provide answers to students' omissions and 90% also disagreed that their teachers' feedback provides correct answers to the wrong responses they make. The overall Cronbach's alpha value for the Items was 0.980, indicating the reliability of the Items. Also an overall mean of 1.28 indicates that the respondents did not agree that their chemistry teachers' feedback were accurate.

PISR: Key Finding 13

Students indicated that their teachers' feedback to them were not specific (overall mean= 1.28).

4.2.3.2 Teachers' Response to Questionnaire on Specific feedback

Items S13-S17 of the questionnaire (Appendix B) required teachers to provide responses in respect of specific feedback. If teachers strongly agreed with the Item they were to tick against *very specific*, agreed, *specific*, and not sure, *rarely*. Teachers' responses have been analysed in terms of frequencies, mean score, SD and CA values and presented in Table 18.

Table 18 Teachers' Self-Ratings on Specific Feedback (n=20)

Items	*Very Spec.*	*Specific*	*Rarely*	*Mean*	*SD*	*CA*
S13. My feedback is directed to what is not done correctly	10(50)	5(25)	5(25)	2.25	0.50	0.903
S15. My feedback is directed to students' responses	10(50)	5(25)	5(25)	2.25	0.96	0.901
S14. My feedback is directed to what is done correctly	10(50)	5(25)	5(25)	2.25	0.96	0.899

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

S16. My feedback provide answers to omissions	10(50)	0(0)	10(50)	2.00	0.50	0.903
S17. My feedback provide correct answers to wrong responses	0(0)	10(50)	10(50)	1.10	0.58	0.902

Note: Figures in brackets are the respective percentages. The Items are ranked by decreasing order of means. Standard Deviation =SD. Cronbach's alpha (CA) for the Items= 0.902. Overall mean = 1.97

From Table 18, majority of the teachers' (75%) recorded that their feedback to students are directed towards what students do not do correctly and also their feedback provide correct answers to students' omissions. Similarly, 75% of the teachers indicated that their feedback to students is directed toward students' responses in class. Also 55% of the teachers indicated that their feedback is directed toward students' responses in class and 50% indicated that their feedback is directed towards what is done correctly. The overall Cronbach's alpha value for the Items was 0.902, indicating the reliability of the Items for the respondents. Also an overall mean of 1.97 indicates that feedback from chemistry teachers to their students is specific.

PISR: Key Finding 14

Majority of the teachers recorded that their feedback to students are specific. (Overall mean = 1.97).

4.2.3.3 Teachers' Responses to Interview Protocol on Specific Feedback

The views of the teacher-participants across the group with respect to the attribute, specific feedback (Appendix R) have been synthesised into themes under categories in relation to the questions, have been presented as Table 19.

Table19. Teachers responses to Interview Questions on Specific feedback (13-17; n=20)

Category	*N*	*Percentage of respondent*
Feedback on what students don't do correctly		
Use crosses to indicate what is not correct	13	65
Use of pre-determined criteria	12	60
Feedback on what students do correctly		
Use ticks to indicate what is correct	9	45
Use of pre-determined criteria	11	55
Feedback directed towards students' omissions		
Let students know if they are right or wrong	10	50
Yes, feedback is towards students omissions	10	50
Specific period, area and place of feedback		
Feedback given at specific period and place	8	40
Feedback given at specific period and area	12	60

From Table 19, it is clear that majority of the teachers (65%) use cross (x) to indicate wrong answers by students. Also most of them (60%) indicated that the use of pre-determined criteria can help teachers to be unbiased and so give accurate feedback to students. About 45% of the teachers said they use ticks to indicate correct answers by students. Whereas 50% of the teachers do let students know whether their answers to questions are right or wrong 50% also recorded that their feedback direct students to what they omit.

Finally, most of the teachers (60%) recorded that special feedback should be given at specific places to avoid embarrassment whereas 40% of the teachers also indicated that some feedback must be given at a specific period and specific areas of the topics being taught may also need some feedback. Emerging themes arising out of the interviews include predetermined criteria; mastery of subject matter and specific feedback; motivation and general discussions, specific period and place of feedback.

PISR: Key Finding 15

Most teachers recorded that the use of predetermined criteria in marking students work eliminates biases and halo effect but they fall short. Teachers with good knowledge of subject matter are able to give specific feedback to students. Teachers are not motivated enough to give their best. Negative feedback affects students' and must be done in isolation and at specific time and place.

4.2.3.4 Observation of Exercise Books for Specific feedback

It was observed from student's exercise books that marked exercises were not graded but had scores made out of the total score. No specific comment was written against wrong answers provided by students. The only written comment observed was, "you could have done better than this." Students therefore could not tell what is wrong with the answers they had provided to the questions in their exercise books.

PISR: Key Finding 16

Exercises were scored out of the total but not graded. No specific comments were written for students to know what was wrong with their responses

4.2.3.5 Observation of Lessons for Specific feedback

Teachers did not involve students in specific topics which called for specific approach and activities e.g. preparation of molar solutions. Certain remarks by some teachers should not have been given e.g. "a primary six children even know this". Some ambiguous questions were not clarified.

PISR: Key Finding 17

Most of the teachers asked ambiguous questions but failed to clarify them. Teachers

failed to involve students in some lessons that called for specific activities.

3.2.4 Research Question 4: How timely is the chemistry teachers' feedback to their students?

Students and teachers responses to the questionnaire, teachers responses to the interview protocol and the observation schedules with the checklist in respect of timely feedback provided answers to this research question.

4.2.4.1 Students' Response to Questionnaire on Timely feedback

Items T18-T22 of the questionnaire (Appendix C) required students to provide responses to timely feedback. Students' responses have been analysed in terms of frequencies, mean score, standard deviation and Chronbach's alpha values and presented in Table 20.

Table 20 Students' Ratings on Timely feedback (n=795)

Items	*Very Timely*	*Timely*	*Rarely*	*M*	*SD*	*CA*
T19.Teacher promptly reacts to responses in class	57(7.2)	93(11.7)	645(81.1)	1.26	1.13	0.950

T22.Teacher goes round during lessons to help	65(8.2)	60(7.6)	670(84.3)	1.24	1.01	0.951
T20.Teacher returns marked assignments a week after submission	55(6.9)	60(7.6)	680(85.5)	1.21	0.97	0.947
T18.Teacher stays longer with students' in need	45(5.7)	25(3.1)	725(91.2)	1.15	0.97	0.948
T21.Teacher returns marked assignments at every other lesson.	5(0.6)	20(2.5)	770(96.9)	1.01	0.89	0.949

Note: Figures in brackets are in percentages. The Items are ranked by decreasing order of means. Standard Deviation =SD. Cronbach's alpha for the Items= 0.949. Mean of means = 1.17

From Table 20, majority of the students (about 81%) disagreed that, their teachers promptly reacts to students' responses. About 84% also disagreed that their teachers go round during lessons to help students in need and about 86% also disagreed that their teachers' return marked assignments a week after submission. Similarly, about 91% of the students disagreed that their teachers stay longer with student' who struggle in class. Finally, 97% of the students disagreed that their teachers' return marked assignments at every other lesson. The overall Cronbach's alpha value for the Items was 0.949, indicating the reliability of the Items for the respondents. Also an overall mean of 1.17 indicates that feedback from chemistry teachers to their students is not timely.

PISR: Key Finding 18

Student-respondents recorded that their teacher's feedback to them during chemistry class are not timely (Overall mean = 1.17).

4.2.4.2 Teachers' Responses to Questionnaire on Timely Feedback

Items T18-T22 of the teachers' questionnaire (Appendix B) required teachers to provide responses in respect of the attribute timely feedback. Teachers' responses have been analysed in terms of frequencies, mean score, standard deviation and Chronbach's alpha values and presented in Table 21.

Table 21 Teachers' Ratings on Timely feedback (n=20)

Items	*Very Timely*	*Timely*	*Rarely*	*Mean*	*SD*	*CA*
T20. I return marked assignments to students a week after submission	2(10)	3(15)	15(75)	1.35	0.50	0.949
T22. I go round to provide to help students who are in need	2(10)	2(10)	16(80)	1.30	1.71	0.950
T19. I react promptly to students' responses	1(5)	3(15)	16(80)	1.25	1.50	0.941
T18. I stay longer with students who struggle in class to help them.	1(5)	1(5)	18(90)	1.15	1.50	0.949
T21. I return assignments every other lesson	0(0)	1(10)	19(90)	1.05	0.50	0.948

Note: Figures in brackets are in percentages. The Items are ranked by decreasing order of means. Standard Deviation =SD. CA for the Items= 0.949. Overall mean=1.22.

From Table 21, most of the teachers (75%) disagreed that they return marked assignments to students a week after submission and 80% disagreed that they go round to help students who are in need. Whereas 80% of the teachers react promptly to students' responses, 90% indicated that they stay longer with students who struggle in class to help them. Finally, 90% of the teachers recorded that they return assignments to students at every other lesson. The overall Cronbach's alpha value for the Items was 0.949, indicating the reliability of the Items for the respondents. Also an overall mean of 1.22 indicates that teachers' feedbacks to their students are not timely.

PISR: Key Finding 19 - Teachers' Responses to Interview Protocol on Timely Feedback

Majority of the teacher-respondents recorded that they do not give timely feedback to their students (overall mean of 1.22).

4.2.4.3 Teachers' Response to Interview Protocol on Timely feedback

The views of the teacher-participants across the group with respect to the attribute, timely feedback (Appendix R) have been synthesised into themes under categories in relation to the questions, have been presented as Table 22

Table 22 - Teachers responses to Interview Questions on Timely feedback (18-22; n=20)

Category	*N*	*Percentage of respondent*
Teacher stays longer with struggling students		
Do not stay longer with struggling students due to co-curricular activities and personal agenda	12	60
As a result of lack of motivation I do not stay to assist struggling students	11	55
Teacher promptly reacts to students' responses		
Immediately react	10	50
Delay negative feedback to students	12	60
Return marked assignments weekly		
Unable to return marked assignments to students every week	10	50
Due to lack of motivation I am not able to mark on time	10	50
Return assignments every other week		
Unable to return marked assignments to students every other week	8	40
Due to my personal job after class I am not able to mark students work	12	60

From Table 22, most of the teachers (60%) indicated that, they do not stay longer to assist students who struggle to understand what is taught in class because they are involved in co-curricular activities as well as their personal activities. Also 55% recorded that they do not go the extra mile to assist students who struggle in class because they are not motivated. Teachers who recorded that they react promptly to student's responses were 50% and those who recorded that they delay giving negative feedback to students were 60%. Whereas 50% of the teachers recorded that they are not able to return marked assignments to students every week, those who recorded that, they are not able to mark on time due to lack of motivation were also 50%.

Finally, 40% of the teachers indicated that, they are not able to return marked assignments to students every other week and 60% also indicated that they are not able to mark students' assignments due to their personal work. Emerging themes include negative feedback; going extra mile for remediation; timely feedback versus delayed feedback; after-class and written feedback.

PISR: Key Finding 20

> Most of the teachers recorded that they do not go the extra mile in staying longer to help needy students due to lack of motivation and also their involvement in co-curricular activities. Also they are not able to mark and return marked assignments after class on time due to their personal activities. Teachers also delay feedback to appropriate time and place if it is negative.

4.2.4.4 Observation of Exercise Books for Timely feedback

Almost all books inspected by the Researcher, had one or two exercises done by students. All exercises were conducted over two months. Very few were marked and some of the exercises did not have dates to indicate how long the exercises were given. Some exercises given in the previous term were still not marked. Teachers never wrote comments to let students know on time what was wrong or correct with their answers.

PISR: Key Finding 21

> Teachers took longer time to conduct class exercises. Teachers do not also have time to mark and write comments to let students know what is right or wrong with the answers they provide to questions in their exercise books.

4.2.4.5 Observation of Lessons for Timely feedback

It was observed from the various lessons that most of the teachers delayed giving feedback to their students in course of the lessons. Questions asked by students for clarification of points were not given prompt responses. A lot of the teachers even refused to tell or give signal as to whether responses by their students were right or wrong.

PISR: Key Finding 22

> Teachers took longer time to respond to student's questions. They also refuse to give a sign of approval or disapproval to enable students know whether their answers were right or wrong.

4.3 Path Analysis of the Attributes of FAST Feedback

Path analysis is a powerful statistical technique that allows for more complicated and realistic models than multiple regressions with its single dependent variable. It can compare different models to determine which one best fits the data. Path analysis can disprove a model that postulates causal relations among variables. In particular, it can examine situations in which there are several final dependent variables and those in which there are "chains" of influence and one variable influences the other variable, which in turn affects another. It determines whether a data is consistent with the model and it is extremely powerful for examining complex models. Path analysis was developed as a method of decomposing correlations into different pieces for interpretation of effects.

4.4 Correlation coefficients among the attributes of FAST feedback

Gardner and Martin (2007) and Jamieson (2004) contend that Likert data is of an ordinal or rank order nature and hence only non-parametric tests will yield valid results. However, Norman (2010) using real scale data found that parametric tests such as Pearson correlation and regression analysis can be used with Likert data without fear of "coming to the wrong conclusion" as Jamieson (2004) puts it. Path coefficients are standardized because they are estimated from correlations (a path regression coefficient is unstandardized). In this study the correlation coefficients describe the strength of the relationship among the attributes of FAST feedback for which Items both students and teachers responded to.

4.4.1 Correlation coefficient for path analysis (students' responses)

The responses by the students to the attributes of FAST feedback have been analysed in terms of correlations and presented as Table 22.

Table 23 Correlation among the Attributes of FAST feedback (students' responses)

Attribute	Frequent	Accurate	Specific	Timely
Frequent	0.000	0.256	-0.396	0.096
Accurate	0.256	0.000	0.558	-0.154
Specific	-0.396	0.558	0.000	0.736
Timely	0.096	-0.154	0.736	0.000

An examination of the simple correlation figures in Table 23 indicates that the relationships between some of the attributes of FAST feedback are weak and others are strong. Where the correlation is less than 0.5 ($r<0.5$) the relationship is weak and where the correlation is greater than 0.5 ($r>0.5$), the relationship is strong. The implication here is that students' perceive the attributes (FAST) of their teachers' feedback in class differently. Thus from Table 23, the relationship between the attributes frequent-accurate, frequent-specific, frequent-timely, and accurate-timely are all weak whilst the relationship between accurate-specific and specific-timely are strongly related.

The pairs of attributes with positive correlation values (frequent-accurate, frequent-timely, accurate-specific, specific-timely), have the tendency of increasing or decreasing together. That is to say students' perception of both attributes are the same. Students for instance think that their chemistry teachers' feedback in class is not accurate enough and so is their thought for specific feedback. Again, students perceive their teachers' feedback is neither accurate nor timely and also their teachers' feedback is neither specific nor timely.

On the contrary, the attributes which correlated negatively (frequent-specific and accurate-timely) show a clear indication that small values of students score of the Items for any of the attributes were associated with comparatively larger values of the other attribute it is paired with or vice versa. For instance, if the frequency of the teachers' feedback is increased, then the specific nature of the feedback will decrease instead. Also, if the frequency of the teachers' feedback is decreased then the feedback will be more specific. Again if the accuracy of feedback increases, then teachers' feedback becomes less timely and vice versa.

4.4.2 Correlation coefficient for path analysis (teachers' responses)

Table 24 also provides the correlation among the various attributes of FAST feedback as shown by the responses of the chemistry teachers to the questionnaire. These values have also been used to draw a path analysis.

Table 24 Correlation among the Attributes of FAST feedback (teachers' responses)

Attribute	Frequent	Accurate	Specific	Timely
Frequent	0.000	0.073	0.846	0.639
Accurate	0.073	0.000	-0.291	-0.291
Specific	0.846	-0.291	0.000	0.602
Timely	0.639	-0.291	0.602	0.000

Table 24 clearly shows that the pairs of attributes which correlated positively were frequent-accurate, frequent-specific frequent-timely, and specific-timely and those that correlated negatively were accurate-specific, and accurate-timely. The implication here is that, for those attributes with positive correlation, a small increase or decrease in any of the attribute of the pair results in a small increase or decrease in the other attribute of the pair. Thus, according to the teachers, their frequent feedback to students is accurate, specific and timely.

The pairs of attributes which correlated negatively did not move together. That is, if one of the paired attributes increases, the other attribute decreases. Thus when the chemistry teacher gives

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

accurate feedback to students, the feedback will not be neither specific nor timely and vice versa. The path model for the teachers' responses to the Items of the various attributes of FAST feedback is represented by Figure 6.

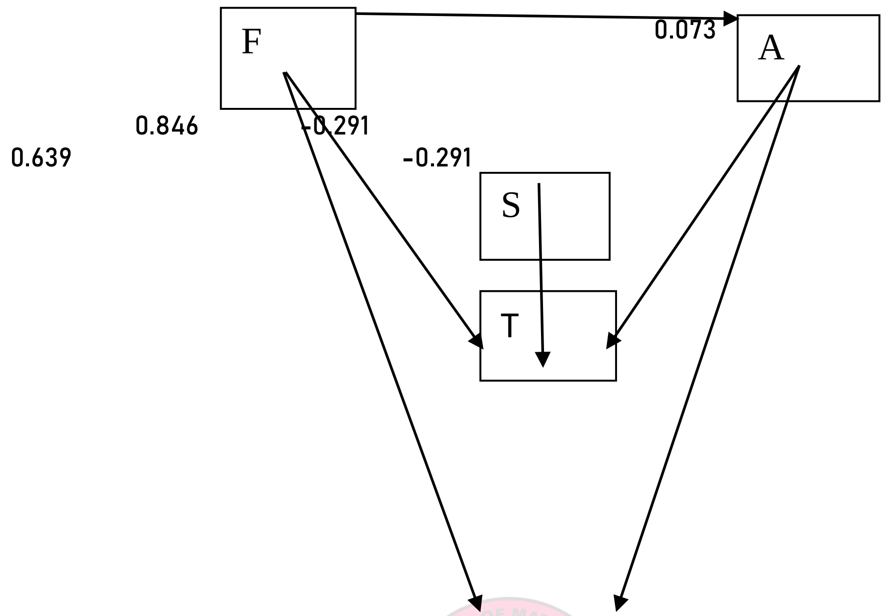

Figure 6: Path Model for FAST feedback- teachers' responses

From Figure 6, it is clear that the attributes of FAST feedback that are weakly correlated (r<0.5) are F-A, F-S, and A-T and the attributes which are strongly correlated (r>0.5) are F-T, A-S and S-T. Also the attributes which are positively correlated are F-A, F-T, A-S, and S-T whilst F-S and A-T are negatively correlated.

4.5 Path Analysis of Teachers and Students Compared

The correlation values obtained for the pairs of the attributes of FAST feedback for both teachers and students have been compared and presented as Table 25.

Table 25: Comparison of the Correlation among FAST

Correlation	*Students*	*Teachers*
Weak r<0.5	F-A; F-S; A-T; F-T	F-A; F-S; A-T
Strong r>0.5	A-S; S-T	A-S; S-T; F-T
Positive	F-A; F-T; A-S; S-T	F-A; F-T; A-S; S-T
Negative	F-S; A-T	F-S; A-T

From Table 25, the nature of the correlation for both teachers and students is almost the same. Where the correlation is weak for the students it is also weak for the teachers (F-A; F-S; A-T) and where it is strong for the students it is also strong for the teachers (A-S; S-T). Again where it is positive for the students it is also positive for the teachers (F-A; F-T; A-S; S-T) and where it is negative for the students it is also negative for the teachers (F-S; A-T).

PIS: Key Finding 23

The result of the path analysis confirms that both students and teachers had almost the same thought about the types of feedback chemistry teachers were providing.

4.6 Intervention and Post-intervention Survey Results (PoISR)

The intervention covered lessons which were taught by the Researcher employing the steps of FAST feedback and making sure that the feedbacks giving to the students during and after classroom discourse were frequent, accurate, specific and timely. The topics covered aspects of chemical bonding found in the curriculum of senior high schools in Ghana. The post intervention survey covered the administration of the worksheets to the students and the probe into the classroom discourse.

4.6.1 Research Question 5: 1. What are the outcomes of FAST feedback method on students' learning of chemical bonding?

This question referred to the data obtained from the intervention survey and the post intervention survey which involved the interaction of the Researcher and 70 first year students of chemistry selected from Yilo Krobo senior high school. The main topic, chemical bonding was taught in five different lessons. Data obtained from the worksheets for every lesson were analysed and presented under Items, number of students who got Items correct and their corresponding percentages.

Lesson One: In determining the previous knowledge of the students about the atom, they were given a test (Appendix L). The scores obtained have been analysed in terms of number of students who got particular Items correct and the respective percentages as presented in Table 26.

Table 26 Work sheet 1: Students Previous Knowledge about the Atom (n=70)

Item	*Respondents who got Items correct*	*Percentage*
Writing of chemical symbols (CS)	48	68.6
Drawing of atomic structures (AS)	35	50.0
Identifying number of shells (NS)	34	48.6
Identifying valence electrons (VE)	19	27.1
Electronic configuration (EC)	14	20.0

Out of the 70 students who responded to the worksheet, 48 (68.6%) were able to write the chemical symbols (CS) of the atoms. Only 35 (50.0%) of the students were able to draw correctly the atomic structures (AS). Also 34 (48.6%) were able to identify the number of shells per atom and 19 (27.1%) were able to identify valence electrons (VE). Finally, 14 (20%) were able to write the electronic configuration (EC) of the atoms.

PoISR: Key Finding 24

A good number of the students had some previous knowledge about the atom. Out of the 70 students 48 were able to indicate chemical symbols of elements and 35 also were able to draw atomic structures correctly whilst 34 identified correctly the number of shells. However, not many of them were able to identify valence electrons nor were they able to write electronic configuration of the given atoms.

4.7 Probe into Researcher-Students Interaction

This probe was designed to elicit from students, their level of understanding of ionic bonding and to ensure FAST feedback delivery during classroom discourse. Students were given a lot of examples (F) of atoms that could combine to form ionic bonds to indicate accurately on the board how they occur (A). Students who asked for clarity of some of the questions were given specific answers (S) to eliminate ambiguity. Prompt feedback to students was given during the interaction (T). Class exercise (worksheet 2) also covered drawing of atoms for each pair of elements given, indicating number of electrons in the valence shells (A) and drawing of arrows to show where the outer electrons would go during chemical reactions (S), and finally drawing the resulting compound. In particular, the probe explored the extent to which students see ionic bonding as a molecular phenomenon (A), with discrete ionic pairs which are internally ionically bonded (S), but attracted to each other by weaker forces. Students were guided to discover for themselves the atoms that could form bonds and also made to draw these atoms as well as the products they eventually formed (F). Students identified the number of electrons that could be found in the valence shells (A). Students also indicated the source where the electrons transferred from (S). Finally, students were taken through how ions could be formed (T).

4.7.1 Responses of students to worksheet on ionic bonding

The results of students' performance on worksheet 2 has been analysed in terms of number of students who got Items correct and the corresponding percentages and presented as Table 27.

Table 27 Students' Performance on Worksheet 2 (n=70)

Item	*Number of respondents who got Item correct*	*Percentage*
Identification of atoms involved in chemical bonding (IA)	65	92.9
Drawing of reactants and Products (RP)	60	85.7
Identification of valence Electrons (VE)	58	82.9
Indication of direction of Electron transfer(DE)	56	80.0
Identification of ions formed in ionic bonds (II)	54	77.1

From Table 27, scores obtained by students were all high. Out of the total number of respondents 65 (92.9%) were able to identify the atoms which could come together to form bonds whilst 60(85.7%) were able to draw the reactants and the products of the pairs of atoms that could form chemical bonds. Whereas 58(82.9%) of the respondents were able to identify the number of electrons in the outermost shells of the atoms (valence electrons), 56 (80%) of the respondents were able to indicate the direction of the electron transfer. Finally, 54 (77.1%) were able to identify the ions which were formed in the process of ionic bond production.

PoISR: Key Finding 25

Most of the students responded appropriately to worksheet 2: Out of the 70 students, 65 identified correctly pairs of atoms of elements that could combine to form ionic bonds whilst 60 drew correctly reactants and products of compounds. Also 58 were able to identify valence electrons whilst 56 were able to indicate the direction of electron transfer. Finally, 54 of the students were able to identify the ions formed as a result of the bond.

4.7.2 Oral Feedback during Classroom Discourse

Throughout the lessons the Researcher employed the FAST feedback approach in giving feedback to students. Students oral responses to questions put across by the Researcher during the classroom discourse were recorded verbatim some of which are as follows:

RQ: How do atoms form bond (A)? SR: atoms are attracted to each other. Something hold atoms and molecules and ions together. RQ: What is that thing that hold atoms, molecules and ions together (S)? SR: magnet, power, energy, force. RQ: Yes, force, but which type of force (S)? SR: magnetic force, electric force, frictional force, gravitational force etc.; RR: It is called electrostatic force of attraction (T). RQ: What happens to atoms before they become attracted to each other (A)? SR: they search for their like, One atom must give another atom something before they can attract each other. RQ: Good and what is that thing called(S)? SR: protons, electrons RQ: Yes, electrons (F). RQ: How can sodium (Na) and chlorine (Cl) form bond then (S)? ; SR: Sodium is in group one and chlorine is in group seven of the periodic table. Group one can add to group seven atoms to form bonds. Na can give its *element* to chlorine. Something then holds them together. RQ: Do atoms give out elements (A)? SR: No. they give out electrons. RR: Good. RQ: What is that thing that holds atoms together to form the compound (S)? SR: It is called electrostatic force (A). RR: Na and Cl can form a bond because Na which has 11 electrons has only one electron in the outermost shell and can easily lose it as compared to chlorine which has 17 electrons and has seven electrons in the outermost shell. Na therefore loses one electron to chlorine and octet rule is obeyed. They are then attracted to each other to form the bond.

PoISR: Key Finding 26

Majority of the students indicated that when an atom loses an electron to another atom to satisfy the octet rule, a bond is established between them.

Lesson Two: Lesson two aimed at using FAST feedback approach to introduce covalent bonding to students. It covered sketches of atoms (F) at the introduction stage and delved into the use of the electron-dot structures to draw compounds formed as a result of bonding (A). Students were also asked to name central atoms and identify shared electron pairs (S). Responses of students which needed feedback were given immediately (T).

4.7.3 Responses of students to worksheet on covalent bonding

Students' responses to Items on worksheet 3 has been analysed in terms of respondents who scored the Items and percentages and presented as Table 28.

Table 28 Students' Performance on Worksheet 3. (n=70)

Items	*Number of respondents who got Item correct*	*Percentage*
Sketch of combination of atoms (CA)	59	84.3
Using electron-dot structures to draw compounds (ED)	58	82.9
Naming of central atoms (NC)	56	80.0
Identification of shared electron pairs (EP)	53	75.7

From Table 28 the number of participants who were able to combine atoms by sketching were 59 (84.3%). This was followed closely by 58 (82.9%) students who were able to draw compounds by the electron-dot structures. Those who were able to name the central atoms were 56 (80.0%) and those who were able to identify shared electron pairs were 53 (75.7%).

PoISR: Key Finding 27

At the end of the lesson, majority of the students were able to respond appropriately to questions in respect of covalent bond. As many as 59 students correctly sketched atoms combining to form bonds and 58 correctly used electron-dot to sketch compounds. Also 56 correctly named central atoms of compounds and 53 identified shared electron pairs in bonding correctly.

Oral feedback during classroom interaction

The Researcher used the FAST feedback method to assist students change some of the misconceptions they hold about covalent bonds. Some of the misconceptions students hold about covalent bonding were revealed during the classroom discourse between researcher and the students and these have been indicated as follows:

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

RQ: Would you say HCl is a covalent or ionic compound (S)? SR: It is ionic bonding. RQ: Why do you say so (A)? SR: While the chlorine atom wants to take an electron to have full outer shell, the hydrogen atom wants to give. So, one electron is transferred from the hydrogen to the chlorine atom. HCl is covalent bond, because it is formed between two nonmetal atoms. They share their electrons. RQ: Is CO2 also a covalent or ionic bond (F)? SR: It is covalent bonding. Both oxygen and carbon atoms need to take electrons. So, they share their electrons with each other. It is covalent bond, because it is formed between two nonmetal atoms. Carbon and oxygen atoms form bond with each other by sharing electrons in their outermost shells (A).

RQ: What about MgCl2? (S) SR: "It is ionic bonding. While magnesium atom is metal, chlorine atom is nonmetal. So, Magnesium atom transfers one electron to each chlorine atom. It is ionic bond, because it is formed between a metal and a nonmetal atom. Bonding is formed by means of the attraction between oppositely charged ions".

RQ: How would you classify NH3 (S)? SR: "It is ionic bonding. Nitrogen is nonmetal. Hydrogen is nonmetal. One electron is transferred from each hydrogen atom to the nitrogen atom." It is covalent bond, because it is formed between two nonmetal atoms. Bonding is formed by sharing of a pair of electrons." The interaction between the researcher and the students pointed the students' level of understanding and provided the researcher with the gap needed to fill. It is clear that students based their concept of type of bonding on the nature of the atom whether metal or nonmetal.

PoISR: Key Finding 28

Most of the students gave answers which indicated their understanding about how covalent bonds are formed. Majority indicated that covalent bonds are formed between two non-metals and ionic bonds are formed between a metal and a non-metal.

Lesson Three: Lesson three dealt with ionic characters found in covalent compounds. The objective was to use the FAST feedback method to guide students to be able to identify compounds which exhibited both ionic and covalent bond characters. Students were taken through electronegativity difference (A) which was the yardstick for determining the nature (S) of the various compounds given (F) as to whether they possessed ionic characters or not. Students were to indicate which compounds were more ionic or more covalent (T). Students were asked to do a lot of exercises on the board during the plenary session (F).

Responses of students to worksheet on ionic characters in covalent compounds

The responses of students to worksheet four on ionic characters found in covalent compounds have been analysed in terms of number of students who scored the Items correct and their corresponding percentages and presented as Table 29.

Table 29 Students' Performance on Worksheet 4 (n=70)

Item	*Number of students who got Item correct*	*Percentage*
Calculation of Electronegativity difference (ED)	64	91.0
Compounds more ionic/covalent (IC)	59	84.3

From Table 28, 64 (91%) students were able to calculate the electronegativity differences (ED) of the various compounds and 59 (84.3%) students were able to determine which compounds were more ionic or more covalent (IC). Students' ability to identify which compound possessed more ionic character or more covalent character was slightly lower than their ability to calculate the electronegativity differences of the elements of the compounds.

PoISR: Key Finding 29

> At the end of the lesson, students were able to use the idea of electronegativity difference to indicate which of the given compounds were more ionic or more covalent: Out of the total number of respondents 64 were able to calculate the electronegativity difference of the atoms involved in bond formation and 59 were able to identify compounds which were more ionic or more covalent.

Oral discourse between researcher and students

RQ: What distinguishes an ionic compound from a covalent compound (S)? SR: The number of electrons, whether the atoms forming the bond can donate and accept electrons, all atoms involved in bonding must donate electrons for sharing. RQ: Is HCl more ionic or more covalent (A)? SR: HCl is more covalent RQ: Yes but why is it so (A)? SR: The electronegativity difference between Hydrogen and Chlorine is less than 1.7 and so is more covalent. RR: Good

PoISR: Key Finding 230

> Most of the students were able to calculate the electronegativity difference of the pairs of atoms forming bonds which enable them to clearly indicate which of the compounds were more ionic or more covalent.

Lesson Four: Lesson 4 covered metallic bonding and the objective was to use FAST feedback methods to guide students to i) identify the physical properties of metals (MP), ii) identify the types of ions formed (TI), iii) identify strength of valence electrons (SV), iv) draw to indicate how metallic bonds (DM) are formed., and (v) arrange metals in order of increasing bond strength (BS). A lot of examples (F) of metals were used to explain how bonding occur in metals (A). The idea of delocalized electrons was used to make students understand (S) how metallic bonding occurs. Students who needed further explanations (S) were assisted without delay (T). The number of students' who scored the Items on worksheet 5 have been analysed in terms of percentages and presented as Table 29.

Table 29 Students' Performance on Worksheet 5. (n=70)

Items	*Number of students who got items correct*	*Percentage*
Physical properties of metallic bonds (MP)	61	87.1
Type of ions formed by metals (TI)	57	81.4
Strength of valence electrons of metals (SV)	55	78.6
Drawing to indicate metallic bonding (DM)	53	75.7
Arrangement of metals in order of bond strength (BS)	52	74.3

From Table 29, students who scored Items on physical properties of metallic bonds (MP) were 61(87.1%) of the total number of respondents. Also 57 (81.4%) scored Items on types of ions formed (TI) and 55 (78.6%) students scored items on strength of valence electrons (SV). 53 (75.7%) students were able to draw to draw how metals form bonds (DM). Finally, students who were able to arrange the metals in order of bond strength were 52 (74.3%).

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

PISR: Key Finding 30

Most of the students responded appropriately to questions on metallic bonding: Out of 70 respondents, 61 were able to write down the physical properties of metallic bonds whilst 57 identified the type of ions formed by metals. Whereas 55 determined the strength of valence electrons in metals, 53 indicated how metallic bonding occur. Finally, 54 arranged the given metals in order of bond strength.

4.8 Perception of students about metallic bonding

With the FAST feedback method the Researcher interacted with the students to unearth some of their misconceptions about metallic bonding. Students explained that there was no bonding in "pure metals" or there was just a force and not a real chemical bond. Some of the students also think that there is some form of bonding in metals, but not "proper bonding". Students again had some misunderstandings about electric current because of the lack of understanding of the metallic lattice. Yet, students indicated that metals have covalent and/or ionic bonding.

They view metals as having metallic bonding, which is a sea of electrons. Students also had difficulties in explaining the relationship between the electric current and movement of the electrons. When asked to explain the structure of solid iron (A, S), some students did not realize that there would be the need for bonding to make the particles stay in the lattice arrangement. Students explained that all iron atoms were the same element that they didn't need to transfer or share their electrons to form any bonds and thus just stuck together without any bonding or with no proper bonding. As a result, they envisioned that metallic lattices contain neutral atoms. Common misconceptions were the concept of sea of electrons, a model in which cations are considered as fixed points in a mobile "sea" of valence electrons.

PoISR: Key Finding 32

Students who related metallic bonding with the sea of electrons didn't seem to understand its role in the bonding. Some students explained that metallic bonding was very weak because metals are malleable. Others supposed that electric current in metals was produced by the movement of atoms or ions.

Lesson Five: Intermolecular bonding was the topic for lesson five. It covered i) dipole-dipole interactions ii) induced dipole-induced dipole interactions and iii) hydrogen bonding. The objective was to use FAST feedback approach to guide students to be able to distinguish among these three types of bonding. Series of examples (F) were used to drum home the idea of intermolecular bonding (A) forming not as a result of the octet rule but as a result of weak forces that exist between the respective atoms (S). Students who needed further clarifications were attended to without delay (T).

Responses of students to worksheet on intermolecular bonding

The performance of student-participants in worksheet six has been analysed in terms of their scores to Items and the corresponding percentages and presented as Table 30.

Table 30 Students' Performance on Worksheet 6. (n=70)

Items	*Students who scored Items correct*	*Percentage*
Sketching to indicate dipole-dipole interactions (DDI)	67	95.7
Sketching to indicate induced dipole-induced dipole interaction (IDID)	64	91.4
Sketching to indicate hydrogen bonding (HB)	61	87.1

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

From Table 30, students scored for sketching compounds to indicate dipole-dipole interactions were 67 (95.7%). Similarly, 64 (91.4%) students scored for sketching induced dipole-induced dipole interaction. The lowest score however, was under hydrogen bonding in which 61 (87.1%) students scored for sketching.

PoISR: Key Finding 33

> At the end of the lesson majority of the students were able to distinguish among the inter-molecular bondings: About 65 were able to sketch to indicate dipole-dipole interaction and 64 were also able to sketch to indicate induced-dipole induced dipole interaction. In addition, 61 respondents were able to sketch to indicate how hydrogen bonds are formed.

4.9 Chapter Summary

The demographic data revealed a total of 815 participants, comprising 795 chemistry students and 20 teachers of chemistry. Pre-intervention questionnaires results were presented in tabular forms and teachers interviews in themes. These were triangulated by the observation schedules for students' exercise books and lessons that were observed. Key Findings out of these pre-intervention results pointed out that, chemistry teachers from the participating SHS do not incorporate FAST feedback in their classroom discourses. Students responses to the post-intervention worksheets presented in tabular forms as well as the probe into the classroom discourses also clearly proves that FAST feedback when used in teaching can help students change their misconceptions to accept the desired knowledge and thus help them to close the gap.

5.0 CONCLUSIONS

This chapter deals with the discussion of the results provided in answer to the research questions. Emerging themes arising out of the research have also been discussed. It covers the demographic results, the pre-intervention survey results (PISR) and the Post Intervention survey results (PoISR). The study further makes references to previous related studies and ends with a chapter summary.

5.1 Categories of Schools and Teacher-participants

The categories of senior high schools that constituted the sample for the study included single sexed and co-educational schools from both rural and urban areas (Table 8). All the single sexed schools were found in urban areas whilst the co-educational schools were from both rural and urban areas of the Eastern Region of Ghana. The single-sexed schools were either for male students only or for female students only and the co-educational schools were for both male and female students (DSR: Key Finding 1). Coeducation advocates agree that there are some small physiological differences in male and female brains. But they also say there is lack of evidence that these differences matter to learning at the individual level. In a meta-analysis of 242 students conducted by Lindberg, Hyde, Petersen, and Linn (2010), gender differences in mathematics performance were examined. It was revealed that girls perform as well in the subject as boys. Other studies suggested that when it comes to mathematics, girls and boys are similarly capable. Hyde and Mertz (2009) reported that while more boys than girls score at the highest levels in mathematics, that gender gap has been closing over time. In fact, they reported that the gap is smaller in countries with greater gender equality, suggesting that gender differences in math achievement are largely due to cultural and environmental factors.

Teachers in any of the school category could either be males only or females only or both sexes. In this study, both sexes of teachers were found in each of the schools that participated (DSR: Key Finding 2). However, there were more male teachers (15) than female teachers (5). It could partly be inferred that teachers who teach chemistry in the schools that participated in the study are mostly males. From Key Finding 2 those who teach chemistry in the senior high schools that participated in the study are all not specialists in the teaching of chemistry. Some of the teachers indeed are holders of degrees in chemistry whilst others graduated in other science related subjects like biology, agricultural science, physics, mathematics and engineering.

This observation puts the participating teachers into three categories according to their academic background. The first group of chemistry teachers is professional chemistry teachers who were trained in both content and pedagogy in chemistry. The teachers in this category studied for bachelor's degree in chemistry (BSc Chemistry) and later studied for Post Graduate Diploma in Education (PGDE) or those who studied Bachelor of Education in science with major in chemistry (B Ed Science Education). The second group of teachers is non-professional chemistry teachers who studied only chemistry (BSc Chemistry) i.e. content and not pedagogy. The third category of teachers is out-of-field teachers who did not study chemistry or its pedagogy but as a result of lack of professional chemistry teachers in science classrooms they find themselves teaching the subject.

Category one teachers are supposed to be the expects who can teach chemistry effectively because they have strong PCK and as a result could teach and give FAST feedback which of course can enhance students' learning. Teachers who have studied for bachelor's degree in chemistry have control over the subject matter which pertains in the chemistry syllabus at the SHS level. This category of chemistry teachers has also been trained in teaching of the subject matter. The combination of the skills of teaching and the knowledge of the subject matter enable such category of teachers to perform effectively and so are able to give FAST feedback to students. To teach is to first understand purposes, subject matter structures, and ideas within and outside the discipline.

Teachers need to understand what they teach and, when possible, to understand it in several ways (Koehler, 2011). The key to distinguishing the knowledge base of teaching lies at the intersection of content and pedagogy in the teacher's capacity to transform content knowledge into forms that are pedagogically powerful and yet adaptive to the variety of student abilities and backgrounds. Comprehended ideas must be transformed in some manner if they are to be taught (Koehler, 2011). The second group of teachers is those who studied content but not pedagogical skills. In this case teachers only talk to students who in turn listen. Teaching is one way, teacher delivery. Such teachers possess only content knowledge (CK) but no pedagogical knowledge (PK) to blend to enable them give FAST feedback to students. The third group of teachers are those who studied in other science related subjects like agricultural science or even mathematics but found themselves teaching chemistry due to lack of chemistry teachers. Such teachers lack both content and pedagogy in chemistry and consequently cannot give FAST feedback to help their respective students to change their misconceptions to enable them learn better.

Pedagogical content knowledge (PCK) and content knowledge (CK) are key components of teacher competence that affect student progress (Kleickmann et al, 2013). However, little is known about how teacher education affects the development of CK and PCK. To address this question, the research group constructed tests to directly assess mathematics teachers' CK and PCK. Based on these tests, Kleickmann et al in 2013 compared the PCK and CK of four groups of mathematics teachers at different points in their teaching careers in Germany. Confirmatory factor analyses showed that PCK and CK measurement was satisfactorily invariant across the teacher populations considered. As expected, the largest differences in CK and PCK were found between the beginning and the end of initial teacher education. Differences in the structures of teacher education were reasonably well reflected in participants' CK and PCK.

Indeed, recent studies have provided strong, representative evidence that teachers' subject-matter knowledge (SMK) affects their instructional practice and their students' achievement gains (Hill, Rowan, and Ball, 2005). Elementary teachers' CK was found to be substantially associated with student gains in mathematical understanding (Hill et al., 2008). Drawing on data from a longitudinal extension to the 2003 cycle of the Organization for Economic Cooperation and Development's Programme for International Student Assessment (PISA) in Germany, Baumert et al (2010) showed that PCK and CK affect student learning. However, despite the high correlation between CK and PCK, CK had lower predictive power for student progress than did PCK. Furthermore, PCK had the decisive impact on key aspects of instructional quality. Against this background, the question of how teacher education affects the development of teachers' subject-specific knowledge is crucial to educational reform (Ball, Lubienski, & Mewborn, 2001). Krauss, et al. (2008) concluded that the latent structure of subject-matter knowledge might vary between different teacher populations. There is some consensus and some preliminary evidence for the notion that CK might be a prerequisite for PCK development.

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

5.2 Research Question 1: How often do chemistry teachers give feedback to their students?

This question referred to the attribute frequent feedback of FAST feedback and sought to find out whether teachers of chemistry from the participating senior high schools often give feedback to their respective students or not. The answer to this question is obtained from Key Findings 3-7 which covers the responses by both teacher-participants and student-participants to the questionnaires and teacher's responses to the interview protocol as well as what was observed during classroom discourse and from students' exercise books.

In this study, it could be inferred from the quantitative results that students do not see their teachers providing feedback frequently to students in class, M =1.30 (PISR: Key Finding 3) but their teachers recorded that they frequently gave feedback to their students during classroom discourse, M= 1.90 (PISR: Key Finding 4). The implication is that teachers' and students' perceptions are at variance in terms of the teachers' ability to give frequent feedback. Naturally, teachers would like to record positively about their work.

The teachers' responses to the interview protocol (PISR: Key Finding 5) proved the students right since teachers recorded that they, gave very few exercises in a term and also they did not mark them regularly. Also teachers indicated that they were not able to give frequent feedback due to; large class size; broad nature of the curriculum; lack of teaching skills; lack of in-service training, out-of-field teachers and negative attitudes of teachers. The lessons which were observed further provided support to what was recorded for the questionnaires by the students and the interview protocol. Thus, during classroom discourse, most of the teachers asked very few questions and responded to only few of the questions asked by students in class (PISR: Key Finding 7). The few exercises given to students during classroom discourses were also not marked nor seen by the teacher-participants (PISR: Key Finding 7). It was also observed from student's exercise books that, very few exercises (maximum, one) were given to students' for three terms and were not marked nor seen by the teachers (PISR: Key Finding 6).

Feedback influences student learning and achievement (Hattie & Timperley, 2007). Previous studies regarding teacher feedback to students also found that teacher feedback in classroom does not occur frequently (Voerman et al., 2012). Frequent feedback provides opportunities for students to practice what they have previously learned. Research tells us that the "brain's flexibility allows the neural networks that were constructed to address such problems to be quickly reworked to deal with more pressing matters" (Ewell, 1997, p. 9). It is worthy of note that important things that have to be retained must be reinforced by repetition. Frequent feedback will definitely help those who hold some misconceptions to change their thoughts for the accepted or desired ones and to close the knowledge gap. Emerging themes arising out of the responses (Appendix R) to the attribute frequent feedback included: Immediate feedback and remediation, oral and written feedback, feedback during classroom discourse, after-class feedback, and factors affecting frequent feedback delivery. These factors include extracurricular activities, motivation, in-service training, out-of-field teachers, class size, time and teacher's attitude (Appendix R).

5.2.1 Theme 1: Immediate feedback and remediation

It is ideal to give feedback as soon as students' give responses to teachers' questions. This will help the students to know first and foremost that what they perceived to be correct is true or not. Secondly, it will assist the students to change their misconceptions to accept the desired response from the teacher. Thirdly, the students become motivated to learn and fourthly they are able to close the knowledge gap. Numerous studies indicate that feedback is most effective when it is given a number of times, rather than a few days, weeks, or months down the line. In one study that looked at delayed vs. immediate feedback, the researchers found that participants who were given immediate feedback showed a significantly larger increase in performance than those who had received delayed feedback (Stenger, 2014).

When students of different ability groups are found in a class, they would all not understand concepts and ideas being taught in class at the same rate. When a teacher discovers this, remediation must be the solution (Juwah et al, 2004). Remediation (also known as developmental education, basic skills education, compensatory education, preparatory education, and academic upgrading) is education designed to assist students in order to achieve expected competencies in core academic skills such as literacy and numeracy. Teachers must be prepared to stay with the students who need help to assist them to understand what was being taught in the general class. Teachers however admitted their failure and inability to offer this help to students in need.

5.2.2 Theme 2: Oral and written feedback

How and when feedback is delivered (e.g. oral or written) affects its influence on student learning (Brown, Harris, & Harnett, 2012). Oral and written feedback to students are both essential in providing feedback that can help students change their misconceptions about events, ideas, concepts and phenomena of nature. Teacher respondents however admitted that they are unable to provide enough oral and written feedback to their students. Teachers must bear in mind that it is only through feedback either oral or written that students could be helped to change their misconceptions and begin to accept the desired responses or even change their behavior. Failure to provide frequent oral or written feedback will make students keep wrong information to themselves. Oral teacher feedback influences learning opportunities in science classrooms. It is evident across science teaching and learning, with a particular focus on how teachers address learners' errors vis-à-vis recasts, explicit corrections, clarification requests, confirmation checks, metalinguistic cues, elicitation, repetition of errors, and translation (Ranta & Lyster, 2007).

5.2.3 Theme 3: Feedback during classroom discourse

Under ideal conditions, teachers are supposed to provide regular feedback to students during classroom discourse. This will help students to compare their performance with the standard, and take action to close the knowledge gap. Teachers however, did not hide from the fact that they are not able to give enough feedback to students. Teachers' refusal to comment on answers that students give in class definitely would not help students in their learning since they may not know whether their responses are right or wrong. Regular feedback during lessons could be expressed from the time the teacher introduces the lesson through the step-by-step development of the lesson to the closure. As the teacher moves along questions that teachers ask must be answered by the students and questions asked by students must be answered by the teacher. Teachers must assist students in their quest for knowledge and so teachers must direct the teaching processes such that the students could identify correct answers from wrong answers. A teacher has the distinct responsibility to nurture a student's learning and to provide feedback in such a manner that the student does not leave the classroom feeling defeated.

Several implications are suggested for science teachers to support their scientific classroom discourse and this include; First elaborative feedback which play critical role in building productive dialogue. Second, feedback questions increase students' engagement in the classroom discourse. Third, evaluative and corrective feedback usually terminates the discourse quickly. Lastly, in a dialogue or through dialogues, talking only about scientific knowledge (SK) does not engage the students in the classroom discourse (Soonchun, 2012).

5.2.4 Theme 4: After-class feedback

Feedback from teachers to students should not only be given during classroom discourse. Teachers spend time to examine students work and write feedback alongside as he/she scores them. Item-by-Item feedback is good for students since that would enable them to identify what really was wrong with the Items they get wrong. Teachers' comment on specific Items will also serve as intrinsic motivation for the students which will let them learn more. Teachers however admitted that they are unable to do much in this direction. Teachers declared that they do other works after school to support their earnings and so do not have enough time to do much. This of course does not auger well for students learning. From all indications, the students' exercise books testify that teachers have not being giving a lot of exercises and take-home assignments. The responses from the teachers' interview and the observation schedules confirm the scores obtained from the questionnaires. Thus the qualitative responses have triangulated the responses from the quantitative study.

The teacher must take a few minutes after each lesson to reflect on what worked well and why, and what could have been done different (Fink, 2005). Identifying successful and less successful organization of class time and activities as well as how feedback to students was given, would make it easier to adjust to the contingencies of the classroom. For additional feedback on planning and managing class time, the teacher can use the following resources: student feedback, peer observation, viewing a videotape of the teacher's teaching, and consultation with a staff member (Fink, 2005).

Teacher-respondents claim they are involved in *extracurricular activities* which prevent them from preparing adequately before going to class or even to mark students' exercises and write feedback on every Item. Extracurricular activities also add to the students' pressure (Group Play, 2012) and inhibit their learning. For some, it would be difficult to juggle two things every day. Sometimes, it can lead to students concentrating on only one and failing on others. The worst is the pressure that the student has to endure. They get tired and lose time to study. Thus, learning is affected. That notwithstanding, teachers are not well *motivated* to go the extra mile in providing frequent feedback to students. Lack of motivation for teachers is a serious problem in the school system. Teachers need to be motivated so that they can in turn motivate the students. Motivation strategies for teachers include prompt payment of salaries, decent accommodation, payment of transportation allowances, free medical service, car and housing loans, etc. These factors of motivation appear to be conspicuously absent in most school system (The species conservation planning sub-committee, SCPSC, 2010).

While appraisal and feedback really help teachers to self-evaluate and improve their teaching, teacher motivation strive to improve teachers' feedback to students and also enable teachers to be fair and transparent (Teaching & learning international survey, TALIS, 2013). This enhances teacher performance and student learning. Students also become motivated to learn because teachers make task match to the level of skill i.e., not so easy as to be boring, and not so hard as to be frustrating (Annie, 2013). Teachers' deliberately fashion the learning exercise so that students work at the very edge of their abilities, and keep upping the difficulty as they improve.

Teachers, whether professional or non-professional need some form of *in-service training* to remind them of their responsibilities. According to Kazmi, Pervez and Mumtaz (2011), inservice training for teachers enables the teachers to be more systematic and logical in their teaching style. Studies by Ekpoh, Oswald and Victoria (2013) shows that, teachers who attend in-service training perform effectively in their work concerning knowledge of the subject, classroom management, teaching method and evaluation of students. Studies by Jahangir, Saheen and Kazmi (2012) also show that in-service training plays a major role to improve the teachers' performance in school. Respondents in this study indicated that, in-service training on strategies for giving feedback to students can help solve this problem. From the discussion above, it clearly shows that in-service training is important for teachers in school as a tool for professional development and to enhance their knowledge and quality of teaching and learning. Teachers are facing new challenges and changes in the education world and it's important for teachers to equip themselves with new knowledge and skills by attending in-service training in order for them to play important and effective role as educators. Besides that, the effectiveness of in-service training is important to ensure that the training is suitable and bring positive effect to the teachers. The effectiveness of the in-service training is influenced by the role of administrator, teacher's attitude, needs analysis and strategies used in the training program.

Respondents again claim that the *broad nature of the curriculum* and their desire to complete it for students to enable them write their examinations also militate against their ability to give frequent feedback. The school curriculum comprises all learning and other experiences that each school plans for its students. The curriculum is the key reference point for teachers, particularly in developing countries, where it is encoded in the official textbook and teacher guides, often the sole resource used by teachers. Teachers' pedagogic approaches, strategies and practices thus serve to enact the curriculum (Alexander, 2009). The curriculum links the macro (officially selected educational goals and content) with the micro (the act of teaching and assessment in the classroom/school), and is best seen as 'a series of translations, transpositions and transformations' (Alexander, 2009, pp.16; original emphasis). The official curriculum is transacted and in the process gets transformed, as 'teachers and students interpret, modify and add to the meaning' embodied in the official specification (ibid.). Thus, curriculum, pedagogy, assessment and feedback are interrelated and mutually influence one another in the day-to-day classroom interaction (Alexander, 2009).

Large class size was also identified as a factor preventing teachers from giving frequent feedback. Teacher-participants claim it is tedious marking many scripts and writing feedback on every Item for every student. In research on early elementary school students, small classes usually mean fewer than 20 students, while for high school students the definition of "small" classes is usually somewhat larger. In addition to the ambiguity about how many students constitute a smaller class, researchers use different strategies for assigning a class-size number. It can mean the number of students enrolled in the course, the number of students completing the course, or the number of students completing major course assignments (Arias & Walker, 2004). Furthermore, there is a shifting relationship between class size and teacher workload. Reducing class size can, for example, increase teacher workload if the number of students per class is lowered but teachers are assigned one more class per day. Overall, research shows that students in smaller classes perform better in all subjects and on all assessments when compared to their peers in larger classes. In smaller classes students tend to be as much as one to two months ahead in content knowledge, and they score higher on standardized assessments. It is worth noting, however, that some studies analyze student assessment results in terms of individual student performance and others in terms of class-wide aggregated performance, which can obscure the differences in individual students' performances.

These positive effects of small class sizes are strongest for elementary school students, and they become more powerful and enduring. That is, students who have smaller classes in early elementary grades continue to benefit from this experience even if they are in larger classes in upper elementary or middle school (Bruhwiler & Blatchford, 2011; Chingos, 2013). Class size also shapes the quality of writing instruction at all levels, including college, because smaller classes are essential for students to get sufficient feedback on multiple drafts. Not surprisingly, smaller classes increase retention at the college level (Blatchford et al., 2002). In addition, participating teachers claim the *time period* allotted for chemistry lessons are not enough for one to give frequent feedback. They recorded that if they continuously give feedback to students they would not be able to cover enough of the scope of the subject and that enough time period is needed to teach and give frequent feedback to their students.

Out-of-field teachers who teach chemistry are not able to give frequent feedback to students because in their view, students may ask them difficult questions and they may not be able to answer. Out-of-field teaching (generally defined as a situation where teachers are appointed to areas or phases of learning for which they have no formal qualifications) is an international phenomenon that can impact on the educational experiences of students (Taylor & Francis, 2014). Teachers in rural and difficult to staff schools are frequently appointed out-of-field due to teacher shortages. Their lack of qualifications and experience relevant to their appointment can present significant challenges to their induction within the profession (Taylor & Francis, 2014). Out-of-field teaching emerged as an important issue that can impact on teachers' sense of efficacy and teacher attrition. When teachers are mis-assigned, systems and schools should provide support structures to assist teachers to develop their competence and to reduce the potential negative impact on teachers and learners (Taylor & Francis, 2014).

Finally, *attitudes* of some teachers, such as absenteeism, and lateness to class, inadequate preparation and laziness deter them from giving frequent feedback. Teachers who exhibit such behaviours have to change to adopt positive attitude such as being regular and punctual to school, making adequate advance preparation for class and doing away with laziness. Such teachers will definitely be able to adopt appropriate methods of teaching and also give frequent feedback to students. The need for better approaches and strategies in science and mathematics teaching has been emphasized by Ojiabor, (2000); Odebode, (2004); Oyodele, (2006) and Osuji (2007). The brain deals with most pressing matters and it is necessary to practice those things that we wish to retain and to receive feedback with, which includes explicit cues about how to learn better, such as that provided deliberately (Ewell, 1997). This influences learning by virtue of the frequency (i.e., number of interactions with a particular environmental stimulus such as a person or a task) of feedback and by the quality of the feedback the learner receives (Ewell, 1997).

Frequent feedback reveals "specific, readily-correctable, mistakes / discrepancies in current practices or in the 'mental models' that lie behind them" (Ewell, 1997, p.9). Without frequent feedback and opportunities for practice, even well-learned abilities cascades (though recovery is not as difficult as initial acquisition).

5.3 Research Question 2 How accurate are the feedback giving by chemistry teachers to their students?

Teachers give accurate feedback if they justify to students how their mark or grade was derived, identify and reward specific qualities in student work, guide students on what steps to take to improve, motivate students to act on their assessment, develop their capability to monitor, evaluate and regulate their own learning (Nicol, 2010). The answer to this question can be obtained from Key Findings 8-12. From the pre-intervention quantitative results, it could be inferred that teachers and student's perceptions of the accuracy of teachers' feedback to students are at variance. Whereas student-respondents recorded that their chemistry teachers' feedback to them during classroom discourse were not accurate (overall mean = 1.20, PISR: Key Finding 8), their respective teachers recorded that the feedback they gave to students were accurate (overall mean= 1.91, PISR: Key Finding 9).

The responses to the interview protocol by the teachers rather supported the students' responses to the questionnaire. Most of the teacher-participants indicated that they sometimes give unfair, biased and inaccurate feedback to their students because of too much work or as a result of halo effect (PISR: Key Finding 10). Further triangulation to what students recorded is also found in the lessons which were observed: "Teachers did not provide much help for students to answer, questions correctly; teachers also failed to reframe questions to help students give the right responses" (PISR: Key Finding 12). Finally, what was observed from students' exercise books buttressed the students' assertion that their teachers do not give accurate feedback: "Teachers did not write any comments against Items students got wrong in their exercise books to help them know exactly what was wrong so that they could do corrections. Negative words and phrases which were seen included poor, crazy, why did you do it this way?" (PISR: Key Finding 11). Emerging themes arising out of the teachers' interviews and the observation schedules included, fair, unbiased and accurate feedback; ambiguity and reframing of questions; work load and halo effect; common errors and plenary session (Appendix R).

5.3.1 Theme 1: Fair, unbiased and accurate feedback

The interview protocol revealed that teachers are generally fair in giving marks to students. However, teachers admitted that they may not be fair on some occasions but this goes unnoticed. Occasionally, students who are tagged academically good in class are given marks which they do not deserve. Sometimes teachers refuse to let students know whether their responses to questions are right or wrong. This comes about because they may be tired after moving from one class to the other. Teachers recorded that they do not have enough time to research into what they teach which could foster their ability to provide accurate feedback to students. According to Hattie (2012), teacher credibility is vital to learning, and students are very perceptive about knowing which teachers can make a difference. There are four key factors of credibility: trust, competence, dynamism and immediacy. In an interview Hattie puts it like that: "If a teacher is not perceived as credible, the students just turn off." Hattie (2012) gives the following examples for teacher credibility: Earn trust by showing trust towards students. Appear highly organised in the presentation of the subject matter. Develop a powerful style of speaking that uses little verbal hesitancy such as "OK" or "you know". Reduce distance between teachers and students by moving or moving away from barriers (e.g., desk, podiums).

5.3.1 Theme 2: Ambiguity and reframing of questions

Something that does not have a single clear meaning is ambiguous. Teachers are expected to give clear and correct feedback to the answers that students give orally in class and in their exercise books to enable them identify the errors about their oral and written responses. It was observed from the students' exercise books that teachers did not give accurate feedback to their students written assignments or class tests (PISR: Key finding 11). Teachers' only tick (√) or cross(X) against the responses of the students to indicate the accuracy or inaccuracy of their responses. Teachers do not write comments against any of the students' responses to enable them know their performance level. Lessons which were observed also revealed that teachers did not reframe their questions to enable students see clearly what the questions were demanding.

Assessment criteria provide the basis for teachers to make academic judgements about the work students produce (Learning & teaching development, LTDS, 2014). They are statements which specify

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

clearly the standards that must be met and what evidence will be used to show achievement of learning outcomes. In other words, what the learner has to do to demonstrate that they have met one or more specific learning outcomes. The teacher therefore writes feedback to reflect the level of performance of the students (LTDS, 2014). To be effective, the criteria should be aligned with the expected learning outcomes and the methods of assessment in order to support and enhance effective learning and teaching (LTDS, 2014).

The most important advice is that teachers must write assessment criteria so that they could write accurate feedback comments to students. This will help the teacher to be clear and unambiguous. It is important to confirm the criteria and written feedback by reading them over and checking them for clarity and ambiguity. There is persuasive evidence that many students do not feel confident or able to interpret assessment criteria (LTDS, 2014). Where students don't understand the criteria, but then receive a good mark for the piece of work, they perceive the criteria to be superficial or meaningless and potentially unfair and invalid. Where students do understand the criteria, they can be a very powerful tool to help them measure and improve their performance (LTDS, 2014). Student evaluations of teacher performance are vital because learning involves the students in the first place. The teachers provide the feedback to the students whilst students on the other hand provide the exact mirror reflection about the teachers' performance in the classroom through assessment. Teachers also believe that students can contribute a lot to the teaching-learning process knowing that the teaching—learning process is dynamic and changes with time (Gordon, 2001). Students can easily observe teacher behaviour and the teaching process and are the best judges of their own learning.

Other studies suggest that many students do read feedback and consider it carefully but the feedback is written in a way that students do not find it useful in improving future work (Higgins, Hartley, & Skelton, 2002). Some studies have further investigated the relationships between grading and descriptive feedback by providing students with both written feedback and grades on assignments. In these cases, the addition of written comments consistently failed to enhance student performance on follow-up tasks (Pulfrey, Buchs, & Butera 2011). Brookhart (2008, p.8) concludes, "the grade 'trumps' the comment" and "comments have the best chance of being read as descriptive if they are not accompanied by a grade." Even when written feedback is read, there is widespread agreement that instructor feedback is very difficult for students to interpret and convert into improved future performance (Weaver, 2006).

5.3.3 Theme 3: Work load and halo effect

Accuracy of feedback refers to the type of feedback that provides appropriate responses to students' answers. To enhance student learning, teachers must always give accurate feedback but in this study teachers indicated that their workloads were too heavy which affects their ability to give accurate feedback (PISR: Key Finding 10). The time and energy spent on grading has been often pinpointed as a key barrier to teachers giving of accurate feedback to students (Schinske & Tanner, 2014). In some cases, the demands of grading require so much teacher attention that little time remains for reflection on the feedback or for aspirations of pedagogical improvement (Schinske & Tanner, 2014). However, just because students generate work does not mean instructors need to grade that work for accuracy. In fact, there is evidence that accuracy-based grading may, in fact, demotivate students and impede learning (Schinske & Tanner, 2014).

The study also revealed that teachers are not able to do so due to halo effect (PISR: Key Finding 10). Halo effect, at the most specific level, refers to the habitual tendency of people to rate attractive individuals more favourably for their personality traits or characteristics than those who are less attractive (Rasmussen, 2008). Halo effect is also used in a more general sense to describe the global impact of likeable personality, or some specific desirable trait, in creating biased judgments of the target person on any dimension. Thus, feelings generally overcome cognitions when we appraise others, (Standing, 2004). In the classroom, teachers are subject to the halo effect rating error when evaluating their students. For example, a teacher who sees a well-behaved student might tend to assume this student is also bright, diligent, and engaged before that teacher has objectively evaluated the student's capacity in these areas. When these types of halo effects occur, they can affect students' approval ratings in certain areas of functioning and can even affect students' grades (Rasmussen, 2008).

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

Teachers themselves admit that sometimes they are biased in the scores they give to students due to the rate at which some students contribute during class discussion (PISR: Key Finding 10). Such students are tagged "good students" and so they never make mistakes. Teachers should be aware of this halo effect because it does not allow them to give accurate feedback to students' responses to teachers' questions in class. This was supported by the examination of students' exercise books where very few exercises which were given were not marked. The few that were seen, the teachers had only scored without writing comments as to what exactly was wrong with the student's answers. Naturally teachers would like to say positive things about their own teaching practices whereas students would want to say exactly what happens in their classroom discourses with their teachers.

5.3.4 Theme 4: Common errors and plenary session

Teacher-participants indicated that, students must be asked to stop work for general discussions (plenary session) to take place when it is discovered that they are making common mistakes (PISR: Key Finding 10). It helps the students to change their misconceptions on time. It is common knowledge that people can learn much from their mistakes as anything yet, traditional teaching methods often deny students the chance to learn from their mistakes by preventing them from making mistakes (Ginsburg, 2012). Setting students up for success like this may seem like the right thing to do. Students' grasp of new concepts and skills is often better when they struggle through the process of learning those concepts and skills than when teacher's error-proof that process (Ginsburg, 2012). Helping students troubleshoot their errors like this should be a primary role of every teacher. Lesson planning should thus be more about anticipating students' errors and preparing to help students learn from those errors than trying to develop presentations that prevent all errors (Ginsburg, 2012). Students must be provided with activities that involve applying information, and must be helped during plenary when they get tripped up (Ginsburg, 2012).

5.4 Research Question 3 To what extent can chemistry teachers' feedback be described as specific?

Specific feedback in chemistry classrooms refers to the teachers' ability to provide exact responses to students to enhance their learning abilities. Students should not be left to make mistakes that can make them confused or discourage them from going the extra mile in their quest for knowledge. The answer to this question is found in PISR: Key Findings 13-17. Students' responses to the questionnaire with respect to specific feedback revealed that, teachers' feedback is not specific. (Overall mean= 1.28, PISR: Key Finding 13). Teachers however, recorded that, their feedback to students are specific. (Overall mean = 1.97, PISR: Key Finding 14).

The teachers' responses to the interview protocol corroborated what they recorded to the questionnaire. Teachers recorded that, they provide specific feedback to students in their exercise books and during lessons (PISR: Key Finding 15). However, lessons which were observed refuted the teachers claim. There were instances where the teachers asked questions which were ambiguous and not specific yet teachers did not clarify them to help students answer the questions. Teachers failed to involve students in some lessons that called for specific activities by students" (PISR: Key Finding 17). Similarly, what was observed from student's exercise books refuted the teachers claim but provided much support to the students' responses: "Students performances in the exercises were scored out of the total marks but not graded. No specific comments were also written for students to know what was wrong with their responses" (PISR: Key Finding 16).

General feedback (such as "good work, average, poor") does not give students an indication of the reasons for their success or failure on a task, and therefore is of less value in aiding learning. Unfortunately, many teachers rely heavily on general feedback (Burnet, 2002). The interview protocol reveals that teachers are not able to give specific feedback to students. Teachers think that they need to have absolute control of the subject matter to enable them give specific feedback. Teachers again do not write comments on students work in their exercise books and so do not give specific feedback on student's work. There is a clear and coherent observation from responses to the questionnaires, interview protocol and the observation schedules that teachers do not provide any specific feedback which could provide clues to help students answer correctly nor provide answers to the omissions made by students. Also teachers' do not provide any feedback that is directed towards what students do correctly or incorrectly. On the whole, teachers' feedback to students is actually not specific. Emerging themes arising out of the

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

interviews include predetermined criteria; mastery of subject matter and specific feedback; motivation and general discussions, specific period and place of feedback.

5.4.1 Theme 1: Use of predetermined criteria in the provision of feedback

Some teachers claim they use marking schemes (predetermined criteria) to enable them mark correctly (PISR: Key Finding 15). Providing the right kind of feedback to students can make a significant difference in their achievement. This can be better achieved if teachers could use pre-determined criteria. It is a 'risky business' If teachers do not use pre-determined criteria to provide feedback to students, (Deeley, 2014, p. 48) because it is possible that students could attempt to manipulate the feedback process in order to award themselves higher grades than are merited. Pre-determined criteria would help eliminate any biases on the part of the teacher.

5.4.2 Theme 2: Mastery of subject matter and provision of specific feedback

The subject matter knowledge of a teacher impacts on teaching and learning process in schools. Understanding of subject matter by a teacher implies that teachers are able to teach the main points of the subject matter to students, and to clarify misconceptions of knowledge (Judama, 2014). This depends to some extent, on the teachers understanding of the subject matter through which impact is made on learning when students are able to use the subject matter taught in class to actively participate in their environment (Judama, 2014). The teacher who is well versed with the subject matter will be able to give feedback which is specific to the needs of the students.

Feedback that improves learning is responsive to specific aspects of student's work, such as test or homework answers, and provides specific and related suggestions. There needs to be a strong link between the teacher's comment and the student's answer, and it must be instructive. This kind of feedback extends the opportunity to teach by alleviating misunderstanding and reinforcing learning (Hattie, 2012). The way feedback is presented can have an impact on how it is received, which means that sometimes even the most well-meaning feedback can come across the wrong way and reduce a learner's motivation (Hattie, 2012).

5.4.3 Theme 3: Motivation and general discussions

Respondents indicated that, if teachers were to be well motivated, they could have time to prepare well to teach effectively and consequently provide specific feedback to students Item by Item (PISR: Key Finding 15). Teachers need to be motivated through provision of teaching-learning materials, allowances and even a way of commending them to enable them give up their best. General class discussion elicits students' responses and exposes their misconceptions. It helps teachers to identify what students are deficient in and to assist them to close the gap to enable them reach the desired goals. Here again, respondents admit that they do not do much as a result of lack of motivation. Eggleton (2007) in his article claims that motivation is the key to effective teaching. After discussing some features of motivation, he explains how teacher personality and style lead to motivation. Personality is one of the aspects of motivation that is difficult to be changed. Some personality features of teachers may be motivating to the students. Among them are teachers' love, kindness, concern, sense of humor and big expectation (Eggleton, 2007).

Eggleton (2007) also maintains that appropriate tasks and interaction can facilitate motivation and learning. Entertainment and fun are not sufficient enough to make a class motivating. The teacher should be able to use various techniques of teaching such as cooperative learning, teacher-student interaction, student-student interaction, competition and problem solving tasks. One more issue that facilitates motivation is the learning atmosphere (Eggleton, 2007). Some motivating factors that help to establish class environment more motivating include teacher discipline, respect and use of routine steps in lesson plans (Eggleton, 2007). Effective teachers highly influence the interest and motivation of their students. Eggleton (2007) also maintains that appropriate tasks and interaction can facilitate motivation and learning.

5.4.4 Theme 4: Specific period, area and place of feedback

Allocated time is the total amount of time available for learning; e.g. the length of the school day or a class period is the "opportunity to learn". The California Commission for Teacher Preparation and Licensing (Fisher, 1978) sponsored the Beginning Teacher Evaluation Study (BTES) with funds provided by the National Institute of Education (Department of Health, Education and Welfare). The study was a multi-phase project which began in 1972 and was completed in June 1978. The overall purpose of the research program was to identify teaching behaviors which are effective in promoting learning in reading and mathematics in elementary schools.

According to the BTES and many subsequent studies, teachers who allocate more time to a specific content area have students who achieve at higher levels than teachers who allocate less time to the same content. The BTES study also noted factors that limit learning or cause students to lose interest during the allocated timeframe, such as: Unscheduled interruptions, public announcements, fire drills, visitors and other school management practices. Uneven transitions between activities and inefficient classroom management procedures that disrupt the learning flow, such as disorderly material distribution or disorganized assignment collection. Over-reliance on seatwork, uninteresting and overly demanding lessons and other non-engaging instructional practices. Teachers must therefore consider the place where lessons are conducted and consequently feedback are given to avoid interruptions and embarrassments.

5.5 Research Question 4 How timely is the chemistry teacher's feedback to their students?

Timely feedback refers to the period between students' responses to questions and when teacher makes them aware of the acceptability of their answers or the mistakes associated with the answers they provide. PISR: Key Findings 18-22 provide answers to this research question. They cover the responses by both teacher-participants and student-participants to the questionnaires and teacher's responses to the interview protocol as well as what was observed during classroom discourse and from students' exercise books. Students responded to the questionnaire that, their teachers' feedback to them during chemistry class is not timely (Overall mean = 1.17, PISR: Key Finding 18). Similarly, the teachers also responded that, their feedback to students during chemistry lessons is not timely (overall mean = 1.22, PISR: Key Finding 19).

These were corroborated by the teachers' responses to the interview protocol with respect to the attribute, timely feedback: "Thus due to lack of motivation teachers' do not go the extra mile to do remediation for students who cannot catch up with their colleagues during classroom discourse. Teachers are unable to return assignments to students on time" (Key Findings 20). Lessons observed also provided further support, "since, teachers delayed giving feedback to their students during lessons and also refused to give signs of approval or disapproval to enable students' ascertain on time whether their answers were right or wrong. Similarly, the exercise books which were observed also buttressed what both teachers and students recorded; "that, almost all books had one or two exercises done by the students. All exercises were conducted over two months. Very few exercises were marked and some of the exercises did not even have dates" (PISR: Key Finding 19). Emerging themes include negative feedback; going extra mile for remediation; timely feedback versus delayed feedback; after-class and written feedback.

5.1 Theme 1: Negative feedback

Teachers recorded that if the feedback is negative such that it would embarrass the affected student the feedback is deferred to another time and place where the teacher would meet the student alone (PISR: Key Finding 20). The existing body of knowledge shows that, over one third of all feedback interventions have negative impact on learning (Hattie & Timperley, 2007; Shute, 2008). The types of feedback that might be harmful to learning, according to three main reviews of research on teacher feedback: Hattie and Timperley (2007), and Shute (2008). These types are praise, and feedback about the self. The finding that praise and feedback about the self, have a negative impact on learning might have an important impact on teacher feedback behaviour in the classroom, since praise is the kind of feedback most often used in the classroom (Hattie & Timperley, 2007; Pauli, 2010; Voerman, Meijer, Korthagen, & Simons, 2012).

Positive feedback must be timely to enhance students' learning (Hattie & Timperley, 2007). If students receive feedback no more than a day after a test or homework assignment has been turned in, it will increase the window of opportunity for learning. Prompt or undelayed feedback given to students is very important to students' learning (Hattie & Timperley, 2007). This is because students need to change their misconceptions on time. Teachers naturally would not provide the actual practices which probably cuts a slur on their image so far as their teaching practices are concerned.

5.5.2 Theme 2: Going the extra mile

Respondents recorded that they are not able to go the extra mile to stay in class after the normal school period to help students who have difficulty in understanding what was taught during the normal classroom discourse (PISR: Key Finding 20). Teachers who care usually go the extra mile to assist students in their learning. To go the extra mile, when the students leave school, the teachers' day is not done. Teacher "milers" stay behind to straighten up, review supply needs, gather original materials that need to be copied, and reflect on the day's lessons or a student's errant behavior (Whitehouse, 2012). Teachers look over students' work and think how best to address their deficits and highlight their strengths.

Teachers assess themselves and redesign their lessons. Teachers make phone calls to parents and sometimes they speak with colleagues about upcoming tests, lessons, trips, or activities (Whitehouse, 2012). Often teachers seek advice from a more seasoned teacher. Some teachers attend professional development or college after school, for instance, several evenings a week. That notwithstanding, such teachers who go the extra mile stay long time with students who need help to assist them after work (Whitehouse, 2012). Once at home, teachers write or create assessments and lessons or tweak old ones. Many of such teachers design their own graphic organizers to scaffold difficult materials. They spend time thinking about how to break difficult concepts into more digestible pieces. They look for ways to make dry material interesting, fun, and relatable to students. They browse the web looking for support materials and lesson ideas (Whitehouse, 2012).

5.5.3 Theme 3: Timely feedback versus delayed feedback

Some teachers recorded that they provide timely feedback because they always respond to students questions or make students aware of their responses to questions they ask as to whether the responses are correct or wrong. Other teachers also recorded that they sometimes delay their feedback to students' responses to their questions to enable them think through what they have given (PISR: Key Finding 20). There has been much research on the timing of feedback, particularly contrasting immediate and delayed feedback. Most of this research has been accomplished without recognition of the various feedback levels. For example, immediate error correction during task acquisition can result in faster rates of acquisition, whereas immediate error correction during fluency building can detract from the learning of automaticity and the associated strategies of learning. Similarly, in their meta-analysis of 53 studies, Kulik and Kulik (2013) reported that at the task level (i.e., testing situations), some delay is beneficial (0.36), but at the process level (i.e., engaging in processing classroom activities), immediate feedback is beneficial (0.28).

Another example demonstrating that the effects of immediate feedback are likely to be more powerful for task acquisition and delayed feedback more powerful for associated strategies of learning was provided by Clariana, Wagner, and Roher Murphy (2000). They found that the effectiveness of delayed compared with immediate feedback varied as a function of the difficulty of items in their test of information taught in a series of lessons. The effect sizes from delayed feedback were −0.06 for easy items, 0.35 for midrange items, and 1.17 for difficult items. These authors suggested that difficult items are more likely to involve greater degrees of processing about the task, and delayed feedback provides the opportunity to do this, whereas easy items do not require this processing and so delay is both unnecessary and undesirable.

5.5.4 Theme 4: Giving feedback after class.

Teachers indicated that written feedback are supposed to be given after class when teachers are free to mark students exercises. Teachers clearly accept their deficiencies in this respect due to the fact that they are saddled with other important work after class (PISR: Key Finding 20). Teachers lack motivation to work hard to satisfy the needs of their students. Marking as a teacher means spending most of free time reading. Most of what a teacher reads is what he or she marks. A set of exercise books can become a novel; more than a novel depending on the class size (Facer, 2014) they may be full of repetition and analysis. The most important thing to do as a teacher is to mark students' books with dedication and rigour and the class will fly (Facer, 2014). Essentially, you can be the greatest educator ever, but if you do not mark, students will not progress; conversely, you can be a bit of a rubbish teacher, but if you mark well, great things could happen (Facer, 2014).

Teachers must balance their time more effectively to be able to mark and write accurate and timely feedback on students' work. Marking alone however is not enough. What is important is feedback (Facer, 2014). When teachers mark student's books, they need to spend time doing something with that marking by giving feedback. At the end, teachers must write an encouraging comment unless they have been truly lazy. Students must be given time to go back and improve their writing.

5.6 Research Question 5 - What are the outcomes of FAST feedback methods on chemistry teaching?

Effective feedback is essential for the learner's growth and professional development. With practice, the teacher will develop his/her own strategy to effectively deliver motivational and useful feedback to learners of all levels. Effective feedback is FAST: frequent, accurate, specific, and timely. The results of students' responses to the worksheets in the five lessons coupled with the classroom oral discourses (PoISR: Key Findings 24-32) prove that, FAST feedback method when used as a teaching strategy in chemistry classrooms yields positive results. Students were able to score very high marks and also able to give good oral responses to questions posed by their teachers. When teacher's feedback are frequent, accurate, specific and timely, students are assured of what they are learning and their misconceptions are cleared to enable them close the knowledge gap (Brookhart, 2008). One of the toughest yet crucial aspects of being a teacher is providing effective and constructive feedback (Monique, 2014). The teacher whether inside or outside the classroom teaching, will have the responsibility of providing feedback which must be praise and constructive at some point. Although it may be uncomfortable for some, there are many techniques to assist the teacher with provision of verbal and written feedback to a learner. The key to effective feedback is the timing and the environment in which the feedback is delivered (Monique, 2014).

The intervention and post-intervention results reveal that FAST feedback provides a key feature for effective chemistry learning. Instructional effect of FAST feedback on the tests as per the worksheets was positive. Bangert-Drowns, Hurley and Wilkinson (2004) did a meta-analysis of 58 experiments taken from 40 reports and it revealed that the effects of feedback were reduced if students had access to the answers before the feedback was conveyed. When this effect had been allowed for, it was then the quality of the feedback which was the largest influence on performance. Feedback is most effective when it is designed to stimulate correction of errors through a thoughtful approach to them in relation to the original learning relevant to the task. Kluger and DeNisi (1996) cited in Krenn, Würth and Hergovich (2013), noted that both positive and negative feedback can have beneficial effects on learning.

Feedback provided by teachers' written responses to students' homework show big effect associated with the feedback treatment. During classroom discourse, commitment to goals is a major mediator of the effectiveness of positive and negative feedback. Van Djik and Kluger (2011) demonstrated that positive feedback increases motivation relative to negative feedback for a task that people "want to do" and decreases motivation relative to negative feedback for a task that people "have to do." Disconfirmatory feedback can also have a negative impact on subsequent motivation and performance for low self-efficacious students (Brockner, Derr, & Laing, 1987; cited by Hattie & Timperly, 2007) argued that low self-efficacious people are more likely to react to negative feedback by experiencing negative effect, exhibiting less motivation on a subsequent task, and attributing the feedback less to effort and more to ability.

5.7 FAST Feedback in Classrooms

FAST feedback model highlights the demands on teachers if they are to teach effectively. First, teachers need to undertake effective instruction and feedback is what happens second. To make the feedback effective, teachers need to make appropriate judgments about when (T), how (A), and at what level (S) to provide appropriate feedback and to which of the questions should be addressed. Such feedback given to students must be done a number of times (F) since repetition helps students to learn well and to remember what is learned. It is difficult to document the frequency of feedback in classrooms, except to note that it is low. Bond, Smith, Baker, and Hattie (2000) intensively documented the daily life of 65 teachers (half who had passed national board certification and half who had not). Although feedback was one of the variables that most discriminated between those who did and did not pass certification as "accomplished" teachers, the frequency was low in the classrooms of both groups (the most common form of feedback was praise).

The climate of the classroom is critical, particularly if disconfirmation and corrective feedback at any level is to be welcomed and used by the students (and teachers). Errors and disconfirmation are most powerful in climates in which they are seen as leading to future learning, particularly relating to processing and regulation. Student engagement in learning is likely to be constrained by the evaluative dimensions of classroom lessons because there is personal risk involved in responding publicly and failing. Too often, the level of risk is determined by the likelihood that a student can supply an answer and by the accountability climate set up by the teacher and other students. Typically, students respond only when they are fairly sure that they can respond correctly, which often indicates they have already learned the answer to the question being asked. Errors, and learning from them, are rarely welcomed. Simply providing more feedback is not the only answer, because it is necessary to consider the nature of the feedback, the timing, and how a student "receives" this feedback (or, better, actively seeks the feedback).

As already noted, students can be biased in their bid to select feedback information. The ways and manner in which individuals interpret feedback information is the key to developing positive and valuable concepts of self-efficacy about learning, which in turn leads to further learning. Teachers need to view feedback from the perspective of the individuals engaged in the learning and become proactive in providing information addressing the five feedback research questions and developing ways for students to ask these questions of themselves. Students, too often, view feedback as the responsibility of someone else, usually teachers, whose job it is to provide feedback information by deciding for the students how well they are going, what the goals are, and what to do next.

There are many ways in which teachers can deliver feedback to students and for students to receive feedback from teachers, peers, and other sources. The implication is not that we should automatically use more tests (Bangert-Drowns, Kulik, & Kulik, 1991). Rather, for students, it means gaining information about how and what they understand and misunderstand, finding directions and strategies that they must take to improve, and seeking assistance to understand the goals of the learning. For teachers, it means devising activities and questions that provide feedback to them about the effectiveness of their teaching, particularly so they know what to do next. Assessments can perform all these feedback functions, but too often, they are devoid of effective feedback to students or to teachers.

5.8 Summary

This chapter discussed the key findings of the study alongside with the research questions which directed the study. For the pre-intervention study, the chapter identified general findings which emerged out of the teachers and student's questionnaires which were triangulated by the teachers' interviews and the observation schedules. Discussion on the post intervention worksheets results and the probe into the classroom discourses by employing FAST feedback methods also yielded some general results. Finally, the summary of the general findings is presented in Table 30.

https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

Table 32 Summary of the General Findings

Type of feedback	*Ideal*	*Actual*
Frequent	Teachers are to give feedback frequently to students to enable them identify the errors they make whilst responding to teachers questions. Frequent feedback also help students to change their misconceptions and accept the desired knowledge.	Teachers who participated in the study were not able to provide frequent feedback to students due to large class size, time constraints, extracurricular activities, lack of motivation, the broad nature of the curriculum, Out-of-field teachers, Lack of in-service training and negative attitudes of some teachers.
Accurate	Teachers should provide accurate feedback to help students change their misconceptions to enable them close the knowledge gap.	Teachers are not able to give accurate feedback to students due to (i) halo effect teachers have about some students tagged as "good students", (ii)tiredness, (iii) limited time for research and (iv) large class size
Specific	Specific feedback makes significant difference in students' achievement. Use of predetermined criteria help give specific feedback to students. Specific feedback is responsive to specific aspects of students work. Teachers with high PCK are able to provide better specific feedback.	Teacher-participants are unable to give specific feedback to students, due to their; (i) failure to use pre-determined criteria(ii) insufficient knowledge of subject matter (iii) failure to provide specific clues that could help students provide correct answers.
Timely	Research indicates that timely feedback have better effects for students' learning. Timely feedback informs learners when their problem-solving processes went wrong.	Teachers who participated in the study delayed giving feedback to their students. Teachers are not well motivated to go the extra mile in giving timely feedback. The desire to complete the syllabi also encourages delayed feedback.

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https://damaacademia.com/sjms/ May 2020 Pages: 47- Volume 2 | Issue 5

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