Doctoral Dissertation

Science Teaching, Classroom Discussion and Contexts in Junior High Schools in Ghana

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DEDICATION

This dissertation is dedicated to all school-age children in Africa

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What shall I render to my God
For all His mercy's store?
I'll take the gifts He hath bestowed,
And humbly ask for more (Charles Wesley)

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LIST OF ACRONYMS

B.E.C.E	Basic Education Certificate Examination
CA	Correct Answer
CRDD	Curriculum Research and Development Division
G.C.E	General Certificate of Education
G.E.S	Ghana Education Service
IAR	Inaudible Response
ICA	Incorrect Answer
ICR	I can't Response
INR	Incomplete Response
JHS	Junior High School
JSS	Junior Secondary School
NI R	No Idea Response
NR	No Response
RPR	Repeated Response
SA	Student Answer
TIMSS 1999	Third International Mathematics and Science Study 1999
TIMSS 2003	Trends in Mathematics and Science Study 2003
TIMSS 2007	Trends in Mathematics and Science Study 2007
TQ	Teacher Question
TRB	Teacher Response Behavior
TRM	Teacher Response Model

UCR	Unclear Response
3-Year TTC Cert A	Three-Year Teacher Training College Certificate A
4-Year TTC Cert A	Four-Year Teacher Training College Certificate A

ABSTRACT

Introduction

Basic education in Ghana, consisting of six years of primary school and three years of junior high school (JHS) education, is faced with many problems. Subjects such as science and mathematics are associated with low learning results (Martin, Mullis & Foy, 2008; Postlethwaite & Wiley, 1992). The poor learning achievements are attributed to poor quality of teaching (GES, 2004). Science teaching is mainly typified by teacher-centered approach (Ottevanger, Akker & Feiter, 2007), rote learning and memorization of facts (Odhiambo, 1972), and teacher presentation of factual knowledge (Quartey, 2007). This approach to teaching and learning reduces the ability of students to engage in verbal interaction which plays an important role in meaning-making. Therefore, this study investigated science teaching, classroom discussion and contexts. It is underpinned by the conception of instruction as a relationship between an individual learner, the instruction, something to be learned, the learning outcome (Bloom, 1976), and the teacher.

Methodology

This study used Third International Mathematics and Science Study (TIMSS) 1999 video study methodology, Matsubara (2009) lesson analysis method, Anderson et al. (2001) taxonomy table (adapted), Teacher Intentions (TI) lesson analysis framework and Teacher Response Behavior (TRB) lesson analysis method developed by this study. The mixed methods research design (quantitative and qualitative) was used. However, this study relied primarily on qualitative measures like interviews, video captured data, and direct observations. The data was collected in 2008 and 2009 by video cameras, TIMSS 1999 video study science teachers' questionnaire, and semi-structured interview guides developed in this study.

Descriptive statistics were carried out on the TIMSS questionnaire, and the interview and the video captured data were analyzed using TIMSS 1999 video study analysis method for science, Matsubara (2009) lesson analysis method, Anderson et al. (2001) taxonomy table, TI lesson analysis framework and TRB lesson analysis method. The TIMSS 1999 video study analysis method covered 11 dimensions such as science content development, classroom talk, and activity structures. The main features of Matsubara (2009) lesson analysis method were a move (a set of a teacher's question and a student's response) and category system which consists of No student

response, Teacher-led response, and Non-led response. Anderson et al. (2001) taxonomy table was used to determine the cognitive and knowledge dimensions of teacher questions and students' answers, and TI lesson analysis framework was used to classify teacher intentions behind questions. TRB lesson analysis method was used to analyze how science teachers respond to students' correct or incorrect answers and no responses. The analysis of the video captured and interview data were informed by the work of Miles and Huberman (1994).

Twenty-three JHS science teachers (19 males and four females) in 20 schools were selected, and each teacher taught a science lesson that was observed in camera. The average age of the teachers was 29 years. In addition, 10 head teachers in the JHS (seven females and three males) with an average age of 49 years took part in the study. Furthermore, 12 of the science teachers and 34 students were later interviewed.

Results and Discussion

Science Teaching

Factors that influence the selection of lesson content by science teachers in Ghana

Science teachers' decision to select lesson content was greatly informed by curriculum guidelines, mandated textbooks, and external examination and standardized tests. This is because science teachers mainly use curriculum materials like science syllabuses, mandated textbooks and Basic Education Certificate Examination past questions.

Organization of lesson time

Science teachers spent most of their lesson time on science instruction, whole class work, seatwork activities, and teacher presentation sessions but very little time was spent on independent work, practical activities and discussion. Science teachers need to organize lesson time effectively on various classroom activities and actively involve students in lessons.

Classroom Discussion and Contexts

Students' cognitive involvement in classroom discussion

Students' answers were usually a demonstration of knowledge, Yes or No responses that were teacher-led, and nonverbal nonphysical responses. Teachers need to use questions to elicit student thinking, regularly invite questions from students, and encourage responses from students.

Knowledge and cognitive dimensions in teacher questions and student answers

Science teachers placed greater emphasis on eliciting factual knowledge rather than other knowledge dimensions. Besides, they stressed recall and played down high order cognitive processes. Furthermore, most of the students' answers were a recall of factual knowledge. Teacher questions need to stress remember, understand, apply, analyze, evaluate, and create cognitive processes as well as factual, conceptual, procedural information, and meta-cognitive knowledge dimensions.

Teacher intentions behind questions

The intentions of the science teachers in this study were mainly to check students' knowledge and focus in the lesson. This limits students' ability during discussions so teacher intentions need to target eliciting student thinking and nurturing student understanding.

Teacher response behaviors to students' answers or no responses and students' feeling

TRB to students' correct or incorrect answers and no responses have been reported. These are encouraging, using, judging, finding out, rejecting, ignoring, and discomforting behaviors. Generally, the students felt happy and motivated after TRB to their correct answers, but mainly discouraged and shy after TRB to their incorrect answers and no responses.

Self-confidence, self-learning and shy-timidity influenced classroom discussion in this study. Self-confidence in students is a result of teacher actions like recognizing students' effort at attempting to answer questions, and using positive reinforcement. Using incorrect answers, finding out about responses and using students to judge answers lead to self-learning. Finally, teacher responses like ignoring and rejecting students' answers and those that cause discomfort to students were put under shy-timidity.

Appropriate teacher response behaviors include encouraging, judging, finding out, and using teacher response behaviors. These positively reinforce students' response behavior. Encouraging and using TRB strengthen students' self-confidence, and judging and finding out TRB promote self-learning in students.

A Teacher Response Model (TRM) for managing students' answers to teacher questions, informed by teacher response behaviors that promote self-confidence and self-learning in students, is recommended as appropriate for science teachers. This model is guided by the conception that every answer (correct or incorrect) is a useful tool for developing lesson content. TRM has five levels. Levels 1, 2 and 3 require that teachers recognize, commend, and use students' correct and incorrect answers as valuable contributions in developing lesson content. Level 4 allows teachers to strategically probe students' answers, and level 5 calls for teachers to modify teacher response behaviors or be flexible in responding to students' incorrect answers or no responses.

Conclusion

Summary, conclusion and recommendations

Science teachers in Ghana do not organize lesson time for effective classroom practices, and curriculum factors mainly influence their decision to select lesson content. The government needs to manage science education, and capacitate science teachers by either supporting programs or acquiring resources aimed at improving the quality of science teaching.

Science teachers stressed recall of factual knowledge rather than eliciting high order cognitive processes and conceptual, procedural and meta-cognitive knowledge dimensions. The quality of students' answers and thinking is a reflection of teacher questions, so the cognitive processes and knowledge dimensions need to be appropriately stressed.

In this study, teacher response behavior to students' answers and no responses are encouraging, using, judging, finding out, rejecting, ignoring, and discomforting response behaviors. The students generally felt discouraged after teachers respond to their incorrect answers and no responses.

Self-confidence, self-learning and shy-timidity were identified as factors that influence classroom discussion. TRB to students' incorrect answers that lead to shy-timidity among students are mainly practiced by the science teachers in this study in Ghana, and this leads to low involvement of students in classroom discussion. Self-confidence and self-learning traits in students enhances classroom discussion so science teachers need to engage in response behaviors that promote self-confidence and self-learning in students, and avoid those that breed shy-timidity. Therefore, TRM is recommended for managing students' answers and no responses.

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Education in Ghana before the colonial time was offered through an informal system where the school was the home, and the teachers were the parents and elders in the family and community (Eyiah, 2004). The curriculum was life, and learning was by observation (Eyiah, 2004). Informal education was later complemented with formal education to meet the fresh needs of the Ghanaian. The first schools were set up by European merchants and missionaries (Eyiah, 2010) in the 16th century. Formal education started with the colonial government in the form of castle schools. The first schools in Ghana were established in the castles built by the Portuguese, hence, popularly called Castle schools (McWilliam & Kwamena-Poh, 1975). These schools were established in the castles along the coast of Ghana (known as Gold Coast before independence) in the 1600s and later became colonial schools (since these schools were under the management of Great Britain during the colonial period) in the 1800s (Eyiah, 2004). The castle schools were followed by mission schools (ibid.), and in the 1830s and 1850s, the Wesleyan and Basel Missionaries established schools in Cape Coast, Dixcove, Anomabu, Accra, and Akropong (ibid.). A formal state education modeled on the British system was followed during the colonial period (Eyiah, 2010).

Since Ghana gained independence from British rule in 1957, subsequent wide reforms have brought the structure of the educational system closer to an American model aiming to make education more responsive to the nations' manpower needs (Eyiah, 2010). The structure of education has been through a series of systems: 6-4-7-4, six years primary school education, four years middle school education, seven years secondary school education, and four years university education (before educational reforms in 1987); 6-7-4, six years primary school education, seven years secondary school education of five year Ordinary level and two years Advanced level education, and four years university education(before the educational reform in 1987 which run parallel with the 6-4-7-4 system); and 6-3-3-4, six years primary school education, three years junior secondary school education, three years senior secondary school education, and four years university education (1987 –2006), and 2-9-4-4 which comprises of two years of pre-school education, nine years of compulsory basic education; four years of senior secondary school education; and four years of tertiary education(2007-2009). Compulsory basic education in Ghana is made up of six years primary school education and three years of junior high school (JHS) education.

Currently (since 2010), the educational system in Ghana is 2-9-3-4 that consists of two years of pre-school education, nine years of compulsory basic education; three years of senior secondary school education; and four years of tertiary education.

Education is one of the essential tools for national development. The level of socio-economic development in the country is strongly linked to education. It is vital for nation building by providing manpower with necessary skills, knowledge (Ahmed, Ming, Jalaluddin, & Ramachandran, 1991; Quartey, 2007; Rogan, Nagao & Magno, 2008) and attitudes (Ahmed, Ming, Jalaluddin, & Ramachandran, 1991). The provision of basic learning needs and the acquisition of life skills are nurtured by basic education.

However, education is faced with many problems in Ghana. Over the years education has not been able to achieve expected outcomes and transform the country into an economic force in the abundance of numerous natural resources. For instance, Singapore, South Korea, and Malaysia had their independence about four-five decades ago, similar to Ghana, but they are now ahead of Ghana in terms of socio-economic development due to the improvement in education. Compared with these countries that were almost at the same level, Ghana has many natural resources like gold, timber, cocoa, diamond and bauxite, whereas they (Singapore, South Korea and Malaysia) do not. But, in 2008, the Gross National Income per capita (purchasing power parity), for Singapore, South Korea, and Malaysia were US$ 47,940, US$ 27,840, and US$ 13,730 respectively while that of Ghana was only US$ 1,320 (The World Bank, 2010). Furthermore, there has been a phenomenal improvement in the quality of education in these countries compared to Ghana. For instance, Singapore, South Korea, and Malaysia outperformed Ghana in both Trends in Mathematics and Science Study (TIMSS) 2003 and TIMSS 2007. In TIMSS 2003, Singapore, South Korea, and Malaysia scored 578, 558, and 510 marks respectively, and Ghana scored 255 marks (Martin, Mullis, Gonzalez & Chrostowski, 2004). In addition, in TIMSS 2007, Singapore, South Korea, and Malaysia scored 567, 553, and 471 marks respectively, and Ghana scored 303 marks (Martin, Mullis & Foy, 2008). Though there was slight improvement in light of TIMSS 2003, the score of TIMSS 2007 is yet low.

In Ghana, one of the major challenges facing the education sector is meeting appropriate learning needs and skills training (Basic Education Division Ghana Education Service, 2004). Folson (2006) reported that "despite a number of reforms the Ghanaian education system has not been successful in its main objective of achieving socioeconomic growth" (pp. 140-1). This may be due to the challenges confronting the delivery of quality education in the country such as poor quality of teaching. The poor quality of teaching and learning which affects education delivery for all (Basic Education Division Ghana Education Service, 2004) could be attributed to the nature of instructional practices of teachers.

Instructional practices of science teachers are those actions exhibited by them in class intended to bring about a change in behavior in the students. In other words, these are basically the classroom practices (teaching and learning practices) of science teachers during instruction, and include actions such as teaching methods and strategies. For that matter, instructional practices and classroom practices are used interchangeably in this dissertation.

Classroom practices have led to poor learning outcomes in subjects like science and mathematics over the years. For instance, Ghana (and other developing countries: Nigeria, Zimbabwe and Philippines) performed poorly in science achievement test in the International Studies in Educational Achievement (IEA) study of science II (Postlethwaite and Wiley, 1992). The average scores for Ghana, Nigeria, Zimbabwe and the Philippines were 45.5%, 40.8%, 41.3%, and 38.2% respectively. The students who took part in the study were 2,769, 804, 2,648 and 10,871 from Ghana, Nigeria, Zimbabwe and the Philippines respectively. Furthermore, the percent of schools that scored below 49.4% in Ghana, Nigeria, Zimbabwe and the Philippines were 64%, 88%, 80%, and 87% in that order. This test was administered in 1984 to students in grades where most 14 year olds were found, and focused on the common topics in the intended curriculum in all the 23 countries that participated in the study. It covered biology, chemistry, earth sciences, and physics. The intended curriculum "is that content which is included in national or state syllabi, the major science textbooks used by students, and – where applicable- the national examinations" (ibid., p. 49). Caillods and Postlethwaite (1989) in Postlethwaite and Wiley (1992) noted that the conditions of education in many African countries have been deteriorating, and this was confirmed by the low science scores in the IEA study.

Additionally, in TIMSS 2003, the poor score of 255 marks by Ghana was far below the international mean mark of 474. The science assessment guideline for TIMSS 2003 focused on two organizing dimensions, that is, a content dimension and a cognitive dimension (Anamuah-Mensah, Asabere-Ameyaw & Mereku, 2004). There were five content areas: Life Science, Chemistry, Physics, Earth Science and Environmental Science (ibid.). Items in these disciplines elicited the use of exact cognitive skills in three domains; factual knowledge, conceptual understanding, reasoning and analysis (ibid). The performance of the Grade 8 students in the five science content areas were: Life science, 256; Chemistry, 276; Physics, 239; Earth Science, 254; and Environmental Science, 267 (ibid.). These were considerably lower than the international averages in each of the content areas (ibid., 2004).

Furthermore, the average score (303) of Ghana was poor in TIMSS 2007 compared with the international mean mark of 500. TIMSS 2007 covered science disciplines such as biology, chemistry, physics, and earth science, and focused on knowing, applying, and reasoning cognitive domains. The low cognitive ability of candidates also accounts for students' inability to answer application questions and questions involving calculations in science (West African Examination Council, 2007).

Anamuah-Mensah, Asabere-Ameyaw and Mereku (2004) also reported that "although Ghanaian students placed high premium on science and mathematics, their mean achievement in science and mathematics was only next to the lowest performing country in the two subjects" (p.89). This according to them "could be that though students may be enthusiastic about science and mathematics, the curricula followed by the students in mathematics and science may be less demanding due to factors such as the pedagogical approach and availability of resources" (p.89). Pedagogically, when teachers address the whole class and invites recall with little independent student contribution, it leads to lower scores (Chacko, 1999). Therefore, the poor performance of students could be due to the nature of the existing classroom practices.

Studies on classroom practices have been both quantitative and qualitative. Qualitative studies involving the use of video have mainly been carried out in developed countries (Greenwalt, 2008; Clark, 2007; Borko, Jacobs, Eiteljorg & Pittman, 2006; Roth, Garnier, Lemmens, Chen, Kawanaka, Rasmussen, Trubacova, Warvi, Okamoto, Gonzales, Stigler & Gallimore, 2006; Plowmann, 1999; Stigler, Gallimore & Hiebert, 1999). The studies on classroom interaction in camera were carried out from the viewpoint of developed countries, and thus not easily applicable to the African setting. Therefore, methodologies used in the present study will discuss the applicability to the African context. For example, Third International Mathematics and Science Study 1995 and Third International Mathematics and Science Study 1999 video study methodologies are developed mainly for analyzing classroom interaction of developed countries.

In Africa studies on classroom interaction have mainly been systematic observation of classroom events using quantitative tools. These studies used checklists to score specified classroom coded behaviors. There are only a few studies that have incorporated video recordings to look into classroom behavior that have been reported. Videotaping of science lessons have been utilized in lesson study for the professional development of teachers (Baba & Nakai, 2009; Jita, Maree & Ndlanane, 2008; Ono & Ferreira, 2010; Ozawa, Ono

& Chikamori, 2009). Furthermore, Matsubara (2009) developed a methodology to measure the level of students' cognitive engagement in science lessons in Zambia.

In Ghana, there has been no study involving the use of video to develop a lesson analysis method for investigating science teaching, classroom discussion and contexts in which students learn during classroom interactions. A method for assessing video recording of science lessons is needed to analyze science teaching and the contexts in which learning takes place. This method will have to be culturally responsive. In view of this it is necessary to analyze video data of science lessons in Ghana to reflect the culture of teaching and learning in the country.

1.2 Background to the Problem

Lewis (1972) reports that "the prospects of accelerating the economic and social development of both the developed and developing countries are increasingly dependent on the application of science to the technological exploitation of whatever natural resources are available" (p. 95). Furthermore, Lewis (1972) states that the main task of science education in Africa are twofold:

1. To ensure that every person has such a grasp of science as to be ready to cooperate with understanding in the application of science to men's needs
2. To ensure a sound foundation of the basic principles and facts of science in those who seek to make careers and serve society as scientists or technologists (p. 97)

In Ghana scientific knowledge has been identified as a necessity for economic growth since science education is the backbone for national development. The two main goals of science education in the country are to instill "scientific literacy and culture for all, so that people can make informed choices in their personal lives and approach challenges in the workplace in a systematic and logical order" (MOE, 2007, p. ii), and "to produce competent professionals in the various scientific disciplines who can carry out research and development at the highest level (ibid.). It has been acknowledged that "modern life requires general scientific literacy for every Ghanaian citizen, a requirement that will result in the creation of a scientific culture in line with the country's strategic programme of achieving scientific and technological literacy in the shortest possible time" (MOE, 2007, p.

ii). Furthermore, scientific culture is regarded as “the catalyst that will help us toward faster development” (ibid).

Science education in Ghana need to target nurturing individuals to acquire desirable scientific knowledge and skills, and attitudes. The attainment of this to a very large extent is a reflection of the nature of classroom instructional practices, and this greatly depends on science teachers. Science teachers exert a significant influence on students in the classroom. They are central to the delivery of quality education (Ministry of Education, 2004). Teacher quality influences the quality of education (Hallak, 1990), and has a major effect on students’ learning outcomes (Fabunmi, 2007). Scientific literacy is well cultivated in the classroom through instruction. The way science teachers behave in class will determine the effective development of scientific knowledge among students.

Exemplary classroom practices are needed to ensure better quality of science education in Ghana. These practices have been identified as helping to improve the quality of classroom instruction. For example, exemplary teachers have greater representational and adaptational repertoire for teaching basic concepts (Clermont, Borko & Krajcit, 1994), are shown to set academic tasks that are cognitively demanding (Treagust, 1991), and apply science to real life situations outside the classroom (Tobin & Garnett, 1988). They also “utilized strategies that encouraged students to participate in learning activities” (Tobin & Fraser, 1990, p. 14); and “were effective in a range of verbal strategies which included asking questions to stimulate thinking, probing student responses for clarifications and elaboration, and offering explanations to provide students with additional information” (ibid., p. 13). Other exemplary classroom practices show that teachers: assess student understanding through content and practical test, and project work; organize the use of equipment very well and efficiently distribute to the class; quickly detect off-task behavior and responded appropriately to them; and are conscious of time management and use certain organizational skills during activity based lessons (Goodrum, 1987).

These exemplary teaching practices exert a strong influence on enhancing classroom instruction in developed countries but are not common in African classrooms. Pedagogies that control classrooms in sub-Saharan Africa are largely: traditional, note-taking, and teacher-centered and content-driven (Ottevanger, Akker & Feiter, 2007). Teachers dominate classrooms (Bassey, 1999). They “deposit knowledge in their students and make withdrawals through the process of testing, quizzes and Socratic questioning” (ibid., p. 85). This breeds passivity, conformity, obedience, acquiescence, and unquestioning acceptance of authority (Bassey, 1999).

Furthermore, the major problems that confront the teaching of science in Africa are inadequate resources for science (Ottevanger, Akker & Feiter, 2007), poor or non-existent training of teachers in science, the rigid adherence to the syllabus, and learning by rote (Odhiambo, 1972). Postlethwaite and Wiley (1992) reports that 67% of teachers perceive science teaching to be hindered by the lack of equipment, and Akyeampong, Pryor and Ampiah (2006) point out that classroom interaction generally tasks students to memorize correct answers or procedures rather than encouraging them to develop knowledge by themselves.

In Ghana, the situation is not different. Science teaching is centered on rote learning and memorization of facts (Fredua-Kwarteng & Arhia, 2005). Learning by rote may have a deeper origin (Odhiambo, 1972). For example, as part of the cultural heritage for the country is the respect for the elderly, that naturally includes teachers (Hassard, 2005). Elders are regarded as custodians of knowledge, and the teacher represents the proverbial “sage on stage” (ibid.). This belief has a strong effect on teaching and learning and “the result is that children are less apt to ask questions in class and the teacher is the final authority of knowledge” (ibid., p.150). Furthermore, “obedience, memorization of material, and the “direct delivery” approach were all a part of the ecclesiastical scholasticism Ghana inherited in the early missionary days of education-and such went to buttress the cultural tendency to do the same” (ibid.). In addition, Beccles (2010) reported that the learning goals of science instruction in Ghana are driven toward knowing science information, rather than understanding scientific ideas and doing science.

Science teaching is mainly characterized by teacher presentation of factual knowledge (Anamuah Mensah, 1999 a; Acheampong, Pryor & Ampiah, 2006; Quartey, 2007) in Ghana. This may be due to the fact that there are inadequate teaching and learning materials to support science instruction (Beccles & Ayebi-Arthur, 2009), and inadequate or no practical work in science lessons. Therefore, students lack practical experience and cannot answer questions based on practical work (West African Examination Council, 2008). Additionally, students do not interact evenly with the few teaching and learning materials available during instruction (Beccles & Ayebi-Arthur, 2009), and this promotes the presentation of factual knowledge by teachers. Teachers exhibit behaviors such as 'chalk and talk' approach, reading from textbooks, and copying and dictating notes for students to write down (Quartey, 2007). However, "chalk and talk" lecturing is effective when it accommodates children's attention span and used for brief periods (Abadzi, 2006), but its prevalence in science classes, which is the case in Ghana, makes it an issue of grave concern.

Teacher presentation of factual knowledge reduces the ability of students to engage in verbal interaction which plays an important role in their understanding. There is low content of discussion with very little room for questioning, and the participation and quality of the classroom discussion will also depend on how teachers respond to answers from students and handle other utterances from students.

In addition, many teachers "do not know how to introduce lessons, how to explain, how to stimulate and motivate students to learn, how to ask questions, how to set students thinking, and how to close a lesson" (Quartey, 2007). They do not tell students about the objectives and purpose of teaching the lesson, and do not have a teaching philosophy that guides them in carrying out their work (ibid.).

Teachers in Ghana also "integrated textbooks into instruction by copying passages and exercises from the textbooks onto the chalkboard and then engaged the pupils on the chalkboard in the teaching and learning of science, mathematics and English (Okyere, 1999, p. 72). Many teachers also prefer students to reproduce what they teach and the notes they give, and this limits critical thinking and creativity on the part of the students (Quartey, 2007). Furthermore, "child-centered techniques such as pair-sharing, pyramiding, group discussion, panel presentation, debates, co-operative learning are completely absent in Ghanaian classrooms" (ibid., p. 4).

These classroom practices have led to the poor performance in science over the years. Pupils perform low in science, technology and mathematics in basic education (Ghana Education Service, 2004; Martin, Mullis, Gonzalez & Chrostowski, 2004; Martin, Mullis & Foy, 2008; Postlethwaite & Wiley, 1992). In Ghana "the issue of the provision of quality education delivery has been identified as a matter of great concern to the MOEYS " (Basic Education Division Ghana Education Service, 2004, p.28). The poor learning achievement in Ghana is due to poor quality teaching (Anamuah-Mensah, Asabere-Ameyaw & Mereku, 2004; Basic Education Division, Ghana Education Service, 2004; De Heer-Amissah et al, 1994). The problem of poor quality teaching and the low ability of students to engage in verbal interaction in basic schools across the country set the stage for an investigation into science teaching, classroom discourse and its contexts. This is necessary as methods are being sought by which science instruction in basic schools can be improved.

1.3 Purpose of the Study

This study was designed to investigate science teaching, classroom discussion and contexts in junior high schools in Ghana. It also examined whether science teachers' response behavior to students' answers and no responses would lead to the realization of the goals of science education in the country. It is guided by the following research questions.

- Science teaching

(Q 1) How do science teachers spend their time on different school activities?

(Q 2) What are factors that influence the selection of lesson content by science teachers?

(Q 3) What is the background information of JHS science teachers?

(Q 4) How do science teachers organize lesson time for various classroom practices that involve social interaction like classroom talk, classroom discussion, studying science, science content development, social organization settings, practical and seatwork activities, and other pedagogical functions in science teaching?

- Classroom discussion and contexts in JHS in Ghana

(Q 5) What is the level of students' cognitive involvement in classroom discussion?

(Q 6) What are the knowledge and cognitive dimensions in teacher questions and students' answers in classroom discussion?

(Q 7) What are teachers' intentions behind questions used in classroom discussion?

(Q 8) How do science teachers respond to students' answers and no responses in classroom discussion?

(Q 9) What are the causes of students' no responses in classroom discussion?

(Q 10) How do students feel after teachers respond to students' answers and no responses?

(Q 11) What factors influence/affect classroom discussion?

(Q 12) What are the appropriate teacher response behaviors to students' answers and no responses?

(Q 13) What are students', science teachers' and head teachers' views about science teaching, classroom discussion and contexts?

1.4 Overview of Methodology

This study mainly used purposive sampling to select both the districts and the schools. Data was collected by using TIMSS 1999 video study science teachers' questionnaire and videotaping procedures, and semi-structured interview guides newly developed in this study. Descriptive statistics were carried out on the questionnaire, and the interview and the video captured data were analyzed using a simplified version of Third International Mathematics and Science Study 1999 video study analysis method for science, Matsubara (2009) lesson analysis method, Anderson et al. (2001) taxonomy table, Teacher Intentions lesson analysis framework and Teacher Response Behavior (TRB) lesson analysis method developed by this study. Following these methods, the findings were discussed and conclusions were also drawn.

1.5 Significance of the Study

The results of the study will provide a resource for improving science teaching in Ghana and other developing countries with similar cultural background. Knowledge about science teaching and what influences this action; organization of lesson time with good classroom practices; and classroom discussion and contexts, will inform classroom teachers on how to develop the teaching and learning of science.

The outcome of the study will also guide policy making and formulation processes by considering the factors that yield effective science teaching and learning. Policy makers, advisors, implementers, and all the stake holders in education will be informed about contemporary ingredients for effective teaching and learning of science.

This study is also believed to promote both reflective teaching of science and serve as a resource to develop school-based in-service training programs in basic schools in the country. Video recording of science lessons will sensitize the science teachers in this study, and those with proximal similarity characteristics, to have a retrospective reflection of their instructional practices. It will also recommend instructional practices for science teachers to follow to maximize the effective use of instructional time and yield positive learning outcomes.

Furthermore, it will sensitize the Ghana Education Service, National Teachers Council, teacher training institutions, basic schools, and science teachers, on the need to integrate videotaping of lessons for reflective teaching practices during pre-service and continuing professional development activities.

In addition, this study will be the gateway for video studies of classroom practices across the country. Observing lessons closely reveals how students learn science. The behavior of students in learning science is well investigated in camera. However, even though the student should be at the center of educational effort, very little research has targeted the individual student (Brophy & Good, 1974; Thorsten, 2007) and the learning process in the classroom. Most studies have rather focused on effective methods of teaching but not on effective methods of learning. Furthermore, Harnischfeger and Wiley (1976) asserts that "the how of teaching is usually conceived too narrowly" (p. 11). It is mistakenly considered as simply teaching technique or style. They claim that teaching is just not passing on curricular content but also "deciding how to parcel that content out for different pupils, in different amounts and various fashions" (ibid., p.7). However, studies have focused mainly on teacher behavior and disregarded pupils' activities, and the interaction between the teacher and pupil (Harnischfeger & Wiley, 1976). In this regard, this could explain why teachers have little knowledge about classroom practices (Brophy & Good, 1974) and how knowledge is constructed during lessons. Clarke (2004) reported that our ability to enhance classroom learning depends on seeing classroom situations from the perspectives of all participants.

In view of this, analyzing video recordings of classroom interactions is seen as a timely intervention to investigate pupils' pursuits and the interaction between teachers and pupils as methods are being sought by which science instruction in basic schools in Ghana can be improved. Video studies simultaneously focus on teacher and student behavior, classroom tasks, and the development of lesson content in the teaching and learning process.

Video recordings of science lessons capture the actions of teachers and students, and makes a minute-to minute thorough investigation into how students "learn science as a process and learn about science in a way that is meaningful" (Tobin, Tippins & Gallard, 1994, p. 46) possible. The wealth of information in video recordings allows researchers access to some of the complexities of learning experiences (Plowman, 1999) occurring in the classroom. Videotaping of science lessons also ensures "the permanence of the record, the retrievability of data to share with others, being able to check findings and easy reinterpretations" (ibid., p. 1).

Video studies in education also exert an influence in shaping classroom instruction. In video analysis "the signs that organize knowledge construction can be decoded in the video feedback" (Tochon, 2007, p. 54). Visual representation "provides a handle to enter the dynamic and continually emerging nature of how knowledge is both created and revealed to self and to other" (Goldman, 2007, p.18). Video records reveal actors, their words and actions within a developing cultural context (Green et al., 2007). It "allows a slow down and multiple viewings" (Goldman & McDermott, 2007, p.111) and enables "analysts to keep track of how observations develop systematically (ibid). The "speaker-hearer interaction is central" (Green, Skukauskaite, Dixon & Cordova, 2007) to the analysis of classroom verbal interaction. Video also provides a mirror image for those who are videotaped to reconsider their actions (Tochon, 2007) and "makes communication visible and potentially reveals behavior nested across levels in precarious and contested interactions (Goldman & McDermott, 2007, p.112).

In addition, the opportunities available to students for learning during science lessons are clearly revealed in video analyses of classroom interactions. Video studies show how language and social interaction relate with pedagogical strategies to shape classroom interaction and the learning of science. Videotaping of classroom interaction afford analysts a platform to closely monitor and investigate deeply what goes on in class when students learn science, teacher and student behaviors during instruction and what influences these actions, classroom activities that cultivate inquiry among students and develop student interest in learning science, the organization of lesson time for various classroom practices, and other pedagogical strategies used by teachers. From these viewpoints, analysts can develop pedagogical strategy models suitable for the teaching and learning of various scientific ideas, students of different ability levels, and physically challenged students. Furthermore, new pedagogical strategies that make the teaching and learning of science easy, interesting and effective are likely to evolve from careful and deep analysis of video recording of classroom interactions.

In addition, there is no study that has used a developed lesson analysis method to evaluate video captured data of science lessons. The use of video to analyze lesson transcripts, the behaviors of teachers and students, and examines lesson content, learning outcomes, and pedagogy are generally lacking in Ghana. Therefore, the use of methods that allow close examination of the interaction between the student, instruction/classroom tasks, lesson content, learning outcome, and the teacher is thus significant and will uncover the complexities of how students learn science.

1.6 Delimitations of the Study

The study was delimited to selected JHS in five districts in Ghana. It was also defined to science teaching, classroom discussion and contexts. The science teaching was delimited to the time science teachers spend on different school activities, what influences science teachers' decision to select lesson content, background information of science teachers, and the organization of lesson time.

The contexts of the classroom discussion were defined to students' cognitive involvement in science lessons, the knowledge and cognitive dimensions of science teachers' questions and students' answers, teachers' intentions behind questions, and science teachers' response behavior to students' answers and no responses.

The other contexts were the causes of students' no responses, students' feeling after teachers' response behavior to students' answers and no responses, appropriate teacher response behavior to students' answers and no responses, factors that influence/affect classroom discussion, and the views of participants about science teaching, classroom discussion and contexts.

1.7 Organization of the Dissertation

The dissertation is organized into six chapters (Figure 1.1). Chapter 1 is the introduction. It contains the background of the study, background to the problem, purpose of the study, and the overview of the methodology. It also covers the significance of the study, delimitations of the study, organization of the dissertation, definition of terms, and the list of acronyms.

Chapter 2 reviews related literature on instructional practices of science teachers, organization of lesson time, classroom discussion and contexts, video studies, learning theories, and the philosophy of teacher questions. It also describes the theoretical and conceptual framework of the study.

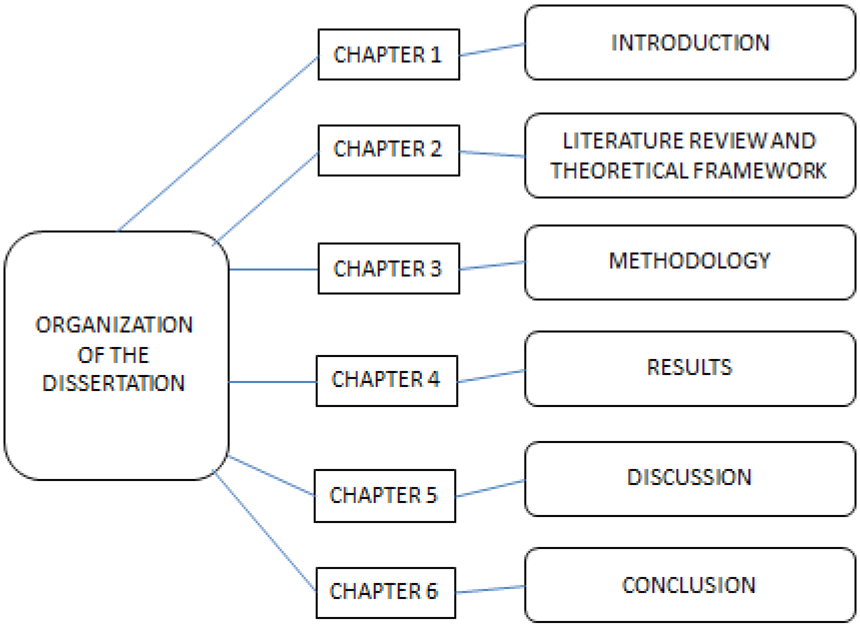

Figure 1.1. Organization of the dissertation

Chapter 3 describes the research design, population and sampling procedures, data collection process, data analysis, and code development.

Chapter 4 is the presentation of results of the study on science teaching. This covers the time science teachers spend on different school activities, factors that shape instructional practices among science teachers, background information of science teachers, and instructional organization of lesson time. It also contains sections on classroom discussion and contexts such as students' cognitive involvement in classroom discussion, knowledge and cognitive dimensions in teacher questions and student answers, teacher intentions behind questions, teacher response behavior to students' answers and no responses, and students' feeling after teacher response behavior to students' answers and no responses. The rest are factors that shape classroom discussion, participants' views about science teaching, classroom discussion and contexts, and appropriate teacher response behavior to students' answers and no responses.

Chapter 5 discusses the results of the study on science teaching, classroom discussion and contexts. It also describes a Teacher Response Model for managing students' answers and no responses, and contains sections on validity measures and the limitations of the study.

Chapter 6 presents the conclusion and recommendations of the study.

CHAPTER 2

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Instructional Practices of Science Teachers

Studies on exemplary teaching practices have revealed that science teachers used well-developed classroom management strategies that facilitated sustained student engagement (Tobin & Fraser, 1990; Goodrum, 1987). The teachers "actively monitored student behavior in their classes by moving around the room and speaking with individuals from time to time, but they also maintained control at a distance over the entire class" (ibid, p. 12). Tobin, Tippins and Gallard (1994) assert that "monitoring student engagement was crucial so that teachers could ensure that their expectations were translated into appropriate classroom behavior and engagement" (p. 53). Some science teachers also used small-group work and whole-class interactive activities and monitored consistent student engagement (Tobin & Garnett, 1988). The use of whole-class interactive classroom settings "was facilitated by the organization of students into a square seating arrangement so that eye contact was possible between most students" (Tobin & Fraser, 1990, p. 14). This was "to focus discussion on the teacher who was seated at the center of one side" (ibid, p. 14).

Tobin and Fraser (1990) in their study revealed that "exemplary science teachers used strategies designed to increase student understanding of science" (p. 13). For instance, "in elementary grades, the activities were based on the use of materials to solve problems and, in high-school grades, teachers often used concrete exemplars for abstract concepts" (ibid, p. 13). It was also reported that exemplary science teachers "were effective in a range of verbal strategies which included asking questions to stimulate thinking, probing student responses for clarifications and elaboration, and offering explanations to provide students with additional information" (Tobin & Fraser, 1990, p. 13). Also, according to Garnett and Tobin (1988), one exemplary chemistry teacher tasked students through questioning to apply what they had learnt to different and new situations to concretize learning , and another teacher attributed his effectiveness to his "ability to clearly explain new material to his students" (p. 5). The latter carefully linked new material to students' previous knowledge (ibid).

Exemplary science teachers also used: materials-centered approach with structured worksheets, team teaching approach, and materials-centered inquiry approach (Goodrum, 1987). Lesson taught by three exemplary science teachers over a two-month period revealed that, generally, instructional behaviors of the teachers involved describing the problem, engaging students to investigate the problem through observation, measurement and construction, and discussing the solution among the students (ibid.).

Treagust (1991) in a case study of two biology exemplary teachers further reported that "both teachers encouraged learning from students of different ability levels" (p. 333). The teachers provided special attention to the weak and able students (ibid). Tobin and Fraser (1990) also reported that one exemplary science teacher involved weaker students who do not talk in class by calling them by their names to read their written answers to questions, and later using their answers for discussion. In addition, exemplary teachers used inquiry through laboratory work during lesson (Treagust, 1991). The inquiry-based activities did not aim at verifying facts and principles, but rather encouraged student independency and curiosity (Treagust, 1991). Other exemplary classroom practices show that teachers assessed students understanding through content and practical test, and project work, organized the use of equipment very well and efficiently distributed to the class; quickly detected off-task behavior and responded appropriately to them, and were conscious of time management and used certain organizational skills during activity based lessons (Goodrum, 1987).

Conversely, instructional practices in Ghana are mainly typified by teacher-centered approach (Bassey, 1999; Ottevanger, Akker & Feiter, 2007), rote learning and memorization of facts (Fredua-Kwarteng & Arhia, 2005; Odhiambo, 1972), and teacher presentation of factual knowledge (Anamuah-Mensah, 1999 a; Acheampong, Pryor & Ampiah, 2006; Quartey, 2007).

2.2 Instructional Organization of Lesson Time

Learning time is a critical determinant of student achievement (Bennett, 1978; Caroll, 1963; Denham & Lieberman, 1980; Gettinger, 1985 & 1989; Kane, 1994). Denham and Lieberman (1980) report that maximizing the amount of lesson time and the time students are involved in academic tasks, is correlated with higher student achievement. However, instructional time, with a correlation of about 0.4 with learning outcomes (Walberg, 1984), "is neither the chief determinant nor a weak correlate of learning" (ibid, p. 23). Therefore, "time appears to be a necessary ingredient but not sufficient by itself to produce learning" (ibid, p. 23). It should be planned with appropriate instructional practices. For example, "examining how science lesson time is organized for different activity types and purposes lays the groundwork for understanding how science content ideas, processes, and structures are represented in the classroom and the kinds of opportunities that students have to participate in learning science" (Roth et al., 2006, p. 29). Furthermore, the analysis of how lesson time is organized in class will determine the time students have for opportunities in learning science (Roth et al., 2006).

However, most studies on school learning have disregarded the activities and pursuits of the pupils (Harnischfeger & Wiley, 1976), especially the time when pupils are covertly or overtly engaged in learning. Bennett (1978) and Gettinger (1985 & 1989) claim that the most important aspect of teaching and learning is the time students are actively involved in learning. Therefore, it is necessary to investigate about the time students are actively engaged in science lessons in Ghana.

2.3 Classroom Discussion and Contexts

Classroom talk is a vehicle that connects teachers, students and classroom tasks. This talk through discussion reveals learners' ability to demonstrate understanding of lesson content, and promotes verbal exchange of ideas, views, thinking, and experiences among learners. Students tend to clarify their thoughts, present their ideas, share their views, and inform one another using specialized language through talking (Lee, 1997). They also make use of their cultural store of knowledge when they engage in discussion about their experiences and achievements (Seiler, Tobin & Sokolic, 2001). Furthermore, “when students present, discuss, argue and critique their designs in a public forum (e.g. whole class discussion), further opportunities are provided for developing a discourse “(Roth, 2001). Students clarify their thoughts, present their ideas, share their views, and inform one another using specialized language of science through talking (Lee, 1997).

Student participation in discussion sessions during lessons develops productive thinking among them and consequently influences their achievement. For instance, Tobin and Fraser (1990) noted that “the key to teaching with understanding was the verbal interaction that enabled teachers to monitor student understanding of science concepts” (p. 13). Furthermore, a favorable environment enhances discussions, and this is supported by Fraser, Walberg, Welch and Hattie (1987) who claim that there is a strong link between education environment and student outcomes.

The use of talk in class is in line with social constructivist thought (Rivard & Straw, 2000). Verbal discourse plays an important role in meaning-making by students (Chin, 2006), and knowledge is created through language discourse in a social activity (ibid.). Additionally, individual and social processes are necessary for student understanding (National Research Council, 1996). The externalization of student ideas through classroom talk for public critique in a constructivistic way depends on teacher questioning practices during discussion sessions.

Discussion can assume the traditional form that involves a three-part sequence, that is, Initiation, Response and Evaluation (IRE) where there is teacher initiation of a question, student response to the question, and teacher evaluation of the response or feedback to the student (Mehan, 1979; Sinclair & Coulthard, 1975; Lemke, 1990), or a dialogic form (Mortimer & Scott, 2003), that is, Initiation, Response, Evaluation, Response and Feedback (IRERF). In this dialogicity, the IRE sequence is again followed by a response from a student, and this is also followed by a feedback from the teacher. Classroom discourse in science has been explored in many studies (Forbes & Davis, 2010; Chin, 2007; Chin, 2006;

Dawes, 2004; van Zee, Iwasyk, Kurose, Simpson & Wild, 2001; Wolf-Michael & Keith, 1997; Klaassen & Lijsne, 1996), and is regarded as a core part of classroom interactive processes since questions are mostly used by teachers.

Goodrum (1987) reported that "the key to developing understanding with children seemed to be related with the quality of the questions asked, in small-group situations and class discussions" (p. 88), and that teachers "used a variety of broad and narrow questions with satisfactory periods of wait time" (ibid). Furthermore, Tobin and Fraser (1990) claim that exemplary science teachers rephrased original questions or asked supplementary questions when students were unable to respond to a question until the students responds. The teachers allowed the students to probe for additional explanation or clarification, and urged questions from them (ibid).

The drive to discover by asking questions is central to the cognitive development of the individual (Morrison & Hanegan, 2008). Employing questions to promote student thinking has been the focus of many research studies on questioning (Chin, 2007: Yip, 2004; DePierro & Garafalo, 2003; van Zee & Minstrell, 1997; Wolf-Michael, 1996; Dantonio & Paradise, 1988; Winnie, 1975 & 1979). The use of questions "can stimulate student thinking and provide feedback for the teacher about students' understanding (Chin, 2007, p. 817). However, the use of questions to evaluate students' knowledge makes teachers custodians of knowledge (Lemke, 1990) and questions that elicit student thinking have been recommended to improve the quality of education (Harlen, 1985). Process-product studies have focused on questioning variables like cognitive processes (Riley, 1981, Riley, 1978) and wait-time (Olajide, 1995; Altiere & Duell, 1991; Tobin, 1980; Tobin, 1984; Swift & Gooding 1983; Rowe, 1974 a; Rowe, 1974 b). Classroom discourse, therefore, is invaluable in the development of scientific literacy. Rivard and Straw (2000) found that discussion among students seems to be a significant means for sharing knowledge among them.

Chin (2006) investigated question-based discourse practices in science classrooms to identify the various ways teachers follow up on students' correct, incorrect and a mixture of correct and incorrect responses. She found that "interactionally, a teacher's avoidance of explicit evaluation or put-downs, acknowledgement of students' contributions, subsequent questions that build on students earlier responses and that stimulate use of various cognitive processes, all appear to promote productive talk activity in students at a level beyond mere recall" (Chin, 2006, p. 1343). Ong (2009) using a framework similar to Chin (2006) also investigated how science teachers use questions and follow up moves in classroom discourse to accelerate students' thinking in creating scientific knowledge.

In other studies involving teachers' questioning behavior, Tobin and Fraser (1990) reported that exemplary science teachers involved weaker students who do not talk in class by calling them by their names to read their written answers to question and later using their answers for discussion. Goodrum (1987) also reported that exemplary science teachers were friendly and generous towards their students. They create a favorable learning environment in the classrooms (Tobin & Fraser, 1990), and use humor in the classroom (Tobin and Garnett 1988). Furthermore, Treagust (1991) ascertained that "teachers manipulated the social environment to encourage students to engage in academic work" (p. 335), and used different ways to commend students (ibid.).

However, these studies were conducted in developed countries and did not touch on how students feel after teachers' respond to students' correct or incorrect answers, or no responses. The process of teaching involves such a rapidly paced sequence of teacher's action and students' reaction that the teacher is hard pressed simply to keep up, let alone monitor his behavior at the same time" (Brophy & Good, 1974), and teachers are generally not aware of their behavior in class (ibid.). Therefore, it is necessary to investigate classroom discourse and its contexts in the cultural context of a developing country like Ghana. Teachers may not be conscious of the way they respond to students' answers. This is because the process of "teaching involves such a rapidly paced sequence of action and reaction that the teacher is hard pressed simply to keep up, let alone monitor his behavior at the same time" (Brophy & Good, 1974, p. 270), and teachers are generally not aware of their behavior in class (ibid.). The way students feel after teachers' responses to students' answers will either promote or inhibit student participation in classroom tasks and discussion sessions. But there are little or no studies on these actions. Franke, Webb, Chan, Ing, Freund & Battey (2009) also reported that "little research-based evidence exists to help teachers make the transition from asking the initial question to pursuing student thinking" (p. 380). There is very little research on following students' responses to questions and the effect of teachers' responses to students' correct or incorrect answers, or no responses on students' feelings in developing countries. In addition, most of the studies on questioning have focused on lessons in western countries and not in the cultural contexts of Africa.

2.4 Video Studies

This section reports on the rationale for video studies and reviews literature on the background to classroom video studies, and the benefits and challenges of video studies.

2.4.1 Rationale for video studies

The use of video to document classroom observations "provides a powerful method for collecting and presenting classroom interactions" (Miller & Zhou, 2007, p. 329) in learning science. The interaction between teachers and students is a continuous and complex process. Understanding this process requires the 'careful and analytical' observation of teaching and learning practices.

Video studies in learning science involve both video recording of lessons and the gathering of supplementary data like teacher's lesson notes, teacher's manual, textbooks, handouts, and students work. Furthermore, unobservable processes like thoughts, attitudes and feelings are also captured with instruments such as interview and questionnaire. These supporting data help to explain the contexts of classroom observation. Video studies of classroom interaction, therefore, enables an analyst to identify teacher behaviors and how learning activities are carried out, and this informs appropriate interventions to be carried out to improve the learning of science.

Systematic and ethnographic observations are the two main approaches to classroom observation (Delamont, 1984). Systematic observation can be done by developing a coding system to be used as a checklist for scoring specified behavior described in the codes (ibid.). Ethnographic means, on the other hand, records classroom interactions between the teacher and learners and later analyze these actions (ibid.). Whereas systematic observation limits the scope of lesson observation and analysis, observation through ethnographic means would enable an analyst to cover a wide range of observations and events for different analyses, and this is best carried out through video recording of classroom interaction in video studies. Furthermore, systematic observation forces researchers to make instant and quick decisions without any opportunity to visually capture the classroom events again. The act of simultaneously judging an event and observing the next event does not allow observers to carefully think about the event before judging. Furthermore, the raters do not have absolute concentration to observe subsequent events. Their judgments, however, may not reflect the actual behavior of students or classroom events, but with video, the analyst can take time to make decisions about classroom events since video recording of science lessons "can be viewed as many times as required" (Plowman, 1999, p. 3).

Although, systematic observation is credited for advancement in research in science teaching, video studies is capable of incorporating both systematic and ethnographic methods, and can capture precisely how students learn in the classroom. Video is appropriate for fairly detailed analyses of language and interactions (Plowman, 1999) since it captures classroom talk, the thinking processes and types of knowledge involved, teacher and student actions, classroom tasks, and teacher-learner interactions. According to Moll (2003), learning takes place through social activity and language discourse (as cited in Zady, Portes & Oches, 2003). Kelly and Duschl (2008) in Mortimer, Lima-Tavares & Jimenez-Aleixandre (2008) claim that studies about the process of knowledge construction relate it to practices associated with knowledge production, communication and evaluation or epistemic practices. Furthermore, the epistemological belief that the knower plays an active role in knowledge development (Kang & Wallace, 2005) makes the use of video a resourceful tool for studying how learners learn science.

2.4.2 Background to classroom video studies

The genesis of video as a research tool is rooted in stenographic recording of lessons about a century ago (Stevens, 1910). Four decades later, Margaret Mead and Gregory Bateson pioneered the use of film for ethnographic studies in early childhood development (Ulewicz & Beatty, 2001). Stigler, Gallimore & Hiebert (2000) report that in the development of micro ethnographic studies, audio and video were used to target specific contextual features of classrooms influencing student participation and achievement. Even though recordings were mainly used to produce the transcriptions of speech, video recording enabled them to identify child speakers by their names on the lesson transcripts and who said what to whom during the analysis. McCurry (2000) also reports that video tape recording was used during pre-service teacher training to help trainees learn skills and reflect upon their practices in the mid-1960s.

Videotaping classrooms gained popularity in the early 1970s, and since then video records have supplied data for careful analysis and precise conclusions in educational research. Tobin, Wu, and Davidson (1989) pioneered video studies of pre school classroom in China, Japan and the United States. Furthermore, Splinder and Spindler (1992) reported on educational anthropology on classrooms. They used video study in a comparative study in two schools to collect cross cultural classroom data, and later used the work for discussion on cultural differences. The study was aimed at the effect culture exerts on the role of the school in the preparation of school children in a changing environment. Stigler, Gonzales, Kawanaka, Knoll & Serrano (1999) conducted the first large-scale comparative video study of eighth-grade mathematics classroom instruction in Germany, Japan, and United States, in 1995, and Roth, Druker, Garnier, Lemmens, Chen, Kawanaka, Rasmussen, Trubacova, Warvi, Okamoto, Gonzales, Stigler & Gallimore (2006) also reported the second large-scale comparative video study of eighth-grade science classroom instruction in Australia, Czech Republic, Japan, Netherlands, and United States, in 1999.

In addition, Greenwalt (2008) used video to analyze how teacher trainees experience videotaping and analysis of their own classroom practices. It is believed that when student teachers reflect and review their pedagogy retrospectively, it motivates them to listen to the students in their classroom, peers, and their own views, in order to improve classroom practices. Borko, Jacobs, Eiteljorg & Pittman (2006) also studied how video could be used to enhance effective discussions about teaching and learning in mathematics professional development. The study used video to enhance effective conversation among teachers after watching videos from their own classrooms, and to find out how these discussions change over time. When they watched their own videos they identified their classroom practices and areas that need improvement. Again watching that of their colleagues helped them to learn new teaching strategies and understand better students' capacity for mathematical reasoning. Clarke (2007) also claims that video can speed up change and facilitate teacher reflection. It is a tool for professional growth, international studies, standard-based culture, and developing a language of professional practice (ibid.).

2.4.3 Benefits and challenges of video studies

The use of video in investigating the teaching and learning of science is an invaluable for improving the quality of science instruction. It involves multiple data sources and puts researchers "in touch with the multiple methods of conducting a study" (Goldman, 2007, p. 6), and this makes research findings more credible. Plowman (1999) also reports that "different methods of analysis can be applied to the same raw data and the video could, for instance, be subject to different techniques by different researchers" (ibid., p.3), in studying how students learn science.

It also plays a very significant role in professional development of teachers. For instance, the use of video in lesson study, has contributed to the improvement of Japanese classroom instruction over the years (Lewis, 2000). Lesson study, a teaching professional development activity, famous in Japan, "refers to lessons that teachers jointly plan, observe and discuss" (Lewis, 2000, p. 3), and the observation, usually, is through videotaping of the lessons for the main purposes of analyzing and discussing. Lewis (2000) claim that "Japanese teachers mention many effects of research lessons on their own professional development, including feedback on their own teaching and new ideas gained from watching others teach" (p.13).

Moreover, Japanese educators reported that they learn to see children or ‘develop the vision to see children in research lessons’ (Lewis, 2000). Watching videos of one’s lesson or that of others allows science teachers to engage in reflective practices to professional develop their careers. According to Schon’s theory of reflective practioner, the act of reflecting-on-action helps the practitioner to spend some time to review his/her actions, and cultivates questions and ideas about these actions and practices (as cited in Smith, 2001). Holodick, Scappaticci and Drazdowski also claim that video is a useful tool for self-reflection models in teacher development and assessment (as cited in McCurry, 2001). Additionally, Fasse and Kolodner (2000) reported that video recordings of exemplary practices can be used for teacher professional development.

However, video studies in science instruction are faced with many challenges. Time limitation and logistical constraints may not allow researchers to use probability sampling to cover the targeted population. For instance it takes a lot of time to collect data and analyze them. This is because science teachers use different methods in teaching different topics so it is important to collect data during all school session in the academic year, and also textual analysis is very demanding. Furthermore, the support structures and processes that are necessary for the researchers and science teachers may be lacking.

Ethical issues also pose challenges in the use of video since some people do not feel comfortable to appear on video. For example some experienced teachers with exemplary practices may also not allow their lessons to be recorded.

2.5 Learning Theories

This section reviews social learning theories, psychological learning theories, and theoretical models on school learning.

2.5.1 Social learning theories

Video shows the constructivist approach to education in which “learners actively create, interpret, and organize knowledge in individual ways” (Gordon, 2008, p. 324). It “makes communication visible and potentially reveals behavior nested across levels in precarious and contested interactions (Goldman & McDermott, 2007, p.112) in the investigation of knowledge development. Kamii and Erwing described Piagets belief that to understand the nature of knowledge, “we must study its formation rather than examining only end products” (as cited in Gordon, 2008). Piaget’s development theory shows that the means by which one arrives at knowledge is significant (Gordon, 2008), so it is very important to study deeply into how students learn science. Gordon (2008) also reported that supported by insights of theorists like Piaget, Vygotsky and Freire, a constructivist approach to learning allows the learner to actively create, interpret and reorganize knowledge in individual ways, and this is clearly revealed in the multiple analyses of video recording of science lessons in video studies in learning science.

2.5.2 Psychological learning theories

The works of Gagne (1977), Glaser (1976), Bruner (1966) and Freire, 2000 have their origin in psychology. Gagne’s psychological model focuses on five main categories of learning outcomes that are verbal information, intellectual skills, cognitive strategies, attitudes and motor skills. According to Gagne, there are internal and external conditions for realizing each type of learning outcome. For example, the learning conditions for attaining verbal information learning outcomes are activating attention and presenting a meaningful context. The condition for achieving intellectual skills is through stimulating retrieval of previously learning components, usually through skilful questioning. Additionally, cognitive strategies, attitudes, and motor skills are elicited through providing opportunities to solve novel problems, insuring feedback, and arranging practice respectively.

Glaser (1976) also reiterates that internal and external learning conditions are necessary for learning. This model starts with a description of competencies to be acquired by the student and the initial learning characteristics. It also describes the implementation of conditions to elicit change in behavior, and ends with assessment of learning outcomes to determine whether a desirable change occurred.

In addition, Bruner's theory of classroom instruction (1966) ensures that the conditions for learning to occur are met. The main components of this theory are predisposition to learn, structure of the curriculum, sequence in which material is delivered, and the nature and pacing of rewards and punishments

Freire psychology of learning (2000) empowers students to think by themselves in the search for knowledge. Students need to engage in activities that will allow them to freely and critically explore their ideas through communication, and outwardly express their thinking through argumentation because "authentic thinking is concerned with reality and takes place in communication'' (Freire, 2000, p. 77).

2.5.3 Theoretical models on school learning

The works of Caroll (1963), Cooley-Leinhardt (1975), Bloom (1976), Harnischfeger-Wiley (1976), and Bennet (1978) have been reviewed. Caroll's model of school learning focuses on the fact that "the learner will succeed in learning a given task to the extent that he spends the amount of time that he needs to learn the task" (1963, p. 725). The amount of time is the actual time spent on learning the task such that the learner is oriented to the learning of the task and actively engaged in it. According to Caroll, the amount of time is categorized into two: time needed in learning a task; and time spent in learning the task. The time needed in learning a task is determined by aptitude, ability to understand instruction such as general intelligence and verbal competence, and the quality of instruction. On the other hand, the time spent in learning a task is determined by the time allowed for learning or the opportunity for learning, and perseverance.

Cooley-Leinhardt (1975) framework is based on Cooley-Lohnes model on school learning, and focuses on the applicability of this model for classroom processes. This model is a revision of Caroll's model and consists of six constructs (Cooley-Leinhardt, 1975). These are initial performance, criterion performance, opportunity, motivators, structure, and instructional events. Initial and criterion performances are student ability constructs whereas the rest are classroom process constructs. This model "specifies that criterion performance is a function of initial student performance and of certain classroom processes that occur in the interval between the assessment of initial student performance and the assessment of criterion performance" (Cooley-Leinhardt, 1975, p. 4). Opportunity is "the possibility for learning what is sampled in the criterion performance measures" (ibid., p. 8), and motivators are student behaviors and attitudes that support learning, or elements that can be factored into an educational environment to enhance learning activities. The structure construct describes how the "curriculum is organized and sequenced, the specificity of the objectives, and the manner in which a student and a curriculum are matched" (ibid., p. 8)

Bloom (1976) asserts that a large number of students can attain a high level of learning capability if classroom teaching and learning process is approached with sensitivity and methodically. Bloom's theory of school learning "is ideally intended to explain the interaction between an individual learner, the instruction, something to be learned, and the learning finally accomplished (Bloom, 1976, p. 12). The student characteristics include students' cognitive entry behaviors and affective entry characteristics. The former is "the prerequisite learning held to be necessary for learning tasks on which instruction is to be provided" (ibid., p. 11) and the latter is "student's motivation to learn the new learning task(s)" (ibid.). Furthermore, the quality of instruction is "the extent to which the cues, practice, and reinforcement of the learning are appropriate to the needs of the learner" (ibid., p. 11).

Harnischfeger-Wiley model is aimed at mediating between the social conditions of learning and the psychological conditions (Harnischfeger-Wiley, 1976). This model contains six main parts put under three groups: background factors, including the curriculum, institutional features, and personal characteristics of teachers and pupils; teaching-learning activities or teacher and learner pursuits; and pupil acquisition or achievement. However, the focus of this model is the teaching and learning process.

Bennett's model of school learning (1978) focused on factors that lead to success in school learning at the primary level. These were quantity of schooling, time allocated to curriculum activity, total active learning time, total content comprehended, achievement on curriculum task, and feedback. According to Bennett, learning time is a critical determinant of achievement. The total active learning time is the time when the student is either covertly or overtly engaged in learning (Bloom and Caroll models), but Bennett claims that only the quantity of time when the student is actually in the process of comprehending the task is directly linked to achievement. Therefore, lesson time is a critical determinant of student achievement.

2.6 Philosophy of Teacher Questions

A teacher's philosophy of questions potentially influences the instructional process. One very core pedagogical strategy that is central in guiding students to have opportunities for learning is the questioning strategy. Questioning since time immemorial, has been regarded as important in learning. Questions "are the basic unit underlying most methods of classroom teaching" (Gall, 1970, p. 707). Aschner (1961) asserts that a teacher should be a skilled questioner. The professional use of questions is significant in learning, and it is for this reason that Gall (1970) stressed that it is a truism for educators that questions exert a significant role in teaching. The Socratic Method encourages teachers to ask questions (Redfield & Rousseau, 1981) that will help learners to develop their thinking skills (Torrance, 1967). According to Torrance (1967), Socrates was of the view that it was essential to ask stimulating questions that assist natural ways of learning. Furthermore, Socrates "knew that thinking is a skill that is developed through practice and that it is important to ask questions that require the learner to do something with what he learns –to evaluate it, produce new ideas from it, and recombine it in new ways" (Torrance, 1967, p. 85). Therefore, the philosophical view that teaching using well-judged leading questions "involves no direct transfer of information but rather allows the pupil to see the truth for himself or herself" (Rowe, 2001, p.6) should guide teachers during instruction.

Science teachers' questions have the potential of initiating classroom discussions, which in turn reveal the processes of the development of knowledge by learners (Mortimer, Lima-

Tavares & Jimenez-Aleixandre, 2008). Learning takes place through the discovery of knowledge by students themselves (Hassard, 2005; Von Secker & Lissitz, 1999), and depends on what they think about during lessons. Student thinking and the processing of their cognitive structures, depends on classroom activities that are cognitively challenging like the professional use of questions by teachers. There is a link between teacher questions and student thinking (Oliveira, 2010; Wolf-Michael, 1996).

A teacher's philosophy of questions to a very large extent will determine the kind and quality of questions used during instruction. Teachers always use questions in class to guide student learning. A teacher's questions normally initiates classroom dialogue and this dialogicity is "seen as revealing processes of knowledge construction by students" (Mortimer, Lima-Tavares & Jimenez-Aleixandre, 2008, p. 1). The purpose of questions, however, should mainly elicit student thinking in order to promote productive learning. The question could either be closed or open depending on the underlying motive because "the cognitive demand of a question is not related to whether it is open or closed" (Amos, 2002, p. 6). Although open ended questions are variable and extend pupils' thinking, draw out their ideas, and encourage them to volunteer points and explore further, thus providing evidence for achievement, closed questions have a place in the classroom (ibid.). They can be used to reassure, find out what pupils know and can recall, lead them from one idea to another, and help them make connections between phenomena, ideas and events (ibid.).

Video investigation of teachers' questions enable analysts to determine the type and purpose of questions, their knowledge dimensions, the cognitive processes involved, and the teacher's intentions. The philosophical underpinnings of questions will guide analysts to have a clear viewpoint to assess video recording of lessons and develop effective questioning strategies to enhance the learning of science. Video analysis of questioning practices serves as a resource for improving their quality in eliciting productive thinking from students in learning science.

2.7 Theoretical and Conceptual Framework

This study is based on the theories that view learning as being developed in action by the students themselves. Knowledge development by students themselves in class is mainly demonstrated by verbal means through classroom discourse. Classroom discourse provides students opportunity to express their ideas about the subject matter content, and nurtures their thinking practices. It also reveals their ability to demonstrate knowing, conceptual understanding, reasoning, applying and analysis, and promotes verbal exchange of views, thinking, and experiences among them. This invariably develops productive thinking among students, and will consequently have a positive effect on students' learning outcomes. However, students' verbal expression of their views/ideas depends on teacher questions or statements that elicit either answers or responses from students, and teacher response behavior to students' answers or responses. The response behavior from teachers to students' answers and responses, especially, students' incorrect answers and no responses has the potential to affect the climate surrounding classroom discussion session, and this will either enhance or limit knowledge development during classroom discussion.

The change from imparting knowledge onto students (knowledge instruction) to actively and cognitively engage students in classroom tasks and activities are best analyzed in camera. Video recording of classroom lessons captures more of what happens in the classroom than other kinds of data collection instruments (Ulewicz & Beatty, 2001). In addition, "videotaped images provide both a lens through which to view classrooms and a tool to develop a shared language with which observers can discuss what they see" (ibid., p.8). These allow in-depth qualitative assessment of classroom practices by analysts to determine the course of knowledge development by students.

Knowledge development by students themselves is a process. When this practice is well nurtured it will empower students and develop their creative thinking process. The paradigm shift to knowledge development by students in learning science is led by the works of social theorists like Piaget and Vygotsky, psychological learning theories (Bruner, 1966; Freire, 2000; Gagne, 1977; Glaser, 1976), theoretical models on school learning

(Bennett, 1978; Bloom, 1976; Caroll, 1963; Cooley-Leinhardt, 1975; Harnischfeger-Wiley, 1976), pedagogical bases, and the philosophy of teachers. Therefore, this study is underpinned by the view of teaching and learning as a relationship between an individual learner, the instruction/classroom task, something to be learned/lesson content, the learning outcome (Bloom, 1976), and the teacher (Figure 2.1).

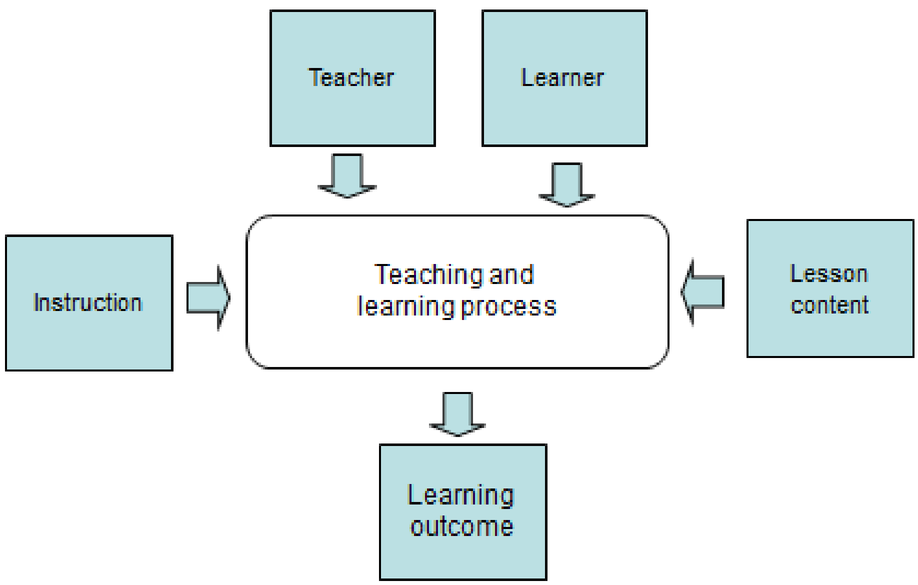

Figure 2.1. Theoretical and conceptual framework

CHAPTER 3

METHODOLOGY

3.1 Research Design

The mixed methods research design was used for this study. This was based on both quantitative approach and field research after purposively selecting the samples (Figure 3.1).

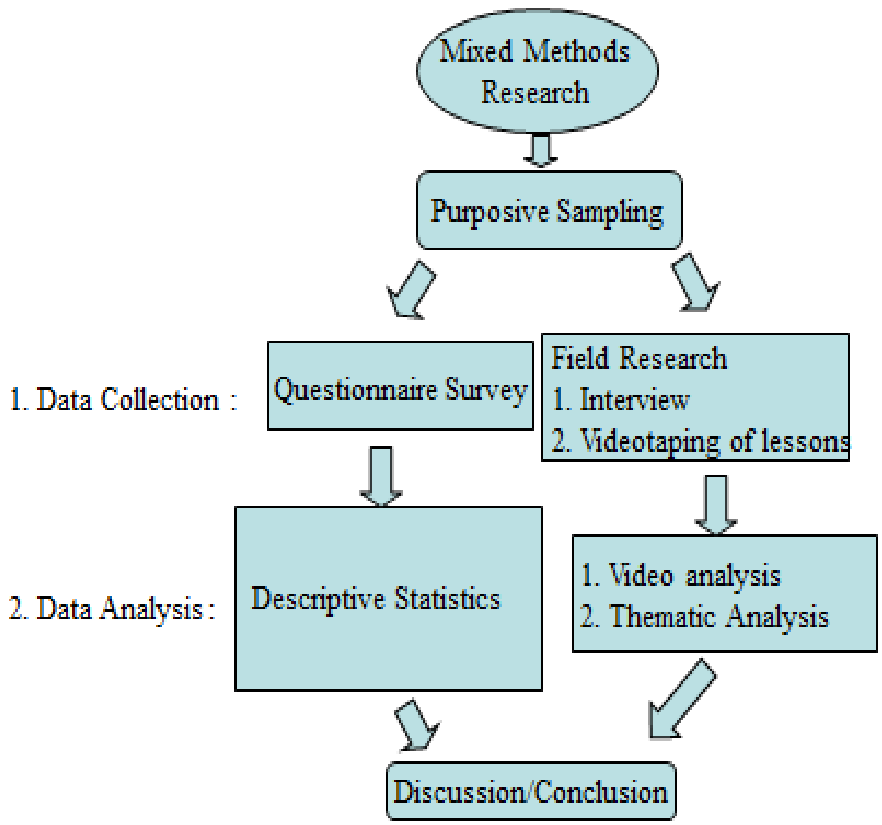

Figure 3.1. Research design

However, this study relied primarily on qualitative measures like interviews, video recording of science lessons, direct observations, and taking field notes (Trochim & Donnelly, 2008). Interview data and video recording of science lessons were mainly analyzed. This was complemented with direct observation and field notes that helped to explain the contexts of the study.

Finally, the findings from the analyses were thoroughly discussed and consequently summarized. Recommendations were later offered to improve the quality of science instruction in basic schools in Ghana.

3.2 Population and Sampling

The population was made up of basic schools, science teachers, science lessons and pupils across the ten regions in Ghana. In order to set the sample schools, the science pass rates (Table 3.1) in the Basic Education Certificate Examination (B.E.C.E) over a period of six years (MOE, 2003, 2004, 2005, 2006 & 2007) were used to select four regions and one district each from the regions in 2008 and 2009. Ashanti, Greater Accra, and Upper West regions were dropped because they had more than 65% pass rate in the B.E.C.E examination results.

Table 3.1 Basic Education Certificate Examination Science Pass Rate

Academic Year	Pass Rate/%									
	Ashanti Region	Brong Ahafo Region	Central Region	Eastern Region	Greater Accra Region	Northern Region	Upper East Region	Upper West Region	Volta Region	Western Region
2006/2007	66.2	61.8	51.2	48.9	71.1	55.6	58.2	68.4	52.7	55.4
2005/2006	68.3	60.8	49.4	46.0	72.0	50.5	60.4	68.5	50.7	52.5
2004/2005	77.4	75.1	64.8	62.8	83.9	70.7	72.4	79.4	64.4	74.0
2003/2004	62.1	56.6	45.2	46.8	71.6	50.7	52.2	64.3	46.3	56.8
2002/2004	63.7	54.1	44.9	48.2	76.6	59.2	58.2	64.0	48.5	56.0
Average	67.5	61.7	51.1	50.5	75.0	57.3	60.3	68.9	52.5	58.9

Northern, Brong Ahafo, Central, and Western regions were selected from the list of the remaining seven regions. The selected districts were Tamale district (metropolitan area), Cape Coast district (metropolitan area), Komenda Edina Eguafo Abirem (KEEA) district (municipality), Asunafo South district, and Sefwi Wiawso district (Figure 3.2).

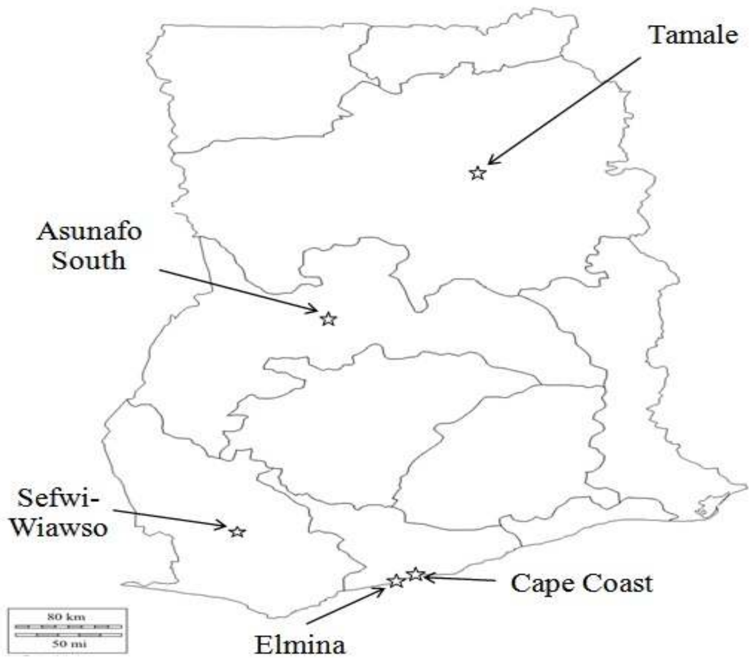

Figure 3.2 Sample site map

Tamale metropolitan area is located in the Northern Region of Ghana. This region has the largest area in Ghana. There are 20 districts in this region, and the main occupation in this area is farming (maize, rice, millet and legume production), and livestock (cattle, sheep) rearing. Cape Coast metropolitan area and KEEA municipality are in the Central Region. This region is the second most densely populated in the country and is divided into 17 districts. Fishing is the main occupation in both Cape Coast metropolis and KEEA municipality. Education in Ghana started in Cape Coast. Asunafo South district is in the Brong Ahofo region. There are 22 districts in this region and the main occupation is farming (cocoa, timber and grains). Sefwi Wiawso district located in the Western Region with 16 other districts. The main occupation is farming (cocoa, timber, tubers).

The five districts had similar occupational distribution patterns. The mainstay of the people in the districts is agriculture and related work like animal husbandry, forestry, fishing and hunting. In addition, they had comparable pass rate in the B. E.C.E in 2003/2004 (MOE, 2004). The schools were selected from a list of schools recommended by the regional education office. These schools were classified as equal performing schools based on their performance in the national exit examinations, teacher-student ratio, availability of textbooks, and school and class sizes.

3.3 Data Collection

This section contains a description of the samples, the data collection instruments and the data collection process.

3.3.1 Description of samples

Twenty JHS were involved in this study in Ghana (Table 3.2). The junior high schools consisted of one mixed private junior high school, and 19 public and mixed schools. The average number of JHS science teachers involved in the study was one. Twenty-three science teachers in the selected schools took part in the study. There were 19 male science teachers (83%) and four female science teachers (17%). The average age of the teachers was 29 years, and the average number of years of teaching in general and teaching science were 6 and 4 years respectively.

Table 3.2 Description of samples

Sample	Description
Junior High Schools(N= 20)	Mixed & public schools (19); Mixed & private (1)
	Average number of science teachers per school (1)
Junior High School science teachers (N= 23)	19 Males (83%) & four Females (17%); Average age (29); Twelve teachers (52%) majored in General Science and eleven teachers (48%) majored in Other than Science
	General teaching experience (6 years); Science teaching experience (4 years)
	Highest Qualification: Sixteen teachers (69.5%) possessed a 3-Yr. Post Sec. TTC Cert 'A'; three teachers (13%) possessed Diploma in Basic Education; two teachers (8.7%) possessed Bachelor of Education degree; one teacher (4.4%) had a Bachelor of Agricultural Science degree, and one (4.4%) had an SSS Certificate
	Two Principal Superintendent teachers (9.1%); Two Senior Superintendent teachers (9.1%); Nine Superintendent teachers (40.9%); Four Assistant Superintendent teachers (18.2%); Five Junior teachers (22.7%)
Junior High School head teachers (N= 10)	Three males (30%) & seven females (70%); Average age (49)
	Seven head teachers (70%) possessed Bachelor of Education degree; One (10%) possessed a 3-Yr. Post Sec. TTC Cert 'A'; One (10%) possessed a Diploma in Education; and One (10%) possessed a Bachelor of Art degree
	Average teaching experience (28); Average number of schools worked as worked as teacher or head teacher are seven and two respectively

Sixteen of the science teachers (69.5%) possessed a 3-Year Post-Secondary Teacher Training Certificate A as the highest qualification. A 3-Year Post Secondary Teacher Certificate A is possessed by teachers who after completing their senior high school pursued teaching as a profession in a Teacher Training College. The program for such students is normally three years (Table 3.3).

Table 3.3 Teacher certificate system in Ghana

Type of Teaching Certificate	Entry Requirement	Certificate awarding institution
2-Year Post Middle Teacher's Cert. 'B'	Middle School Leaving Certificate(MSLC)	Teacher Education Division, GES
2-Year Post 'B' Teacher's Cert. 'A'	Middle School Leaving Certificate(MSLC)	Teacher Education Division, GES
4-Year Post Middle Teacher's Cert. 'A'	Middle School Leaving Certificate(MSLC)	Teacher Education Division, GES
3-Year Post –Secondary Teacher's Cert. 'A'	GCE O' Levels	University of Cape Coast (Institute of Education)
Specialist	GCE O' Levels	University of Cape Coast (Institute of Education)
Diploma	GCE O' Levels 4-Year Post Middle Teacher's Cert. 'A'	University of Cape Coast (Institute of Education)
Diploma in Basic Education (DBE)	Senior Secondary School Certificate GCE O' Levels	University of Cape Coast (Institute of Education)
Bachelor in Education	GCE A' Levels Senior Secondary School Certificate 2-Year Post –Secondary Teacher's Cert. 'A'	University of Cape Coast & University of Education

Adapted Antwi, 1992

Furthermore, three science teachers (13%) had Diploma in Basic Education, two (8.7%) had a Bachelor of Education degree, one (4.4%) possessed a Bachelor of Agricultural Science degree, and one (4.4%) possessed a Senior Secondary School (SSS) Certificate. Furthermore, two of the teachers (9.1%) were at the rank of Principal Superintendent and two (9.1%) were at the Senior Superintendent level (Table 3.2). There were also nine (40.9%) and four (18.2%) teachers at the Superintendent and Assistant Superintendent levels respectively. There were five junior teachers (22.7%) and the teacher who possessed the Senior Secondary School Certificate had no rank because he was regarded by the GES as a pupil teacher.

The head teachers were made up of seven females (70%) and three males (30%) (Table 3.2). Seven of them (70%) had a Bachelor of Education degree, one (10%) possessed a Bachelor of Art degree, one (10%) possessed a Diploma in Education, and one (10%) had a 4-Year

Teacher's Certificate A. The average age and teaching experience of the head teachers were 49 and 28 years respectively. They were all of the rank of Assistant Director of Education. In addition, the average number of schools they had worked as a teacher and head were seven and two years respectively.

Twenty-three science lessons taught by different science teachers were observed in the junior high schools. The science disciplines of the lessons were mainly Biology, Chemistry, Physics, Agriculture, and Other. The lesson topics for the biology lessons were: Digestion; Reproduction; Functions of Blood; Diffusion; and Human Eye (Table 3.4).

Table 3.4 Lesson topics

Region	District/Municipal	Circuit	Lesson Code	Lesson Topic	Class
Central	Cape Coast	Pedu Abura	1	Farming System	B. S. 7
			2	Diffusion	B. S. 8
			3	Diffusion	B. S. 8
		Cape Coast	4	Diffusion	B. S. 7
			5	Soil	B. S. 8
			6	Calculation of Power	B. S. 8
			7	Forces and Pressure	B. S. 8
			8	Eclipse of the Moon	B. S. 7
			9	Climate	B. S. 8
	Komenda/Edina/ Eguafo/ Abirim	Elmina	10	Reproduction	B. S. 8
			11	Types of Water	B. S. 8
			12	Diffusion	B. S. 8
Western	Sefwi-Wiawso	Wiawso	13	Changes in Matter	B. S. 8
			14	Reproduction	B. S. 8
		Dwinase	15	Reproduction	B. S. 7
			16	Chemical Formula	B. S. 8
			17	Force	B. S. 9
Brong Ahafo	Asunafo South	Kukuom	18	Digestion	B. S. 7
			19	Reproduction	B. S. 8
			20	Hard Water	B. S. 8
			21	Functions of Blood	B. S. 7
		Kamerikrom	22	Pressure	B. S. 8
Northern	Tamale	Tamale	23	Human Eye	B. S. 9

The topics for the chemistry lessons were: Types of Water; Hard Water; Chemical Formula; and Changes in Matter, and those for physics were Pressure, Force, Power, and Eclipse of the Moon. Farming Systems and Soil were the topics in Agriculture, and the topic Climate was put under the category Other.

3.3.2 Data collection instruments

Questionnaires, interview guides and camcorders were used for the data collection. Third International Mathematics and Science Study 1999 Video Study Australian science teacher questionnaire was used, and items that focused on teachers' background experiences and workloads, as well as factors that influence the selection of the content of lessons were used. Some of the items were adapted in such a way that it accounted for cultural differences (Appendix 1). For example the items "During the last two years, how many university courses have you taken in science or science education?" and "Please describe the main thing you would like students to learn from this lesson" were slightly changed to "During the last two years, how many university courses have you taken in science or education?" and "What was the main thing you wanted students to learn from this lesson" respectively. Furthermore, the option of one of the items focusing on the factors that influence the teacher's decision to select lesson content was changed from 'national, state, or school curriculum guidelines' to 'national curriculum guidelines', and the option 'Basic Education Certificate of Education past questions' was added to the options for the same item. Some of the new items used were "What was your major field of study in the Teacher Training College" and "Have you ever attended in-service training for science teachers".

In addition, semi-structured interview guides (see Appendices 2, 3 and 4) with the same format and sequence of questions were administered to science teachers, students, and head teachers respectively. The interview guides solicited the views of students and science teachers on how science teachers respond to students' correct or incorrect answers and no responses in class, students' feeling after a teacher's response to students' answers, causes of no responses from students, appropriate teacher responses to students' incorrect no responses and for encouraging inactive students to answer questions in class, and participants' views about science teaching, classroom discussion and contexts (Table 3.5).

Table 3.5 Focus of items

Focus of interview items	Target/Participant
Teacher response behavior to students' correct or incorrect answers and no responses	Teachers & Students
Student feeling after teacher response behavior	Teachers & Students
Causes of students' no response	Teachers & Students
Appropriate teacher response behavior to students' correct or incorrect answers, students' no responses, and for encouraging inactive students to answer questions in class	Head teachers, teachers and students
Views about science teaching, questioning discourse and its contexts	Head teachers, teachers and students

Selected head teachers also responded to the item that elicited appropriate teacher responses to students' incorrect no responses and for encouraging inactive students to answer questions in class. Some of the items the students responded to were: 'how does your teacher respond to a correct answer from you'; 'how does your teacher respond to your wrong answer'; and 'how do you feel after your teacher's response to your wrong answer?

3.3.3 Data collection process

The science lessons of 11 science teachers in 10 different junior high schools were videotaped in February and March, 2008, and the teachers responded to a teacher questionnaire. In February and March, 2009, 12 more science lessons taught by different teachers were videotaped in 10 different junior high schools. The science teachers whose lessons were observed gave their consent for their lesson to be videotaped by completing a letter of consent. The 12 science teachers whose lessons were observed in 2009, 10 head teachers and 34 selected students were later interviewed for about one hour, 30 minutes, and 40 minutes respectively. The selected students for the interview were made up of students who correctly or incorrectly responded to questions, and those who did not respond to questions at all. For the students who responded to questions, a teacher's both positive and negative uses of reinforcement were used as criteria for selecting them. The students who did not respond to questions were randomly selected.

The students were interviewed first, followed by science teachers and later head teachers. This sequence made the children felt very important and as a result of that they freely and willingly responded to the items. The participants were asked to take their time and respond to the items at their convenience and in their own way. This helped in establishing a good rapport between the researcher and the respondents. After establishing rapport, the interview was conducted in such a way that there was sharing of power between the researcher and the respondents. The respondents were given the chance to also solicit the views of the researcher on topics related to the theme of the interview and the study in general.

The researcher mainly followed Third International Mathematics and Science Study 1999 video study videotaping procedures to collect video data in Ghana, although there were some differences in the type and number of equipment used because of logistical constraints. Two camcorders labeled as Teacher camera and Student camera were used to videotape science lessons.

Three main principles guided the data collection procedures: documenting the teacher; documenting the students; and documenting tasks (Jacobs et al., 2006). The cameras were used to document teacher actions, student actions, and classroom tasks (TIMSS-R Video Study, Data Collection Manual). All the recordings were done in real lesson time (ibid.).

After recording the lesson, the researcher administered the teacher questionnaire to the science teachers and reminded them of the need to kindly complete the teacher questionnaire before the end of the day.

3.4 Data Analysis

Third International Mathematics and Science Study 1999 video study analysis method for science and Matsubara (2009) lesson analysis method were used to analyze science teaching and the organization of lesson time, and the level of students' cognitive involvement in lessons respectively. A taxonomy table designed by Anderson et al. (2001) was later used to analyze the cognitive and knowledge dimensions of teachers' questions and students' answers. The cognitive process dimension guide (Table 3.6) and the knowledge dimension guide (Table 3.7) informed the analysis of the knowledge and cognitive dimensions in science teachers' questions and students' answers.

Table 3.6 The cognitive process dimension guide

COGNITIVE PROCESS	CATEGORY
Remember	Recognizing (identifying); Recalling (retrieving)
Understand	Interpreting (clarifying, paraphrasing, representing, translating); Exemplifying (illustrating, instantiating); Classifying (categorizing, subsuming); Summarizing (abstracting, generalizing); Inferring (concluding, extrapolating, interpolating, predicting); Comparing (contrasting, mapping, matching); Explaining (constructing models)
Apply	Executing (carrying out); Implementing (using)
Analyze	Differentiating (discriminating, distinguishing, focusing, selecting); Organizing (finding, coherence, integrating, outlining, structuring); Attributing (deconstructing)
Evaluate	Checking (coordinating, detecting, monitoring, testing); Critiquing (judging)
Create	Generating (hypothesizing); Planning (designing); Producing (constructing)

Source: Anderson et al., 2001

Table 3.7 The Knowledge dimension

MAJOR TYPE	SUBTYPE
Factual Knowledge	Knowledge of terminology; Knowledge of specific details and elements
Conceptual Knowledge	Knowledge of classifications and categories; Knowledge of principles and generalizations; Knowledge of theories, models, and structures
Procedural Knowledge	Knowledge of subject specific skills and algorithms; Knowledge of subject-specific techniques and methods; Knowledge of criteria for determining when to use appropriate procedures
Meta-cognitive Knowledge	Strategic knowledge; Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge; Self-knowledge

Source: Anderson et al., 2001

Furthermore, Teacher Intentions lesson analysis framework was used to analyze the intentions behind teacher questions, and Teacher Response Behavior lesson analysis method was later used to analyze how science teachers respond to students' correct or incorrect answers and no responses. The works of Miles and Huberman (1994) and Green et al. (2007) formed the basis for the analysis of the interview and video captured data using the TRB lesson analysis method.

The video recording of the science lessons were first duplicated and later transcribed and time-coded. Generally, the stages in the analysis of the video were watching the unedited video recording of the science lessons, transcribing the verbal interaction, and marking all the discussion segments to clearly show the teacher's questions or statements that elicit responses, students' answers and responses, and teacher's responses to students' correct or incorrect answers and no responses. A discussion segment basically contained a teacher question, a student response to the question, and the teacher's evaluation remark. Each question or answer was counted as one whether it was short or long. A question or statement that elicits a response was either a sentence or at least one word, and complete or incomplete. A student response was an answer to a question from a teacher. The student responses ranged from one or two words to incomplete and complete sentences.

3.4.1 Third International Mathematics and Science Study 1999 video study analysis guide

The Third International Mathematics and Science Study 1999 video study analysis guide for science was adapted for the analysis of the lessons. This guide covered 11 dimensions of classroom practices of science lessons. These were lesson structure (Dimension 1), classroom talk (Dimension 2), social organization structure (Dimension 3), activity structures (Dimension 4), function structures (Dimension 5), learning environment (Dimension 6), independent activities (Dimension 7), content categories (Dimension 8), types of knowledge (Dimension 9), science content development (Dimension 10), and practical assignments (Dimension 11). Independent practical work activities (Dimension 7) and practical assignments (Dimension 11) were not applicable to the lessons as preliminary analysis revealed a very low content of practical work in the lessons. Therefore, Dimensions 7 and 11 were not included in the final analysis.

The analysis of a dimension basically involved viewing the entire lesson**,** followed by viewing critical portions again, then marking all relevant segments on the lesson time-coded transcripts during the viewing, and finally determining the length of time.

Dimension 1

This is the period of time designed for: class activities/general classroom instruction (lesson); activities that allow pupils to learn science (science instruction); activities that do not allow pupils to learn science (non-science); administrative activities and discussion (science organization); and the inability to code a segment of a lesson due to a technical problem with the camcorder (technical difficulty). In the lesson transcript, the beginning and end of the lesson was first marked, and the lesson was later divided into segments of science instruction, science organization, non-science, and technical difficulty. There were the 4 codes under this dimension, and the lesson time for these was later computed.

Dimension 2

The segments of the teacher's and pupils talk intended for the whole class were clearly marked for Dimension 2, and the duration was subsequently calculated. The only code was public talk.

Dimension 3

Independent seatwork and practical activities based on the social organization type were captured by Dimension 3. These segments were first marked and the duration subsequently scored.

Dimension 4

This focuses on the instructional practices during the science instruction segment. This dimension includes activities during which students worked on whole-class work, whole-class seatwork, whole-class practical work, independent practical work, independent seatwork, copying notes, silent reading, and divided class. These 8 codes were all coverage codes, that is considered as segments of a typical lesson. Other codes included teacher-student interaction, discussion, and presentation. All the codes under this dimension were clearly marked, and the duration was calculated.

Dimension 5

This describes pedagogical function structures like reviewing previous content, developing new content, assigning homework, going over homework, assessing student work, going over assessment, and administrative. These codes were also clearly marked, and the duration for each function was computed.

Dimension 6

This is the physical classroom learning environment like room type, science related commercial and natural objects, books and notebooks, and computers. The rest were overhead projectors, specialized visual technologies, blackboards, adult teaching assistant, grading, routine lesson opener, and school uniform. The presence of these in a classroom was noted for all the lessons.

Dimension 7

This describes the types of independent seatwork and independent practical work activities. It probed into the kinds of tasks students are expected to complete during these activity settings. It also investigated discussion segments.

Dimension 8

This is the categories or various disciplines of the lesson content. The eight broad categories of the science content codes were earth science, life science, physical science, science, technology, and mathematics, history of science and technology, environmental and resource issues related to science, nature of science, and science and other disciplines.

Dimension 9

This is the types of knowledge developed in science instruction. These are canonical knowledge, real-life issues, real-life issues used to develop canonical knowledge, procedural and experimental knowledge, classroom safety knowledge, nature of science knowledge, meta-cognitive knowledge, and blank segments/activities, that is, activities that did not offer opportunities for students to learn science.

Dimension 10

This focuses on the development of science content in the classroom. It covered the density of publicly-presented canonical ideas, different types of evidence used to develop science knowledge and linked to main ideas, level of difficulty of the science content, and how science content was developed. All these were clearly marked on the transcripts and the duration was later determined.

Dimension 11

This mainly probed further independent practical activities and explored motivating whole-class activities.

3.4.2 Matsubara (2009) lesson analysis method

The level of students' cognitive involvement in the lessons was analyzed using Matsubara 2009 lesson analysis method. The main features of this lesson analysis method are a move and category system (Matsubara, 2009). A move is a set of a teacher's question and a student's response to the question (Smith, 1967; Fujii, 1983). A move, normally, has an underlying intention. When two or more moves have identical teacher intention, they are classified as one move with an intention or simply an intentional move (Matsubara, Beccles & Ikeda, 2010). The category system consists of three main groups, namely: No student response, Teacher-led response, and Non-led response (Matsubara, 2009). No Student response is the condition when there is no verbal and physical response or no verbal response but physical response to a teacher's question. This is because the main target of the analysis was verbal interactions. Teacher-led response is the condition when students' responses are led by a teacher or initiated by a teacher and students repeat or say with the teacher not demonstrating their knowledge or thinking; and Non-led response is the condition when students' responses are not led by the teacher or students initiate their answers demonstrating their knowledge or thinking (ibid.). When it comes to international cooperation, it is important to pay close attention to the local context of a country or region (Lewin, 1993). Thus, this was developed by considering the context of Zambian science lessons and the situation of science education at the lower secondary level in the country. This method was developed by paying attention to the context of the country. Matsubara (2009) revealed the level of student engagement in various segments of a lesson like introduction, discussion, demonstration and conclusion.

During the analysis, the moves in the lesson transcripts were identified and subsequently assigned category codes using Matsubara (2009) lesson analysis guide (Table 3.8). For example, the statement, the blood is made up of what; neither elicited a verbal nor a physical response from students. Thus, this move (Move 1) was scored as NR 1 (Table 3.9). However Move 2 that elicited no verbal response from students but a physical response was scored as NR 2.

Table 3.8 Matsubara lesson analysis guide

Type of Response	Category	Description
No Student Response	NR 1	No verbal and No physical response
	NR 2	No verbal response but physical response only
Teacher Led Response*	LU	Response to a teacher's utterance
	L 1	Yes/No response to a teacher's led question
	L 2	Longer response to a teacher's led question
Non Led Response**	UN	Response to a teacher's utterance
	NY/NN	Response showing agreement or disagreement
	DI	Response demonstrating information and/or knowledge
	DR	Response demonstrating reasoning and/or thinking
	QT	Question to the teacher
	QP	Question/response to other pupils

*Teacher Led Response: Students' responses are led by a teacher; teacher initiates answers and students repeat or say with teacher; **Non Led Response: Students' responses are not led by teacher; students initiate their answers

Source: Matsubara, 2009

Table 3.9 Examples of moves and category codes

Move number	Person	Content of verbal exchange	Category code
1	T	The blood is made up of what?	NR 1
	S	(no verbal response, and no raising of hands)	
2	T	What is plasma?	NR 2
	S	(No verbal reply, but students raise their hands)	
3	T	One what? Practical way that you can use what? to make water to be soft when you are washing with what? Soap	LU
	S	Soap	
4	T	Did you hear?	L 1
	S	No madam	
5	T	The second one is what?	L 2
	S	Distribution of heat	
6	T	The blood cells transport what?	UN
	S	Oxygen	
7	T	Do we all agree?	NY/NN
	Ss	Yes	
8	T	What is digestion?	DI
	S	It is the breaking down of food substances into smaller pieces	
9	T	What is the function of the conjunctiva?	DR
	S	It covers and protects the inner part of the eye	
10	S	Sir, what is the function of the lens	QT
	T	The lens and all these are supposed to ...	
11	S	Which one is correct?	QP
	S	This one	

T: Teacher; S: One student; Ss: Students.

3.4.3 Anderson et al. (2009) taxonomy table

A taxonomy table developed by Anderson et al. 2001 (Table 3.10) was used for the classification of teacher questions and students' responses into the various cognitive and knowledge dimensions.

Table 3.10 Knowledge dimension and cognitive process of science teachers' questions and students' answers

The Knowledge Dimension	Utterance	The Cognitive Process Dimension						
		Remember /% (N)	Understand /% (N)	Apply /%(N)	Analyze /%(N)	Evaluate /%(N)	Create /%(N)	Total /%(N)
Factual Knowledge	TQ							
	SA							
Conceptual Knowledge	TQ							
	SA							
Procedural Knowledge	TQ							
	SA							
Meta-cognitive Knowledge	TQ							
	SA							
Total	TQ							
	SA							

TQ: Teacher Questions; SA: Student Answers; N: Number of Teachers' Questions or Students' Answers

Source: Adapted Anderson, et al., 2001

A question or a statement, usually, contains a verb and a subject. The verb was used to determine the cognitive process in the question and the subject was used to classify the knowledge dimension. For example, in the statement, "State the components of blood" asked by a teacher during the lesson introduction stage, the cognitive process was remember, and the knowledge dimension was factual knowledge. The verb "state" elicited the cognitive process of recall, and the part "components of blood" represents factual knowledge about blood.

The purpose of the question and its placement in the stage of the lesson was also considered during the classification. For instance, a question could elicit understanding of knowledge from students in the development stage of a lesson and the same question can elicit recall of knowledge when used during the closure stage of a lesson to evaluate student knowledge. The Cognitive Process Dimension Guide (Table 3.6) was used to classify the questions into the cognitive domains namely; remember, understand, apply, analyze, evaluate, and create.
Remember level is the lowest cognitive process and create level is the highest cognitive process. These are essentially a revised version of Bloom's taxonomy. Remember cognitive process is the recognition or identification and recall or retrieval of knowledge. Understand cognitive process is the interpretation, exemplification, classification, summation, and inference of knowledge (ibid.). Furthermore this cognitive process is also the comparison and explanation of knowledge. The execution and implementation of knowledge describes apply cognitive process. Analyze cognitive process is the differentiation, organization, and attribution of knowledge. The checking and critique of knowledge describes evaluate cognitive process, and the generation, planning and production of knowledge is create cognitive process. The cognitive processes of teacher questions are intended to nurture students' cognitive structures. They are also aimed at eliciting students' knowledge about the content of lessons, so a teacher's question also has a knowledge dimension.

During the analysis, the statement 'state the components of blood' asked in the introduction stage of the lesson to review the prior knowledge of the students was classified as remember because the purpose was to recall or retrieve knowledge. The same method was used to classify students' answers.

On the other hand, the Knowledge Dimension Guide (Table 3.7) was used in the classification of the subject part of the question into the knowledge dimensions: factual, conceptual, procedural, and meta-cognitive knowledge. For example, knowledge of terminology and knowledge of specific details and elements was classified as factual knowledge.

Factual knowledge is the simplest and most important facts or ideas connected to the lesson content. Factual and conceptual knowledge can also be classified as canonical knowledge which is "the knowledge science produces" (Roth et al., 2006, p. 48). Canonical knowledge includes scientific facts, concepts, ideas, processes or theories (Roth et al., 2006). Procedural knowledge is sometimes referred to as procedural and experimental knowledge, and signifies "how to do science-related practices such as manipulating materials and performing experimental processes" (ibid., p.49).

3.4.4 Teacher Intentions lesson analysis framework

Teacher questions or statements/word(s) that elicit responses during classroom discourse, usually, have underlying motives. These motives are the intentions for posing those questions during classroom discussions. Teacher intentions are the reasons behind teacher questions or what teachers want or plan to achieve with questions. Teacher intentions were classified into six main groups in this study. These were instructional management purposes, checking students' attention in the lesson, checking students' science content and experiential knowledge, checking students' procedural knowledge and observation skills, checking students' understanding of lesson content, and eliciting student thinking (Table 3.11). For example, the teacher intention behind the question 'What is plasma' directed to a student who was not paying attention in class was scored as instructional management intention.

Furthermore, the intention behind teacher questions or statements/word(s) that elicit either Yes or No response such as "are you with me", "do you understand" and "okay" were scored as checking students' attention in the lesson. However, teacher intention behind questions that challenged students to demonstrate understanding of lesson content like "give one example of a physical change in our daily lives" was scored as checking students' understanding.

Table 3.11 Teacher intentions lesson analysis framework

Teacher Intention	Code	Type of Question	Guidelines
Instructional Management	QM	Management strategy questions	Classroom control and organization questions such as asking about absentees (e.g. Where is Kofi?), intentionally directing a question to a student who is sleeping, disturbing or not paying attention.
Students' focus/attention in the lesson	QF	Require Yes/No answers	Questions that check that students are paying attention in class and following the lesson
Students' prior science content knowledge (factual and conceptual), daily life experiences, and observations, and ability to read and draw	QKP	Students' daily life experiences, and observation	Questions that check students' prior daily life experiences and observations
	QCK1	Require at least one word/term answers	Questions that check students' prior content knowledge
	QCK2	Require at least one sentence answers	Questions that check students' prior content knowledge
	QRK	Require students to read	Questions that check students' ability to read
	QDK	Require students to draw	Questions that check students' ability to draw or label
Students' procedural and experimental knowledge	QPK	Require students to use science process skills/demonstrate procedural knowledge	Question that checks students process skills/demonstration of procedural knowledge
Students' understanding	QUK	Require students to demonstrate understanding	Questions that check students' understanding of lesson content
Eliciting student thinking	QAK	Require the application of knowledge	Questions that check students' ability to use knowledge in novel situations
	QNK	Require the analysis of knowledge	Questions that check students ability to analyze knowledge
	QEK	Require the evaluation of knowledge/ allow students to question science content and student responses	Questions that check students ability to evaluate knowledge
	QCK	Require development of knowledge	Questions that require students to develop knowledge

Management strategy questions and questions that require Yes/No answers were analyzed as questions that had teacher intentions that were for instructional management purposes and checking students' attention in the lesson respectively. The criteria for determining questions or statements that check students' science content and experiential knowledge were questions or statements that mainly task students to either recognize (identify) or recall (retrieve) lesson content (Table 3.6). These questions or statements mainly: elicit students' prior content knowledge; elicit students' knowledge in daily life experiences/observations; require at least either one word/term answer or one sentence answer; and require either students to read or draw. Checking students' procedural knowledge/observation during classroom discourse was guided by questions that require students to use science process skills. In addition, checking students' understanding was informed by questions that require at least one sentence answer to interpret, exemplify, classify, summarize, compare, and explain lesson content (Table 3.6).

The criteria for eliciting student thinking were questions or statements that required students to either apply, analyze, evaluate or develop lesson content.

3.4.5 Teacher Response Behavior lesson analysis method

The verbal exchanges between the science teachers and students during the discussion sessions were then extracted to study how science teachers respond to students' answers and responses. Figures 3.3, 3.4, 3.5 and 3.6 represent samples of discussion segments.

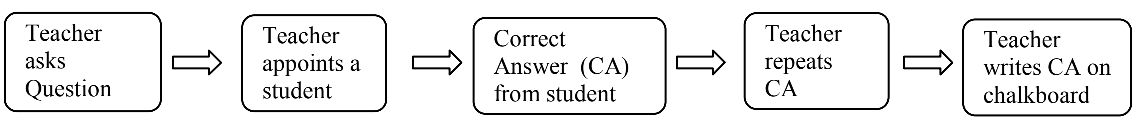

Figure 3.3 A teacher's response behavior to a student's correct answer

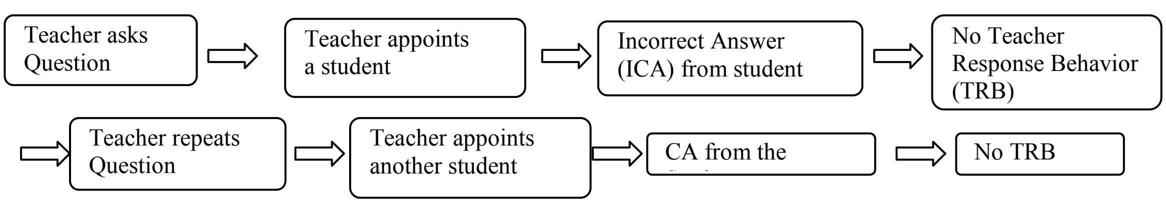

Figure 3.4 A teacher's response behavior to a student's incorrect answer

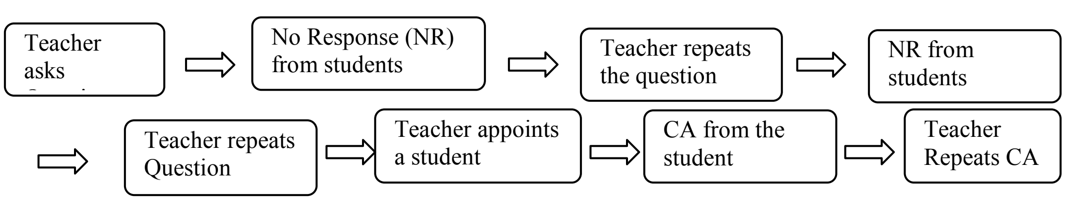

Figure 3.5 A discussion segment containing at least a teacher's response behavior to a student's no response

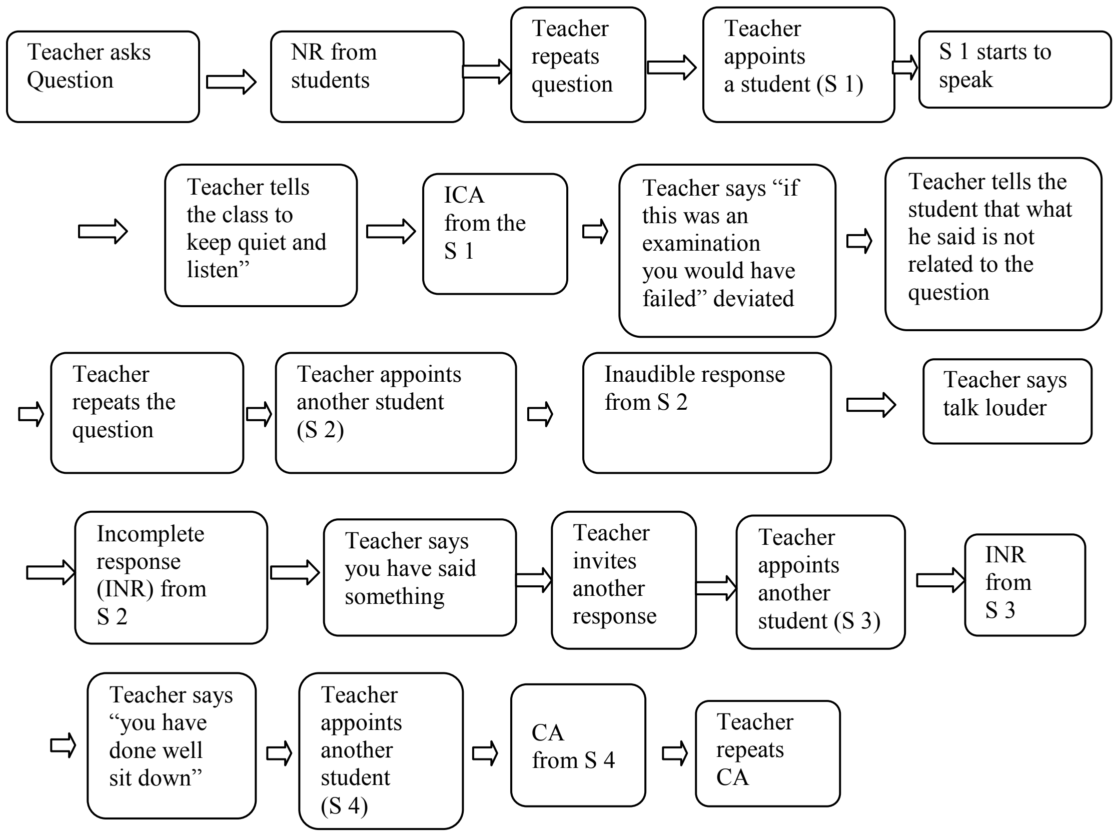

Figure 3.6 A teacher's response behavior to students' answers

Teacher responses towards students' correct or incorrect answers and no responses from the video and the interview were listed, and tabulated to find the frequencies. A correct answer is a right response to a question or a response that is generally true and accepted as the answer to the question. An incorrect answer is a wrong response to a question or a response that is generally not true and unacceptable. It is also a deviation from what the question demands. Additionally, teachers' perceptions of correct and incorrect answers were considered since the focus was on teachers' responses to students' answers, and also because of the fact that a teacher's response will depend on what he/she considers to be as correct or incorrect. Therefore, a correct answer is also an incorrect answer perceived as correct by the teacher to a question, and an incorrect answer is an answer that is correct but perceived by teachers as incorrect. No response is the condition when students do not raise their hands to respond to teacher questions or when a student called upon to respond to a teacher question does not talk.

The students' correct or incorrect answers and no responses were then thematically analyzed. The stages of the thematic analysis were data immersion, initial coding, creating categories, and identifying themes (Appleton, 1995; Green et al., 2007). The researcher and four raters repeatedly read through the teacher responses towards students' responses extracted from the video, the interview, and contextual data to get immersed in them (Green et al., 2007.). This was followed by coding, and data that were related were later put into categories using Table 3.12 as a guide. For instance, teacher responses that 'used responses from students to develop the lesson' were categorized as 'using responses', and teacher response behavior towards students' incorrect answers reported by science teachers themselves such as the use of gestures like shaking the head, saying "no", and calling another student to respond to the question were put under rejecting teacher response category. Furthermore, no teacher response and teacher responses such as "sit down" were categorized as ignoring teacher response behavior. Pattern coding was subsequently used to combine categories that described similar patterns to look for themes (Appleton, 1995; Green et al., 2007; Miles & Huberman, 1994).

Therefore, rejecting and ignoring teacher response behavior were unified under the theme shy-timidity which is the state of being shy and timid and afraid to talk in class. Similarly using and judging teacher response behaviors and teacher responses that encouraged students were classified as self-learning and self-confidence respectively. Self-learning' is engaging in processes to discover correct answers to questions by students themselves, and self-confidence is the condition where students are able to freely and outwardly express their views, ideas and opinions easily in class. The interview data were also analyzed in the same way.

Table 3.12 Guidelines for categorizing teachers' response behavior to students' correct or incorrect answers, and no responses; causes of students' no responses; and students' feelings

Category	Description	Guideline
Use	Using students' responses to develop the lesson	Linking students' response to lesson content; using incorrect answers as correct answers for other questions
Find out	Probing for information that will guide teaching strategy and help students to discover knowledge	Asking students whether they understood lesson content/Question; asking students for reasons for their responses; asking students to proof their responses
Judge	Probing responses to evaluate them	Asking students to evaluate the correctness or incorrectness of a response
Encourage	Actions that motivate students to respond to teacher questions	Use of verbal and nonverbal rewards; recognition of students' answers and efforts; reformulation of teacher questions; providing hints/clues
Reject	Not accepting students' Responses	Use of negative verbal cues; teacher getting angry; call another person after an incorrect answer; interrupting incorrect answers
Ignore	Not passing a comment on a student responses or telling the student to sit down	No teacher response to a students' response; call another person after a no response
Discomfort	Physical actions that do not make a student comfortable	Asking a student to keep standing during lessons; caning of students; sacking a student from class as a form of punishment
Discourage	Actions that do not motivate students to respond to teachers' questions in class	Use of negative verbal and nonverbal rewards; Ignoring students' responses; Rejecting students' responses; Discomforting response actions
Depend	Students' feeling is determined by how teachers respond to students' incorrect answers	Teacher responses that encourage/discourage students; Teacher responses that discourage students
Verbal intelligence	This is the ability of the students to use the language of instruction	Lack of English language proficiency
Student characteristic	These are features of students that affect their learning	Not paying attention in class; Not serious at studying; mood of students; feels proud;
Student aptitude	This is the ability level of students	Students' learning capabilities
Thinking about question	The process when the cognitive structures are processing students' thinking	No response behavior but attempting to respond to the question
Do not know the answer	Condition when students do not know the answer	No response with no attempt to respond to the question
Teacher response behavior	The way teachers respond to students' answers and no responses	Use; Find out; Encourage; Question hint; Reject; Ignore; and Discomfort
Teaching strategy (unclear question or lesson content)	The teaching strategy used and the clarity of teacher questions or lesson content	Non-participatory teaching strategies and unclear teacher questions or lesson content
Home	The place students live	Influence from the family and the social unit in students houses
Extra-curricular activity	Activities not directly related to curriculum	Sporting activities, club activities
Class behavior	The attitude of the class	Laughing at students who give wrong answers;
Shy	The condition of drawing back from no answering questions because of fear and timidity	Feeling of shyness, timidity; introverts

3.5 Code Development

This gives account of the theoretical view of classroom verbal interaction and the coding system developed in this study.

3.5.1 Theoretical view of classroom verbal interaction

Verbal interaction is the vehicle that connects teachers, students and classroom tasks. Classroom activities are mainly carried on in verbal interaction between the teacher and students (Bellack et al., 1968), and this interaction plays an important role in meaning-making by students (Bellack et al., 1968, Chin, 2006). There are very few classroom activities that can be carried on without using language (ibid.).

However, student engagement in classroom verbal interaction will depend on factors such as the nature and purpose of teacher questions. A teacher's question that is simple, brief and clear is likely to elicit high response rate than a question that is not well phrased. In addition, a teacher question that elicits student ideas or thinking will probably elicit varied student responses than a question that evaluates student knowledge. Teacher response towards students' answers, students' verbal competence, students' scientific knowledge base, and the cultural setting of the classroom practice, also, influence classroom verbal interaction.

In this study, teacher questions or statements that elicit responses from students, student responses to teacher questions, teacher response to student answers, student questions, and teacher responses to student questions were identified as the main parts of classroom verbal interaction, and subsequently coded. In addition, the cognitive processes and the knowledge dimensions were also considered.

3.5.2 Coding system

Preliminary analysis was carried out to help generate the codes. The codes were mutually exclusive, and centered on six main themes. These were (1) Speaker, (2) Teacher reactions, (3) Student Utterances, (4) Cognitive Process, (5) Knowledge Dimension, and
(6) Teacher Intention of questioning

(1) Speaker

The Speaker denotes the source of the utterance

Teacher (T); Student (S); Student 1 (S 1); Students (Ss)

(2) Teacher reactions

Teacher reactions are either utterances from teachers or nonverbal teacher behaviors to students' answers and no responses. The utterances were limited to questions or statements that elicit response from student, and teachers' verbal response behavior to students' answers. Teachers' nonverbal response behaviors are nonverbal teacher behavior.

(a) Questions or statements that elicit response from student

Teacher Questions were coded as TQ, and Teacher Statements as TS

(b) Teacher response behavior to students' answers and no responses

Teacher response behavior (TRB) to students' answers and no responses were coded as follows:

Using Response Behavior (URB); Finding out Response Behavior (FRB); Judging Response Behavior (JRB); Rejecting Response Behavior (RRB); Ignoring Response Behavior (IRB); Discomforting Response Behavior (DFRB); Encouraging Response (ERB); Discouraging Response Behavior (DSRB); Depending Responses (DPRB)

(3) Student utterances

Student utterances are the words spoken by the student. These were limited to students' answers or responses to teacher questions, and student questions about the lesson content.

(a) Student questions about the lesson content

Student Questions were coded as SQ.

(b) Students' answers or responses to teacher questions

These were denoted as follows: Correct Answer (CA); Incorrect Answer (ICA); No responses (NR); Unclear Response (UCR); Incomplete Response (INR); Inaudible Response (IAR); Repeated Response (RPR); No Idea Response (NIR); I Can't Response

(ICR)

(4) Cognitive Process

The cognitive process of an utterance is the level of thinking it represents, and this was coded as follows: Remember (RCP); Understand (UCP); Apply (APCP); Analyze (ANCP); Evaluate (ECP); Create (CCP)

(5) Knowledge Dimension

The knowledge dimension of an utterance is the type of knowledge it represents, and subsequently denoted as: Factual Knowledge (FKD); Conceptual Knowledge (CKD); Procedural Knowledge (PKD); and Meta-Cognitive Knowledge (MKD) in this study.

(6) Teacher Intention of Questioning

This is the purpose of teacher questions. It was coded as follows:

Instructional Management (QM);

Checking students' attention/focus in the lesson (QF);

Checking students' prior knowledge/daily life experiences or observations (QKP);

Checking students' word science content knowledge (QCK 1);

Checking students' sentence science content knowledge (QCK 2)

Checking students' ability to read (QRK);

Checking students' ability to draw/label (QDK);

Checking students' procedural knowledge (QPK);

Eliciting students understanding (QUK);

Eliciting application of knowledge (QAK);

Eliciting analysis of knowledge (QNK);

Eliciting evaluation of knowledge (QEK);

Eliciting development/creation of knowledge (QCK)

CHAPTER 4

RESULTS

4.1 Science Teaching

4.1.1 Science teachers' time spent on different school activities

Science teachers in this study in Ghana spent an average of 28 hours per week on all teaching and other school-related activities, and the results from the TIMSS 1999 video study revealed that science teachers in Australia, Czech Republic, Japan, Netherlands and USA reported spending an average time on all teaching and other school-related activities ranging from 38-45 hours per week (Table 4.1).

Table 4.1 Average weekly hours science teachers spent on teaching and other school related activities in selected junior high schools in Ghana and other countries

Activity	Ghana	Australia	Czech Republic	Japan	Netherlands	USA
Teaching science class	7	14	16	16	19	20
Teaching other classes	8	3	6	1	4	4
Meeting with other teachers to work on curriculum and planning issues	3	2	1	1	1	2
Work at school related to teaching science	3	7	6	6	4	7
Work at home related to teaching science	3	6	6	4	7	6
Other school-related activities	4	5	7	12	5	6
All teaching and other school-related activities	28	38	42	40	40	45

As can be seen from Table 4.1, science teachers in Ghana spent a smaller average number of hours on all teaching and other school-related activities than their counterparts in the other countries. They also reported spending an average of 7 hours in a week teaching science classes, and compared with the results of the TIMSS 1999 video study, it is seen that science teachers who participated in that study reported spending between 14 and 20 hours in a week teaching science classes. Therefore, science teachers in this study in Ghana, spend about half the time used by the countries that participated in the TIMSS study in a week teaching science classes.

Furthermore, the science teachers in Ghana reported spending an average of 8 hours in a week teaching other classes, and compared to science teachers in Australia, Japan, the Netherlands and USA this is about twice more than the time used in these countries. However, the number of hours that science teachers in Czech Republic spent on teaching other classes was about the same as in Ghana.

Science teachers in Ghana also reported spending 3 hours per week for meeting with other teachers to work on curriculum and planning issues and compared with the countries that took part in the TIMSS 1999 video study, it is seen that science teachers from these countries spent between 1 and 2 hours on meeting with other teachers to work on curriculum and planning issues. They also spend 3 hours per week each on work at school related to teaching science, and work at home related to teaching science and those from the other countries spend between 4 and 7 hours per week on the same activities. Additionally, in Ghana, the science teachers spent an average of 4 hours on other school-related activities in a week, and in Australia, Czech Republic, the Netherlands and USA, according to the results of the TIMSS 1999 video study, the science teachers spent between 5 and 7 hours weekly on other school related activities. However science teachers in Japan spent 12 hours in a week on other school-related activities.

4.1.2 Factors that influence the selection of lesson content

In this study, curriculum guidelines, mandated textbooks, and external examination and standardized tests greatly influence decision to teach lesson content in at least 72% of the lessons in the selected junior high schools in Ghana (Table 4.2). Compared with the other countries that participated in TIMSS 1999 video study, it is seen that curriculum guidelines greatly influenced decision making in at least 60% of the lessons in Australia, Czech Republic and the USA, and mandated textbooks played a major role in selecting lesson content in at least 52% of the lessons in Czech Republic, Japan and the Netherlands.

Furthermore, teachers' assessment of students' interest/needs, played a role in making decision to teach lesson content in 53% of the lessons in Ghana, but compared to the results of TIMSS 1999 video data, science teachers in 74% of the lessons in USA reported that this greatly influenced their decision, and between 25% and 47% of the science teachers in the other countries reported that this influenced their decision.

Table 4.2 The percentage of teachers who agree on the items as major factor in the decision to teach lesson content in selected junior high schools in Ghana and other countries

Factor	Ghana /%	Australia /%	Czech Republic /%	Japan /%	Netherlands /%	USA /%
Cooperative work with other teachers	27	32	6	5	44	25
Curriculum guidelines	76	60	93	20	41	84
External examinations & standardized tests	72	-	3	5	7	23
Mandated textbooks	78	32	67	52	74	26
Teacher's comfort or interest in the topic	40	27	47	15	37	41
Teacher's assessment of students' interest / needs	53	47	39	44	25	74

Cooperative work with other teachers and teacher's comfort or interest in the topic exerted the least influence on decision to select lesson content in this study in Ghana, and the TIMSS 1999 video study also revealed a similar pattern among the countries that participated in that study.

4.1.3 Background information of the science teachers

4.1.3.1 <u>Science teachers' education preparation</u>

Most science teachers in this study in basic schools in Ghana have qualifications below undergraduate degree compared to those from JHS in Australia, Czech Republic, Japan, Netherlands and USA (Table 4.3). In these countries most science teachers have either graduate degrees or undergraduate degrees. A few science teachers in Ghana have either undergraduate degrees or high school certificate.

Table 4.3 Distribution of science lessons by teacher's highest level of education in selected junior high schools in Ghana and other countries

Country	Highest level of education/% (N)			
	Graduate degree	Undergraduate degree	Below undergraduate degree	High School Certificate
Ghana (N=23)	0	26.1 (6)	69.5 (16)	4.4 (1)
Australia (N=87)	11	85	4	0
Czech Republic (N=88)	100	0	0	0
Japan (N=95)	8	92	0	0
Netherlands (N=79)	39	61	0	0
USA (N=84)	39	61	0	0

Forty eight per cent (48%) of the science teachers in Ghana majored in 'other than science' (non-science) subject areas and 52% majored in General Science (Table 4.4). None majored in Life Sciences, Physics, Chemistry and Earth Sciences. However, in Australia, Czech Republic, Japan, Netherlands, and USA, the science teachers, mainly majored in the science disciplines.

Table 4.4 Science lessons taught by teacher's major in selected junior high schools in Ghana and other countries

Major area of study	Ghana /%(N)	Australia /%	Czech Republic /%	Japan /%	Netherlands /%	USA /%
Life Science	0	47	48	20	4	4
Physics	0	15	33	30	44	0
Chemistry	0	29	32	31	37	4
Earth Sciences	0	11	48	10	6	6
General Science	52 (12)	4	0	100	0	11
Science-Total	52 (12)	87	95	100	99	64
Other than science	48 (11)	13	5	0	0	36

The science teachers in this study in Ghana have an average teaching experience of 6 years in overall teaching and 4 years of teaching science but the overall teaching experience and the number of years of teaching science in the other countries ranged from 12 -21 years and 10-19 years respectively (Table 4.5).

Table 4.5 Summary and dispersion measures for science teacher's teaching experience in selected junior high schools in Ghana and other countries

Teaching experience	Statistic	Ghana /years	Australia /years	Czech Republic /years	Japan /years	Netherlands /years	USA /years
Years Teaching	Mean	6	15	21	15	14	12
	Median	4.0	16	21	15	11	7
	Range	1-11	0-39	1-41	1-34	1-36	1-35
Years of teaching science	Mean	4.0	14	19	14	12	10
	Median	4.0	15	18	15	9	7
	Range	1-9	0-39	1-39	1-34	1-33	1-35

4.1.3.2 Professional development opportunities

As indicated in Table 4.6, 45% of the lessons in Ghana were taught by science teachers who had taken some diploma courses prior to this study, and 38-56% of the lessons in Czech Republic, Japan, Netherlands and USA were taught by science teachers who took at least one science or science education university course. However in Australia, only 9% of the lessons were taught by science teachers with that experience. The average number of professional development activities in Ghana was 3 and in the other countries this ranged from 2-5.

Table 4.6 Science lessons taught by teachers who participated in science- related education courses and average number of professional development activities in selected junior high schools Ghana and other countries

Country	Lessons taught by teachers who took at least one science/science education/education course/%	Average number of professional development activities
Ghana	45	3
Australia	9	3
Czech Republic	56	2
Japan	38	2
Netherlands	50	2
USA	49	5

The science teachers in Ghana (54%) reported that they mainly take part in professional activities focusing on science instructional techniques (Table 4.7) whereas their counterparts in the other countries participate in diverse professional development activities.

Table 4.7 Percentage of science lessons by teachers' participation in professional development activities or academic courses in selected junior high schools in Ghana and other countries

Professional development activity	Ghana /%	Australia /%	Czech Republic/%	Japan /%	Netherlands /%	USA /%
Classroom management and organization	5	37	6	19	16	21
Cooperative group instruction	0	29	7	12	36	48
Interdisciplinary instruction	0	14	5	-	3	48
Science instructional techniques	54	36	36	50	43	66
Standards-based teaching	0	36	0	29	22	52
Teaching higher-order thinking skills	0	22	0	0	11	44
Teaching students from different cultural backgrounds	0	13	0	0	8	31
Teaching students with limited proficiency in their national language	0	5	0	0	5	18
Teaching students with special needs	0	23	7	6	12	36
Use of technology	14	79	45	42	68	84
Other professional development activities	18	46	42	18	25	44

Besides, 44% and 24% of the science teachers (Figure 4.1) in this study in Ghana reported that a colleague teacher observed their teaching of an entire lesson once or twice in a year, or never did at all respectively, and 50% and 27% of the science teachers in this study in Ghana also reported that they either observed their colleagues teaching of an entire lesson once or twice, or not at all in a year respectively.

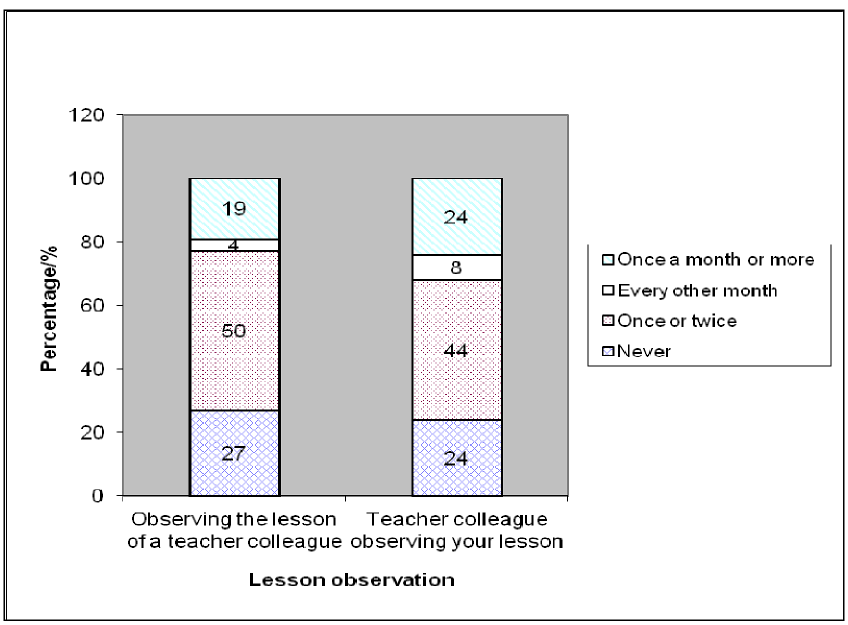

Figure 4.1 Lesson observations per year in selected junior high schools in Ghana

4.1.3.3 Science teachers' learning goals for science lessons

In Ghana, science teachers mainly focus on knowing science information, followed by awareness of the usefulness of science in life rather than understanding scientific ideas and doing science (Table 4.8). On the other hand science teachers from the other countries spread their foci on knowing and understanding of science, doing science, and context of science, although the extent of foci differs from country to country. There is a remarkable difference between science teachers in this study in Ghana and those from Japan. For instance, 75% and 0% of the science teachers in Ghana reported focusing on knowing science information and understanding scientific ideas respectively, whereas 14% and 70% of the science teachers in Japan focused on knowing science information and understanding scientific ideas respectively.

Table 4.8 Percentage of lessons by teacher-identified goals in selected junior high schools in Ghana and other countries

Goal for the lesson		Ghana /%	Australia /%	Czech Republic /%	Japan /%	Netherlands /%	USA /%
Knowing and understanding science	Knowing science information	75	20	59	14	23	23
	Understanding scientific ideas	0	51	7	70	27	23
	Understanding nature of science	0	4	0	0	0	4
Doing science	Carrying out a scientific experiment, project, or activity	4	4	6	10	15	17
	Developing generic thinking skills	0	0	0	3	8	5
	Learning laboratory skills	0	11	10	15	12	6
	Using scientific inquiry skills	0	13	6	8	11	22
Context of science	Awareness of the usefulness of science in life	21	19	12	9	17	22
	Collaborative work in group	0	0	0	0	10	8
	Independent work	0	5	0	3	11	7

4.1.3.4 **Learning environment**

The students usually wear uniforms and have their lessons in a regular classroom with a blackboard (Table 4.9). The entire students have textbooks and notebooks but commercial and natural products are inadequate. Generally, there were no teaching assistants, and routine lesson opener was also rare.

Table 4.9 Learning environment in selected junior high schools in Ghana

Observed Learning Environment	Description	% (N)
Room	Regular Room	100 (23)
Commercial and natural products	Commercial products	21.8 (5)
	Natural products	8.7 (2)
Books	Textbook	100 (23)
	Notebook	100 (23)
Education technology	Overhead Projector	0
Blackboard	Blackboard	100 (23)
Teaching assistant	Teaching assistant	4.4 (1)
Grades/scores	Grades/scores	0
Routine lesson opener	Routine lesson opener	13.0 (3)
Student uniforms	Student uniforms	100 (23)

4.1.3.5 **Attitudes about teaching**

Science teachers in this study in Ghana generally agreed on: engaging in activities to professionally develop their careers like pursuing opportunities to learn how to improve science teaching, and watching television programs about new developments in science (Table 4.10). Furthermore, they also generally agreed that: they encouraged girls to develop an interest in science; work hard to get both boys and girls involved in science; preferred teaching students of low, high and different ability levels; enjoy teaching students of this age group; are somehow impressed with the quality of thinking of students; and have strong background in the subject areas they teach.

Moreover, they agreed that: their work as a science teacher is appreciated by their students, colleague teachers, and parents; they have adequate opportunities during the school day to collaborate with colleagues about science; and think that they are effective teachers. However, they generally disagreed that they have adequate materials and facilities to support the teaching of science.

Table 4.10 Attitudes to teaching among science teachers in selected junior high schools in Ghana

Attitude	Extent of agreement*
I actively pursue opportunities to learn how to improve my science teaching	1.0
I like to watch TV programs about new developments in science	1.1
I have a strong science background in the subject areas I teach	1.6
Teaching science is rewarding work	1.8
I am enthusiastic about teaching science	1.5
I have adequate materials and facilities to support my teaching of science	3.1
I have adequate opportunities during the school day to collaborate with colleagues about science	2.6
I am often impressed with the quality of thinking of my students	1.9
Girls in this school are encouraged to develop an interest in science	1.2
I work hard to get girls involved in science	1.4
I work hard to get boys involved in science	1.3
I prefer teaching low ability students	2.1
I prefer teaching high ability students	1.7
I prefer to teach a class that has students of different ability levels	1.4
I enjoy teaching students of this age level	1.6
My work as a science teacher is appreciated by my students' parents	1.8
My work as a science teacher is appreciated by my students	1.2
My work as a science teacher is appreciated by my teacher colleagues	1.2
I think that I am an effective teacher : I am confident that my students learn nearly all of what I teach	1.5

* 1: Strongly agree; 2: Slightly agree; 3: Slightly disagree; 4: Strongly disagree

4.1.3.6 Extent of access to available resources

The majority of science teachers in this study in Ghana did not have access at all to computers, computer software, computers with internet connections, microscope, A/V equipment like TV, VCR, overhead projectors, and science laboratory, and 73% of the science teachers reported that there were too few or little teaching supplies/materials like chemicals, magnets and rulers, and reference materials like books, journals and magazines (Table 4.11).

Table 4.11 Extent of access to available resources selected junior high schools in Ghana

Resource	Extent of Access/% (N)		
	Not at all	Too few or little	Enough
Computers	83(19)	17 (4)	0
Computer software	91 (21)	9 (2)	0
Computers with internet connections	96 (22)	4 (1)	0
A/V equipment	83 (19)	17 (4)	0
Teaching supplies/materials	26 (6)	74 (17)	0
Microscope	83 (19)	17 (4)	0
Science laboratory	100 (23)	0	0
Reference materials	87 (20)	13 (3)	0

4.1.4 Instructional organization of lesson time

4.1.4.1 Public talk and time spent on studying science

Most of the lesson time (87.9%) in the science lessons selected for this study in Ghana was spent on public talk, and the mean time was 33.6 minutes per lesson. The public talk involved mainly teachers' talk for the hearing of the whole class.

The average duration of science lessons in Ghana was 39 minutes and that for Australia, Czech Republic, Japan, Netherlands and USA ranged from 40-51 minutes (Table 4.12).

Table 4.12 Mean, median, range, and standard deviation of the duration of science lessons in selected junior high schools in Ghana and other countries

Country	Mean	Median	Range	Standard Deviation
Ghana (N=15)	39	40	18-74	14
Australia(N=87)	49	45	21-92	14
Czech Republic (N=88)	46	45	39-52	1
Japan (N=95)	50	51	40-65	4
Netherlands(N=79)	47	46	37-90	8
USA (N=84)	51	46	33-119	16

Science teachers in Ghana spent an average time of 38 minutes on science instruction, and their counterparts who participated in the TIMSS 1999 video study spent between 43 and 48 minutes on science instruction (Table 4.13).

Table 4.13 Mean, median, range, and standard deviation of actual science instruction of science lessons in selected junior high schools in Ghana and other countries

Country	Mean	Median	Range	Standard Deviation
Ghana	38	39	18-73	15
Australia	44	42	16-89	13
Czech Republic	44	44	39-51	2
Japan	48	48	38-59	4
Netherlands	43	42	32-84	7
USA	47	43	30-119	15

The science teachers in Ghana, Australia, Czech Republic, Japan, Netherlands and USA spent a high percentage of lesson time, ranging from 91-97% on science instruction, and the least, between 1-3% on non-science (Table 4.14). Although, science teachers in all five countries generally spent a small percentage of the lesson time on science organization, Ghanaian science teachers in this study and those from Czech Republic spent the least.

Table 4.14 Average percentage of science lesson time devoted to non-science, science organization, and science instruction in selected junior high schools in Ghana and other countries

Distribution of science lesson time	Ghana/%	Australia/%	Czech Republic/%	Japan/%	Netherlands/%	USA/%
Science instruction	97	91	97	94	91	92
Science organization	1	7	2	4	5	6
Non science	1	2	1	1	3	2

Outside interruptions, non-science segments and science organization segments were some activities that mainly punctuated the flow of lesson presentation. Science lessons in this study in Ghana are less interrupted by science organization and non-science segments than in the TIMSS study in the other countries (Table 4.15). However, the extent of interruption by outside interruptions is comparable with those in Australia, and USA.

Table 4.15 Science lessons with any instance of outside interruptions, non-science segments, and science organization segments in selected junior high schools in Ghana and other countries

Type of lesson interruption	Ghana/%	Australia/%	Czech Republic/%	Japan/%	Netherlands/%	USA/%
Science organization segments	20	90	61	76	85	92
Non-science segments	27	47	56	42	72	38
Outside interruption	40	42	7	-	16	45

4.1.4.2 Lesson organization for different instructional purposes

Science teachers who took part in this study in Ghana developed new content in all their lessons, and reviewed previous content and assessed student learning in 73% and 40% of the lessons respectively (Table 4.16). They neither did not go over homework nor performed other purposes like assigning homework, going over assessment, and administrative work. Science teachers in the TIMSS study developed new content and performed other purposes in almost their entire lesson. Apart from Netherlands, reviewing previous content occurred in many lessons than assessing student learning in Ghana and the other countries. Generally, going over homework did not occur in many lessons apart from Netherlands where 45% of the science lessons contained going over homework segments.

Table 4.16 Science lessons that contained at least one segment of a given type of lesson purpose in selected junior high schools in Ghana and other countries

Purpose	Ghana/%	Australia/%	Czech Republic/%	Japan/%	Netherlands/%	USA/%
Developing new content	100	97	99	100	99	96
Reviewing previous content	73	41	84	33	8	42
Going over homework	0	2	3	0	45	17
Assessing student learning	40	0	50	5	18	14
Other purposes	0	99	98	99	100	92

This study demonstrated that science teachers in Ghana organized most of the lesson time (87%) for developing new content, very little time for reviewing previous content (7%), followed by assessing student learning (Table 4.17). They devoted no time for going over homework and other purposes in the observed lessons. Science teachers from Netherlands, Australia, Czech Republic, Japan and USA in the TIMSS study also spend the highest percentage of their lesson time, that is, 85%, 67%, 93%, 78% and 79% respectively on developing new content. Apart from science teachers from Netherlands, those from the other countries in the TIMSS study spent more time on reviewing previous content than on other purposes.

Science teachers from the Netherlands spent 1% of the lesson time on reviewing previous content and 7% on other purposes. They also spent the more time on going over homework than the science teachers from the rest of the countries who either spent at most 3% or none of the lesson time on this pedagogical function in the TIMSS study.

Table 4.17 Distribution of science lesson time devoted to each type of lesson purpose in selected junior high schools in Ghana and other countries

Purpose	Ghana/%	Australia/%	Czech Republic/%	Japan/%	Netherlands/%	USA/%
Developing new content	87	85	67	93	78	79
Reviewing previous content	7	8	19	3	1	8
Going over homework	0	0	1	0	12	3
Assessing student learning	5	0	9	1	2	3
Other purposes	0	7	4	3	7	8

Developing new content only occurred in a smaller percentage of the science lessons in Ghana and Czech Republic in the TIMSS study, and pedagogical functions involving both developing new content and reviewing previous content occurred in a higher percentage of the lessons in these countries. For instance, 27% of science lessons in Ghana were devoted to developing new content only during instruction, and 73% contained both developing new content and reviewing previous content segments during science teaching (Table 4.18). Developing previous content only, also occurred in 16% of the lessons in Czech Republic, and science teachers from this country developed new content and reviewed previous content in 84% of the lessons. However, in Australia, Japan, Netherlands and USA in the TIMSS study, more science lessons contained developing new content segments than developing new content and reviewing previous content segments. None of the lessons in all the countries in this study and in the TIMSS study contained reviewing only previous content segments.

Table 4.18 Science lessons that developed new content only, developed new content and reviewed previous content, and reviewed previous content only in selected junior high schools in Ghana and other countries

Purpose	Ghana/ %	Australia/ %	Czech Republic/%	Japan/ %	Netherlands/ %	USA/ %
Developing new content only	27	60	16	67	91	57
Developed new content and reviewed previous content	73	37	84	33	8	39
Reviewed previous content	0	0	0	0	0	0

4.1.4.3 <u>Lesson organization for practical and seatwork activities</u>

Although, the Ghanaian science curriculum employs science teachers to use two periods per week (80 minutes) for practical activities out of six periods per week (Teaching Syllabus for Integrated Science Junior High School, 2007) science teachers who participated in this study organized most of the lesson time (85%) for seatwork activities and very little time (12%) for practical activities (Table 4.19).

Table 4.19 Science instruction time in science lessons devoted to practical activities and seatwork Activities in selected junior high schools in Ghana

Activity	Ghana/%	Australia/%	Czech Republic/%	Japan/%	Netherlands/%	USA/%
Seatwork	85	57	84	70	73	85
Practical	12	42	14	27	26	12

Furthermore, independent seatwork activities and independent practical work activities occurred in 40% and 7% of the science lessons in Ghana respectively (Table 4.20), and they spent 5% and 2% of lesson time on these activities respectively. Apart from science teachers from Australia in the TIMSS study who spent 57% of the lesson time on seatwork activities and 42% on practical activities, science teachers who participated in this study in Ghana and in the TIMSS study spent at least 70% of the lesson time on seatwork activities and at most 27% on practical activities.

Table 4.20 Distribution of science lessons with independent activities in selected junior high schools in Ghana

Social organization structure	Distribution of science lessons/%	Distribution of science lesson time/%
Independent seatwork activities	40	5
Independent practical work activities	**7**	2

4.1.4.4 <u>Lesson organization for whole-class and independent work</u>

It was revealed in Table 4.21 that very little time was organized for whole class practical activities (9%), independent practical activities (2%), and independent seatwork activities (5%) in Ghana. The individual seatwork activities were mainly individual work. Furthermore, 89% of the lesson time was organized for whole class work, and only 7% of the time was devoted to all independent activities.

Table 4.21 Science instruction time in science lessons devoted to each combination of science activity and social organization type in selected junior high schools in Ghana and other countries

Social organization type		Ghana /%		Australia /%		Czech Republic /%		Japan /%		Netherlands /%		USA /%	
Independent work	Seatwork	7	5	52	19	17	13	49	15	47	28	45	23
	Practical work		2		33		4		34		19		22
Whole class work	Seatwork	89	80	47	38	81	71	51	42	49	42	54	50
	Practical work		9		9		10		9		8		4
Divided class		0		0		2		0		4		1	

4.1.4.5 Science content of lessons

(a) Science disciplines addressed in the lessons

Most (67%) of the science lessons in Ghana was devoted to life sciences, followed by chemistry (20%), and only 13% of the lessons focused on physics (Table 4.22).

Table 4.22 Science lessons devoted to various science disciplines in selected junior high schools in Ghana and other countries

Content discipline	Ghana/%	Australia/%	Czech Republic/%	Japan/%	Netherlands/%	USA/%
Life science	67	24	36	19	32	18
Physics	13	49	29	36	47	16
Chemistry	20	15	25	37	9	17
Earth science	0	5	0	7	0	28
Other areas	0	8	9	-	10	20

None of the lessons touched on earth sciences or other areas in Ghana. The lessons in the other countries in the TIMSS study were generally devoted to earth sciences, life sciences, physics, chemistry and some other areas.

(b) Types of science knowledge in the lessons

All the science lessons observed in Ghana addressed canonical knowledge, and 93% and 13% of them addressed real-life issues and procedural and experimental knowledge respectively (Table 4.23). Generally, most (69-100%) of the lessons in the other countries in the TIMSS study addressed canonical knowledge, real-life issues, and procedural and experimental knowledge.

Table 4.23 Science lessons that addressed various types of knowledge during public talk in selected junior high schools in Ghana and other countries

Type of knowledge	Ghana/%	Australia/%	Czech Republic/%	Japan/%	Netherlands/%	USA/%
Canonical	100	97	100	99	85	84
Real-life issues	93	75	88	61	70	75
Procedural and experimental	13	92	77	95	69	78
Classroom safety	0	40	17	37	11	23

Furthermore, the science teachers in these countries addressed classroom safety knowledge. It is, thus, observed that the science teachers in Ghana addressed procedural and experimental knowledge to a very little extent, and consequently did not address classroom safety knowledge. They addressed nature of science in 7% of the lessons, and about 4-6% of the lessons in the TIMSS study in Australia, Czech Republic, Japan, Netherlands, and USA addressed nature of science.

Seven percent of the lessons in Ghana addressed meta-cognitive knowledge, but "the percentage of eighth-grade science lessons that contained any public talk about meta-cognitive strategies ranged from 17 percent in Japan to 24 percent in the United States (Roth et al, 2006, p. 54).

All the lessons contained some blank segments/activities. Science teachers observed in Ghana devoted more time (59% of lesson time) to the development of canonical knowledge in class than the other types of knowledge (Table 4.24). They also spent 21% of the lesson time on real life issues used to develop canonical knowledge, and 15% of the lesson time on blank segments/activities where the students have no opportunities to learn science. The blank activities included non-instructional talk like classroom greetings, mentioning of content at the topic level only, non-public talk like giving instructions to one or two students, digression from the topic, outside interruptions, classroom management strategies, and instances of silence in the classroom. Very little time (1% of lesson time) was organised for procedural and experimental knowledge. They also spent an average of 0.1% of public talk on nature of science and their counterparts in the other countries in the TIMSS study spent not more than 1% on nature of science.

Table 4.24 Public talk time in science lessons devoted to various types of knowledge in selected junior high schools in Ghana and other countries

Type of knowledge	Ghana/%	Australia/%	Czech Republic/%	Japan/%	Netherlands/%	USA/%
Canonical	59	35	59	44	33	31
Real-life issues	21	12	14	6	17	15
Procedural and experimental	1	17	12	25	11	17

4.1.4.6 Developing science content

(a) Science content in the lessons

The source of content organization was mainly from both science teachers and textbooks.

Almost all of the lessons were content-focused and offered the students opportunity to learn facts through whole class teacher presentation of facts and discussion. More science lessons observed in Ghana (87%) contained at least 15 public canonical ideas than those from the other countries (Table 4.25). The percentage of science lessons that contained at least 15 canonical ideas in the other countries ranged from 7-26%.

Table 4.25 Science lessons that contained a high number (at least 15) of public canonical ideas in selected junior high schools in Ghana and other countries

Public canonical ideas	Ghana/ %	Australia/ %	Czech Republic/%	Japan/ %	Netherlands/ %	USA/ %
Density	87	11	26	7	16	17

(b) Science terms and technical terms

Science lessons in Ghana in this study contained the least number of scientific terms per lesson compared with those from the other countries (Table 4.26). Furthermore, the average number of highly technical science terms (17) per lesson was more than that of the science terms (3). However, the average number of science terms per lesson was higher than that of the highly technical science terms per lesson in the other countries in the TIMSS study.

Table 4.26 Average numbers of science terms and highly technical science terms per lesson in selected junior high schools in Ghana and other countries

Scientific terms	Ghana	Australia	Czech Republic	Japan	Netherlands	USA
Science terms	3	22	56	19	18	26
Highly technical science terms	17	10	33	10	7	12
Total	20	32	89	29	25	38

(c) Coherency of science content

Science teachers observed in Ghana, generally, developed science content through presentation of facts and definitions by making connections through unidentified approaches and inquiry in 60% and 40% of the lessons respectively (Table 4.27). However, science teachers from the other countries mainly developed science content by making connections through inquiries and applications in the TIMSS study.

Table 4.27 Science lessons that primarily developed science content through various approaches for making connections in selected junior high schools in Ghana and other countries

Type of connection	Ghana /%	Australia/%	Czech Republic/%	Japan/%	Netherlands/%	USA/%
Making connections through inquiries	40	43	15	57	14	17
Making connections through applications	0	13	14	16	7	14
Making connections through unidentified approaches	60	-	-	-	6	-

Seventy-three percent of science lessons in this study in Ghana, and 65% and 44% of science lessons in Netherlands, and USA respectively in the TIMSS study contained activities for learning content with weak or no conceptual links. Additionally, 27% of science lessons in this study in Ghana, and 27% and 30% of the lessons in Netherlands and USA respectively in the TIMSS study contained learning science content opportunities with strong conceptual links respectively (Table 4.28). However, science teachers in Australia, Czech Republic and Japan in the TIMSS study stressed learning science content with strong conceptual links in their lessons. Fifty-eight percent, 50% and 70% of the science lessons in Australia, Czech Republic and Japan respectively focused on learning science content with strong conceptual links, and 30%, 50% and 24% of their lessons respectively touched on learning content with weak or no conceptual links.

Table 4.28 Science lessons by focus and strength of conceptual links in selected junior high schools in Ghana and other countries

Focus and strength of conceptual links	Ghana /%	Australia /%	Czech Republic/%	Japan/%	Netherlands /%	USA /%
Doing activities with no conceptual links	0	12	0	6	8	27
Learning content with weak or no conceptual links	73	30	50	24	65	44
Learning content with strong conceptual links	27	58	50	70	27	30

(d) Goal statements and summary statements

Generally more of the lessons observed in Ghana contained goal statements than summary statements. For instance 67% of the lessons in Ghana contained goal statements and 33% contained summary statements (Table 4.29). Similarly, 74-95% of the science lessons in the other countries in the TIMSS study contained goal statements and 6-41% contained summary statements. More science lessons in Australia, Czech Republic, Japan, Netherlands and USA contained goal statements than in science lessons in Ghana.

Table 4.29 Science lessons with goal statements and summary statements in selected junior high schools in Ghana and other countries

	Ghana/%	Australia/%	Czech Republic/%	Japan/%	Netherlands/%	USA/%
Goal statement	67	95	93	78	83	74
Summary statement	33	24	35	41	6	11

(e) Challenging and basic science content

Many science lessons observed in Ghana (67%) contained basic content and 33% contained basic and challenging content (Table 4.30). This pattern was similar in the lessons in

Table 4.30 Challenging and Basic Science Content in selected junior high schools in Ghana and other countries

	Ghana/%	Australia/%	Czech Republic/%	Japan/%	Netherlands/%	USA/%
Challenging content	0	9	25	7	13	19
Basic and challenging content	33	33	56	29	37	32
Basic content	67	57	18	65	47	48

Australia, Japan, Netherlands and USA in the TIMSS study. However, whereas some science lessons (7-19%) in these countries contained challenging topics, science lessons in Ghana did not. Many (56%) science lessons contained basic and challenging content in Czech Republic according to the TIMSS study than basic content (18%).

4.1.4.7 Using evidence to develop science content

(a) Types of evidence used in the lessons

Forty percent, 27% and 53% of science lessons observed in Ghana incorporated at least one instance of first-hand data, phenomena and visual representations respectively (Table 4.31).

Table 4.31 Science lessons that incorporated at least one instance of first-hand data, phenomena, and visual representations in selected junior high schools in Ghana and other countries

Type of evidence	Ghana/%	Australia/%	Czech Republic/%	Japan/%	Netherlands/%	USA
First-hand data	40	81	69	90	67	70
Phenomena	27	70	55	77	54	43
Visual representations	53	81	94	95	81	78

Compared with the other countries in the TIMSS study, it is seen that a smaller number of the science lessons in Ghana contained at least one of these types of evidence. First-hand data, phenomena and visual representations occurred in 67-81%, 43-77%, and 78-95 % of the science lessons in these countries respectively.

(b) <u>Types of visual representations used in the lessons</u>

Science teachers in this study in Ghana used diagrams and other visual representations to support science knowledge in 20% and 33% of the lessons respectively (Table 4.32). They did not use visual representation in 47% of the lessons. However, science teachers in the other countries in the TIMSS study used visual representations like 3-dimensional models, graphic organization, diagrams and formulas to develop science lesson.

Table 4.32 Science lessons that incorporated various types of visual representations to support science knowledge in selected junior high schools in Ghana and other countries

Type of Visual Representation	Ghana /%	Australia /%	Czech Republic/%	Japan /%	Netherlands /%	USA /%
3-dimensional model	0	12	31	5	14	6
Graphic organization	0	53	44	43	36	46
Diagrams	20	56	78	80	57	52
Formulas	0	5	39	17	12	10
Other Visual Representations	33	10	19	8	11	13
No Visual Representation	47	0	0	0	0	0

(c) <u>Multiple sets of the same type of evidence</u>

Twenty percent, 13% and 20% of science lessons observed in Ghana supported all main ideas with more than one set of first-hand data, phenomena and visual representations respectively (Table 4.33). Compared with the other countries, it is seen that a smaller number of the science lessons in Ghana supported all main ideas with more than one set of these types of evidence.

Table 4.33 Science lessons that supported all main ideas with more than one set of first-hand data, phenomena, and visual representations in selected junior high schools in Ghana and other countries

Type of evidence	Ghana/%	Australia/%	Czech Republic/%	Japan/%	Netherlands/%	USA/%
More than one piece of First-hand data	20	56	29	67	21	26
More than one piece of Phenomena	13	45	22	55	15	18
More than one piece of Visual representation	20	40	54	59	23	42

Science teachers from the other countries in the TIMSS study supported all main ideas with more than one piece of first-hand data, phenomena, and visual representations in 21-67%, 15-55%, and 23-59% of the lessons respectively.

(d) Multiple types of evidence

Science teachers observed in Ghana rarely support main ideas with all these types of evidence at the same time during lesson presentation. They used first-hand data, phenomena, and visual representations to support one main idea in 7% of their lessons (Table 4.34). However, the use of all the three types of evidence at the same time to support main ideas according to the TIMSS study occurred in 14-65% of the lessons in the other countries.

Table 4.34 Science lessons that supported all main ideas with first-hand data, phenomena, and visual representations in selected junior high schools in Ghana and other countries

Type of Evidence	Ghana /%	Australia /%	Czech Republic/%	Japan /%	Netherlands /%	USA /%
First-hand data, Phenomena, and Visual Representation	7	47	33	65	14	18

4.1.4.8 Diagrams, graphs, and mathematical calculations

Independent work involving mathematical calculations occurred in 7% of science lessons observed in Ghana, and 12-30% of science lessons in the other countries according to the TIMSS study (Table 4.35). Seven per cent of the science lessons in Ghana included independent work on diagrams, and 2-25% of science lessons in the other countries in the TIMSS study contained independent work on diagrams. There were no independent work on graphs in Ghana in this study and Czech Republic in the TIMSS study, but 3-12% of science lessons in Australia, Japan, Netherlands and USA in the TIMSS study contained independent work on graphs.

Table 4.35 Science lessons that included independent work on graphs, diagrams, and mathematical calculations in selected junior high schools in Ghana and other countries

Independent work	Ghana/%	Australia/%	Czech Republic/%	Japan/%	Netherlands/%	USA/%
Graphs	0	3	-	10	10	12
Diagrams	7	2	6	12	25	21
Mathematical calculations	7	12	22	18	30	23

4.1.4.9 Collaboration and communication

(a) Individual work and pair/group work

Science teachers observed in Ghana rarely engage students in independent individual work and pair/group work. They engaged students in independent individual work and pair/group work in 40% and 13% of the lessons respectively (Table 4.36). But their counterparts from the other countries in the TIMSS study engaged students in independent individual work and pair/group work in 60-70% and 27-74% of the lessons respectively.

Table 4.36 Science lessons with independent individual work and pair/group work in selected junior high schools in Ghana and other countries

Activity	Ghana/%	Australia/%	Czech Republic/%	Japan/%	Netherlands/%	USA/%
Individual work	40	67	65	60	70	62
Pair/Group work	13	74	27	71	34	60

(b) Teacher-student talk during whole-class work

Science teachers observed in Ghana mainly spent their lesson time on public presentations (57%) and less time (35%) on public discussion (Table 4.37).

Table 4.37 Science instruction time per science lesson devoted to public presentations and discussions during whole-class work in selected junior high schools in Ghana and other countries

Activity	Ghana/%	Australia/%	Czech Republic/%	Japan/%	Netherlands/%	USA/%
Public discussions	35	15	33	10	13	19
Public presentations	57	3	45	37	35	34

Those from the other countries in the TIMSS study spent between 3% and 45% of the lesson time on public presentations and between 10% and 33% on public discussions.

4.2 Classroom Discussion and Contexts

4.2.1 Students' cognitive involvement in classroom discussion

From the analysis it emerged that students' answers were mainly a demonstration of knowledge or information {34.3% (40)} per lesson (Table 4.38). This was followed by Yes or No responses that are led by the teacher {23.3% (29)}.

Table 4.38 Level of student engagement in classroom discussion in selected junior high schools in Ghana

Lesson Topic	Number of Moves/ %(N)										
	No Student Response		Teacher Led Response			Non Led Response					
	NR 1	NR 2	LU	L 1	L 2	UN	NY/ NN	DI	DR	QT	QP
Changes in Matter	25.2 (52)	2.9 (6)	4.9 (10)	10.7 (22)	0	0	3.4 (7)	43.7 (90)	9.2 (19)	0	0
Reproduction	33.3 (26)	1.3 (1)	10.3 (8)	14.1 (11)	0	0	1.3 (1)	35.9 (28)	1.3 (1)	2.6 (2)	0
Reproduction	9.7 (15)	3.3 (5)	13.6 (21)	52 (80)	7.8 (12)	0	3.3 (5)	4.0 (6)	5.2 (8)	1.3 (2)	0
Chemical Formula	15.6 (20)	5.5 (7)	0.8 (1)	15.6 (20)	0	0	2.3 (3)	48.4 (62)	10.2 (13)	1.6 (2)	0
Force	4.7 (5)	12.2 (13)	10.3 (11)	11.2 (12)	2.8 (3)	0	0	39.3 (42)	11.7 (20)	0.9 (1)	0
Digestion	16.2 (11)	4.4 (3)	0	30.9 (21)	5.9 (4)	0	0	41.2 (28)	1.5 (1)	0	0
Reproduction	16.5 (19)	0.9 (1)	7.0 (8)	24.3 (28)	0	0	0.9 (1)	44.3 (51)	0.9 (1)	5.2 (6)	0
Hard Water	45.1 (32)	2.8 (2)	0	21.1 (15)	1.4 (1)	2.8 (2)	1.4 (1)	22.5 (16)	2.8 (2)	0	0
Functions of Blood	30.1 (28)	6.5 (6)	0	10.8 (10)	3.2 (3)	0	10.8 (10)	36.6 (34)	2.2 (2)	0	0
Pressure	34.7 (52)	0	0.6 (1)	34 (51)	0	0	0.6 (1)	26.0 (39)	4 (6)	0	0
Human Eye	13.8 (19)	5.1 (7)	0	31.9 (44)	0	0	8.0 (11)	34.8 (48)	2.2 (3)	4.3 (6)	0
Total	22.3 (25)	4.1 (5)	4.3 (6)	23.3 (29)	2.0 (2)	0.3 (0.2)	2.9 (4)	34.3 (40)	4.7 (7)	1.5 (2)	0

In addition, 22.3% (25) of students' answers were no verbal no physical responses. There was no question from a student to a student but 1.5% (2) of students utterances were questions to teachers. The responses from students that show their reasoning and thinking abilities were low 4.7% (7).

4.2.2 Knowledge dimensions and cognitive processes in science teachers' questions and students' answers

Teacher questions and students' answers were analyzed based on the method adapted from Anderson et al. (2001). It emerged that most of the questions used by the 23 teachers contained remember cognitive process of factual knowledge (Table 4.39).

Table 4.39 Factual knowledge and cognitive dimensions in Teacher Questions

Teacher code	The Knowledge Dimension	The Cognitive Process Dimension					
		Remember /% (N)	Understand /% (N)	Apply /%(N)	Analyze /%(N)	Evaluate /%(N)	Create /%(N)
A	Factual Knowledge	68.3 (15)	4.5 (1)	0	0	0	0
B		14.8 (4)	0	0	0	0	0
C		65.5 (20)	9.4 (3)	0	0	0	0
D		35.8 (5)	0	0	0	7.1 (1)	0
E		73.3 (11)	0	0	0	0	0
F		30.9 (13)	2.4 (1)	2.4 (1)	0	0	0
G		67.7 (23)	0	0	0	0	0
H		40.9 (9)	13.6 (3)	9.1 (2)	0	4.6 (1)	0
I		69.2 (9)	23.1 (3)	0	0	7.7 (1)	0
J		94.7 (71)	4.0 (3)	0	0	0	0
K		21.7 (5)	17.4 (4)	0	0	0	0
L		63.5 (33)	3.9 (2)	0	0	0	0
M		33 (9)	11.0 (3)	15.0 (4)	0	0	0
N		75 (21)	0	4.0 (1)	0	0	0
O		60.7 (37)	3.3 (2)	0	0	1.7 (1)	0
P		17.6 (3)	0	0	5.9 (1)	0	0
Q		66.6 (16)	0	0	0	0	0
R		40.6 (6)	6.7 (1)	20.3 (3)	6.7 (1)	0	0
S		45.9 (39)	17.6 (15)	17.6 (15)	3.5 (3)	7.1 (6)	0
T		82.0 (9)	0	0	0	0	0
U		33.3 (8)	0	58.3 (14)	0	0	0
V		36.0 (9)	0	56.0 (14)	0	0	0
W		45.0 (13)	10.0 (3)	3.5 (1)	0	38.0 (11)	0

Very few questions contained apply, analyze and evaluate cognitive processes of factual knowledge and none of the questions contained create cognitive process. Furthermore, less than 50% of the questions used by Teachers B, D, F, K and P, and more than 50% of the questions used by the remaining 18 teachers mainly targeted about three cognitive areas of factual knowledge. As indicated in Table 4.40, more than 50% of the questions used by

Teachers B, D, F and K targeted about three cognitive dimensions of conceptual knowledge.

Table 4.40 Conceptual knowledge and cognitive dimensions of Teacher Questions

Teacher code	The Knowledge Dimension	The Cognitive Process Dimension					
		Remember /% (N)	Understand /% (N)	Apply /%(N)	Analyze /%(N)	Evaluate /%(N)	Create /%(N)
A	Conceptual Knowledge	4.5 (1)	13.6 (3)	9.1 (2)	0	0	0
B		18.5 (5)	37.0 (10)	29.7 (8)	0	0	0
C		12.5 (4)	3.1 (1)	9.4 (3)	0	3.1 (1)	0
D		21.4 (3)	21.4 (3)	14.3 (2)	0	0	0
E		13.3 (2)	6.7 (1)	6.7 (1)	0	0	0
F		16.7 (7)	33.3 (14)	14.3 (6)	0	0	0
G		5.9 (2)	0	0	0	0	0
H		9.1 (2)	22.7 (5)	0	0	0	0
I		0	0	0	0	0	0
J		1.3 (1)	0	0	0	0	0
K		21.7 (5)	30.5 (7)	0	0	0	0
L		1.9 (1)	26.9 (14)	1.9 (1)	0	1.9 (1)	0
M		0	22.0 (6)	0	0	0	0
N		0	21.0 (6)	0	0	0	0
O		9.8 (6)	24.6 (15)	0	0	0	0
P		0	11.8 (2)	11.8 (2)	0	0	0
Q		21.0 (5)	12.5 (3)	0	0	0	0
R		13.3 (2)	0	0	0	0	0
S		3.5 (3)	4.7 (4)	0	0	0	0
T		18.0 (2)	0	0	0	0	0
U		4.2 (1)	4.2 (1)	0	0	0	0
V		0	4.1 (1)	4.1 (1)	0	0	0
W		0	0	0	0	0	0

These teachers had 4, 5, 4 and 10 years of teaching experience respectively. Teachers B and D possessed a 3-Year TTC Cert A as the highest qualification, but the highest qualifications of Teachers F and K were Diploma in Basic Education and Bachelor of Education respectively (Table 4.41). In addition they all majored in Science.

However, less than 50% of the questions used by the rest of the teachers elicited cognitive dimensions of conceptual knowledge. Besides, procedural and meta-cognitive knowledge dimensions in the questions used by the science teachers were very low, especially, meta-cognitive knowledge (Table 4.42). Only one teacher used one question to elicit understand cognitive process of meta-cognitive knowledge dimension.

Table 4.41 Teaching experience, qualification and major at college or university of science teachers in selected junior high schools in Ghana

Teacher	General Teaching Experience/years	Qualification	Major at College/University
A	10	Diploma in Basic Education	Science
B	4	3-Year TTC Cert A	Science, Math and Technical Skills
C	7	3-Year TTC Cert A	Social Studies and Science
D	5	3-Year TTC Cert A	Science
E	10	3-Year TTC Cert A	Agricultural Science and Science
F	4	Diploma in Basic Education	Science
G	10	Bachelor of Education and 3-Year TTC Cert A	Science
H	4	Diploma in Basic education	Technical Skills and mathematics
I	9	3-Year TTC Cert A	Social Studies and Life Skills
J	3	Bachelor of Agricultural Science	Agricultural Science
K	10	Bachelor of Education and 3-Year TTC Cert A	Science
L	4	3-Year TTC Cert A	Agricultural Science
M	2	3-Year TTC Cert A	Technical Skills
N	11	3-Year TTC Cert A	Science
O	7	SSS Leaving Certificate	SSS subjects
P	10	3-Year TTC Cert A	Science and Math
Q	3	3-Year TTC Cert A	Agricultural Science
R	4	3-Year TTC Cert A	Social Studies
S	3	3-Year TTC Cert A	Social Studies and RME
T	1	3-Year TTC Cert A	Physical Education and Agricultural Science
U	5	3-Year TTC Cert A	Pre-Technical skills
V	3	3-Year TTC Cert A	Science
W	5	3-Year TTC Cert A	Science and Technical Skills

Table 4.42 Procedural and meta-cognitive knowledge dimension and cognitive dimensions in Teacher Questions

Teacher code	The Knowledge Dimension	The Cognitive Process Dimension					
		Remember /% (N)	Understand /% (N)	Apply /%(N)	Analyze /%(N)	Evaluate /%(N)	Create /%(N)
A	Procedural Knowledge	0	0	0	0	0	0
B		0	0	0	0	0	0
C		0	0	0	0	0	0
D		0	0	0	0	0	0
E		0	0	0	0	0	0
F		0	0	0	0	0	0
G		14.7 (5)	2.9 (1)	0	0	8.8 (3)	0
H		0	0	0	0	0	0
I		0	0	0	0	0	0
J		0	0	0	0	0	0
K		0	8.6 (2)	0	0	0	0
L		0	0	0	0	0	0
M		15 (4)	4 (1)	0	0	0	0
N		0	0	0	0	0	0
O		0	0	0	0	0	0
P		52.9 (9)	0	0	0	0	0
Q		0	0	0	0	0	0
R		6.7 (1)	0	6.7 (1)	0	0	0
S		0	0	0	0	0	0
T		0	0	0	0	0	0
U		0	0	0	0	0	0
V		0	0	0	0	0	0
W		0	0	0	0	0	0
A-V	Meta-cognitive Knowledge	0	0	0	0	0	0
W		0	3.5 (1)	0	0	0	0

For example, only five teachers targeted procedural knowledge dimension. Teachers G and P asked the highest number of questions (nine questions). Teacher G is the only teacher who used questions to cover remember, understand and evaluate cognitive dimensions of procedural knowledge. Furthermore, this teacher used questions that elicited cognitive processes of factual, conceptual and procedural knowledge. Teacher P also used questions to elicit cognitive processes of procedural knowledge. In addition more that 50% of the questions used by this teacher focused on procedural knowledge. Teachers G and P each had 10 years of teaching experience and possessed a 3-Year TTC Cert A and Bachelor of Education degree as the highest qualification respectively.

Therefore, Teachers B, D, F, K, G and P will be regarded as better than the rest of the science teachers in this study regarding the use of teacher questions. These teachers have an average teaching experience of 7.2 years whereas the remaining 17 teachers had an average teaching experience of 5.4 years. In addition three teachers (50%) among those who performed better possessed Bachelor of Education degrees and a Diploma in Basic Education. But out of the remaining teachers, only three (18%) possessed Diplomas in Basic Education and a Bachelor of Agricultural Science degree. It must be noted that Bachelor of Agriculture degree is not a professional qualification for teaching science in Ghana. Therefore, only two teachers possessed a professional qualification. Furthermore, from this set of remaining 17 teachers, only six (35%) majored in science at college (Table 4.41).

Consequently, the emphasis the science teachers placed on the knowledge dimensions and cognitive processes in their questions differed according to teaching experience, qualification and major at either college or university.

Generally, 72.1%, 25.1%, 2.7% and 0.1% of the science teachers' questions or statements contained factual knowledge, conceptual knowledge, procedural knowledge and meta-cognitive knowledge dimensions respectively (Table 4.43).

Table 4.43 Knowledge Dimension and Cognitive Process of Science Teachers' Questions and Students' Answers in selected junior high schools in Ghana

The Knowledge Dimension	Utterance	The Cognitive Process Dimension						
		Remember /% (N)	Understand /% (N)	Apply /%(N)	Analyze /%(N)	Evaluate /%(N)	Create /%(N)	Total /%(N)
Factual Knowledge	TQ	53.6 (378)	6.2 (44)	8.7 (61)	0.6 (4)	3.0 (21)	0	72.1 (508)
	SA	57.4 (526)	4.2 (38)	6.6 (60)	0.9 (8)	2.7 (25)	0	71.8 (657)
Conceptual Knowledge	TQ	7.4 (52)	13.6 (96)	3.8 (27)	0	0.3 (2)	0	25.1 (177)
	SA	6.8 (62)	15.1 (138)	3.8 (35)	0	0.1 (1)	0	25.8 (236)
Procedural Knowledge	TQ	2.0 (14)	0.6 (4)	0.1 (1)	0	0	0	2.7 (19)
	SA	1.8 (16)	0.1 (1)	0.6 (5)	0	0	0	2.5 (22)
Meta-cognitive Knowledge	TQ	0	0.1 (1)	0	0	0	0	0.1 (1)
	SA	0	0.1 (1)	0	0	0	0	0.1 (1)
Total	TQ	63.0 (444)	20.5 (145)	12.6 (89)	0.6 (4)	3.3 (23)	0	100 (705)
	SA	65.8 (604)	19.5 (178)	11.0 (100)	0.9 (8)	2.8 (26)	0	100 (916)

TQ: Teacher Questions; SA: Student Answers; N: Number of Teachers' Questions or Students' Answers

It follows that a total of 97.2% of the science teachers' questions or statements touched on canonical knowledge (that is factual and conceptual knowledge). This is similar to the results of TIMSS 1999 video study. Roth et al. (2006) report that the percentage of eighth-grade science lessons that addressed canonical knowledge during public talk were 97%, 100%, 99%, 85% and 84% in five developed countries, namely, Australia, Czech Republic, Japan, Netherlands and the United States respectively.

However, regarding procedural and experimental knowledge, and meta-cognitive knowledge, the results in this study differ significantly from TIMSS 1999 video study. For instance, whereas the percentage of eighth-grade science lessons that addressed procedural and experimental knowledge during public talk were 92%, 77%, 95%, 69%, and 78% in Australia, Czech Republic, Japan, Netherlands and the United States respectively, only 2.7% of science teachers' questions or statements that elicit response from students focused on procedural and experimental knowledge in Ghana. Furthermore, "the percentage of eighth-grade science lessons that contained any public talk about meta-cognitive strategies ranged from 17% in Japan to 24% in the United States" (Roth et al., p. 54). But, in this study, a mere 0.1% of science teachers' questions or statements touched on meta-cognitive knowledge dimension.

Similarly, 71.8%, 25.8%, 2.5% and 0.1% of the students' answers contained factual knowledge, conceptual knowledge, procedural knowledge and meta-cognitive knowledge dimensions respectively. Thus, the knowledge dimensions in students' answers are a reflection of the knowledge dimensions in science teachers' questions or statements.

In addition, most of the science teachers' questions or statements (63.0%) were aimed at asking students to remember knowledge (Table 4.43). It was also observed that 20.5% of the science teachers' questions or statements elicited understanding of knowledge, 12.6% elicited application of knowledge, 0.6% focused on analysis of knowledge, and 5.2% evaluated students' knowledge. Therefore, it is seen that very few questions or statements elicited higher order cognitive processes like the analysis and evaluation of knowledge. Similarly, most of the students' answers (66.0%) were directed at remembering of knowledge, 19.5% were a demonstration of understanding, 11.0% drew out application of knowledge, and 0.9% and 2.8% showed students' demonstration of analysis and evaluation of knowledge respectively. Therefore, the cognitive processes in students' answers seem to be a representation of the cognitive processes in science teachers' questions or statements. This is consistent with the findings of Mills, Rice, Berliner and Rosseau "that the chances are about even that there will be a correspondence between the cognitive level of the question asked and the cognitive level of the response that was elicited" (1980, p. 194). Furthermore, it is seen that very few answers contained higher order cognitive processes like the analysis and evaluation of knowledge. There was no question or statement that tasked students to be involved in creative cognitive processes in all the knowledge dimensions (Table 4.43). Additionally, it emerged that teacher questions or statements and students' answers rarely contained meta-cognitive knowledge dimension.

Furthermore, science teachers' questions or statements either mainly evaluated student knowledge or elicited student thinking to a small extent. The questions or statements that evaluated student knowledge were mostly low order questions, elicited a large number of responses from the students, and mainly drew out recall of factual knowledge. In contrast, the few high order questions or statements mainly drew out understanding and application of knowledge, and elicited a small number of responses from students. For example, in the lesson on Pressure in liquids, the teacher asked one question (TQ 1) four times but only a single student (S 1) responded to the question (Table 4.44). The low response could be due to the fact that the students either did not understand the lesson content or the question because of its wording. Although, the aim of the question (TQ 1) was to elicit students' understanding after a demonstration activity, it was not well phrased and thus not clear. If questions or statements are not phrased correctly, it might not get the required response although high order. It would have been better for the teacher to have reformulated TQ 1 into TQr 1.

Table 4.44 Lesson transcript for the topic Pressure

Person	Utterance	Verbal interaction	Knowledge Dimension	Cognitive Process
T	TQ 1	Why is it that the pressure, why is it that the this thing, the hole, the first hole the water does not spring as equal length or as equal distance at the bottom	Conceptual	Understand
Ss	SA:	No response	NC	NC
T	TQ 1	Listen to the question, why is it that the hole A, if you name it A, B, C, the hole A the water does spring the same distance as it springs in the last bottom which is hole C, why? Yes?	Conceptual	Understand
S 1	SA:	Inaudible response	NC	NC
T	TS	Again	NC	NC
S 1	SA:	Inaudible response	NC	NC
T	TC	Now did you get the question?	NC	NC
Ss	SA:	No response	NC	NC
T	TQ 1	Now, the the, I'm say that now the water that comes out from the first hole is not longer as the one comes from what the last hole and I'm say why?	Conceptual	Understand
Ss	SA:	No response	NC	NC
T	TQ 1	The question says why?	Conceptual	Understand
Ss	SA:	No response	NC	NC
	TQr 1	Why did the water from the three holes spring to different distances?	Conceptual	Understand

T: Teacher; S1: Student 1; Ss: Students; TQ 1: Teacher Question 1; TQr 1: Proposed TQ 1;
SA: Student Answer; TC: Checking; NC: Not coded; TS: Teacher Statement

Students' answers and responses could also be limited by teacher response behavior to students' answers and responses. For instance, in one lesson on Digestion, the teacher remarked that "you see if this was an examination you would have deviated; the question was 'what is digestion', and you are trying to come out with something that has nothing to do with digestion". This teacher remark towards an incorrect answer from a student completely shut down the verbal interaction between the teacher and the student. Instead of probing the student's thinking processes, the teacher ended the conversation abruptly. This remark by the teacher could dampen the enthusiasm of the student to the extent that he might neither volunteer to respond to any question or statement nor respond when appointed to provide an answer (Beccles & Ikeda, 2011), for fear of being reproached again.

However, there were isolated cases where teacher questioning were successful. For instance, Table 4.45 shows episodes of some interactive sequences that tasked students to exhibit mainly understanding and analysis of conceptual knowledge.

Table 4.45 Lesson transcript for the topic Changes in Matter

Person	Utterance	Verbal interaction	Knowledge Dimension	Cognitive Process
T	TQ 2	so what can you say about the two things. We have the mortar a mixture of sand and cement. What can you say about that mortar and this one what can you say about that	Conceptual	Analysis
T	TQ 2r 1	Mortar and this one what can you say about it	Conceptual	Analysis
S 1	SA	(Inaudible response)	NC	NC
T	TS	People want to hear	NC	NC
S 1	SA	As for the mortar water is added to it	Procedural	Analysis
T	TS	Water is added to it	NC	NC
S 1	SA	And the mixture of sand and cement ???	NC	NC
T	TQ 2r 2	So generally, what particular thing is added. What thing you know that whatever is added, something new happen so what can you say here or yes.	Conceptual	Analysis
S 2	SA	New substances are formed.	Conceptual	Analysis
T	TS	Aha . New substances are formed.	Conceptual	Remember
	TQ 2r 3	So in effect you can say that the two things are not the same.	Conceptual	Analysis
T	TQ 2r 3	Are they the same?	Conceptual	Analysis
Ss	SA	No sir	Conceptual	Analysis
T	TQ 2r	Is mortar the same as cement and sand and water mixed together?	Conceptual	Analysis
Ss	SA	No sir	Conceptual	Recall
T	TQ 2r	This is a typical example of what? What example of change is this Esi?	Conceptual	Analysis
S 3	SA	A chemical change	Conceptual	Analysis
T	TS	This is a chemical change	NC	NC
T	TQ 3	Why is it a chemical change. why is it a chemical change. this is a typical example of chemical change. why is it a chemical change. yes eh Dan	Conceptual	Understand
S 4	SA	Because a new substance is formed.	Conceptual	Understand
	TQ 4	So it has changed to what.	Conceptual	Analysis

T: Teacher; S 2: Student 2; S 3: Student 3; S 4: Student 4; Ss: Students; TQ 2: Teacher Question 2; TQ 2r: Teacher Question 2 reframed; TQ 3: Teacher Question 3; TQ 4: Teacher Question 4; TS: Teacher Statement

This teacher greatly involved students in demonstration activities and used visual support materials to present lesson content to elicit student thinking and class participation. The teacher probed students' answers and responses and asked questions about students' observation before seeking for the reasons behind them. These teacher actions might have helped students to clearly understand the question.

It is seen in Lesson Transcripts 1 and 2 that the knowledge dimensions and cognitive processes in teacher questions and students' answers are clearly revealed. The lesson on Pressure in Liquids tasked students to demonstrate understanding of conceptual knowledge whereas analysis, understanding and recall of mainly conceptual knowledge were nurtured in the lesson on Change of State (Lesson Transcript 2). This analysis shows clearly the kind of knowledge and the level of cognition being developed in the lessons, which informs teachers about student thinking and scientific knowledge development in class.

4.2.3 Teacher intentions behind questions

Teacher intentions were analyzed by using the teacher questions and the purpose of the questions during science lessons. The intentions of the teachers in this study were mainly to check students focus in the lesson (38%) and students' prior science content knowledge/experiences/observation/reading and drawing/labeling abilities (42%) (Table 4.46). The teachers laid less emphasis on checking students' procedural knowledge (2%), checking students' understanding (5%), and eliciting student thinking (8%).

Table 4.46 Teacher intentions of science teachers in selected junior high schools in Ghana

Teacher Intention	Lesson Code*													Average %/(N)	
	Code	L 8	L 13	L 14	L 15	L 16	L 17	L 18	L 19	L 20	L 21	L 22	L 23		
Instructional management	QM	1.6 (1)	6.9 (8)	3.7 (1)	14.1 (13)	0	11.9(5)	0	4.5 (3)	0	2.3 (1)	4.4 (4)	15.8 (12)	5 (4)	5 (4)
Checking students' focus/attention in the lesson	QF	55.6 (35)	10.4 (12)	14.8 (4)	65.2 (60)	21.6 (16)	0	64.7 (22)	37.3 (15)	57.6 (19)	25.6 (11)	58.2 (53)	39.5 (30)	38 (23)	38 (23)
Checking students' prior science content knowledge (factual and conceptual), daily life experiences and observations, and ability to read and draw	QPK	4.7 (3)	19.0 (22)	37.0 (10)	5.4 (5)	16.2 (12)	28.6 (12)	20.6 (7)	7.5 (5)	21.1(7)	13.9(6)	8.8 (8)	18.4 (14)	17 (9)	42 (24)
	QCK	12.7 (8)	14.7 (17)	18.5 (5)	4.4 (4)	39.2 (29)	19.1(8)	11.8 (4)	19.4 (13)	3.0 (1)	9.3 (4)	14.3 (13)	5.3(4)	14 (9)	
		1.6 (1)	11.2 (13)	11.1 (3)	2.2 (2)	1.4 (1)	7.1 (3)	2.9 (1)	28.4 (19)	12.1 (4)	34.9 (15)	1.1 (1)	0	10 '5)	
	QRK	0	0.9 (1)	0	0	0	0	0	0	0	4.7 (2)	0	0	1 (0.3)	
	QDK	0	0	0	0	0	0	0	1.5 (1)	0	0	1.1 (1)	0	0.2 (0.2)	
Checking students' procedural and experimental knowledge	QEK	3.2 (2)	8.6 (10)	0	3.3 (3)	0	7.1 (3)	0	0	0	0	5.5 (5)	0	2 (2)	2 (2)
Checking students' understanding	QUK	4.7 (3)	11.2 (13)	3.7 (1)	1.1 (1)	16.2 (12)	4.8 (2)	0	1.5 (1)	0	9.3 (4)	3.3 (3)	3.9(3)	5 (4)	5 (4)
Eliciting student thinking	QAK	8.0 (5)	6.0 (7)	11.1 (3)	4.4 (4)	1.4 (1)	21.4 (9)	0	0	6.1 (2)	0	3.3 (3)	1.3 (1)	5 (3)	8 (6)
	QNK	3.2 (2)	6.9 (8)	0	0	0	0	0	0	0	0	0	0	1 (1)	
	QEK	4.7 (3)	4.3 (5)	0	0	4.1 (3)	0	0	0	0	0	0	15.8 (12)	2 (2)	
	QCK	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total		100 (63)	100 (116)	100 (27)	100 (92)	100 (74)	100 (42)	100 (34)	100 (67)	100 (33)	100 (43)	100 (91)	100 (76)	100 (63)	100 (63)

*See Table 3.4 (page 41) for lesson topics

4.2.4 Teacher response behavior

Three main kinds of students' answers and responses to teacher questions that emerged from the analysis of the video and lesson transcripts had been analyzed (Table 4.47). These were correct answers (52.5%), incorrect answers (9.3%), and no responses (24.4%).

Table 4.47 Types of students' answers and responses to teacher questions in selected junior high schools in Ghana

Student answer/ response	Lesson											Total /N	Averag e % (N)
	1	2	3	4	5	6	7	8	9	10	11		
Correct	40 (24)	27.5 (11)	65.4 (19)	42.6 (20)	80 (36)	44.4 (8)	59.6 (31)	40.9 (18)	58.1 (50)	70.7 (58)	49.3 (71)	346	52.5 (32)
Incomplete Correct	0	0	10.3 (3)	8.5 (4)	0	16.7 (3)	1.9 (1)	0	3.5 (3)	2.4 (2)	4.2 (6)	22	4.3 (2)
Unclear	3.3 (2)	7.5 (3)	3.5 (1)	0	2.2 (1)	5.6 (1)	0	0	1.2 (1)	1.2 (1)	4.9 (7)	17	2.7 (2)
Incorrect	23.3 (14)	7.5 (3)	10.3 (3)	6.4 (3)	4.5 (2)	11.1 (2)	7.7 (4)	4.6 (2)	16.3 (14)	4.9 (4)	6.3 (9)	60	9.4 (6)
Repeated	1.7 (1)	0	3.5 (1)	0	4.5 (2)	0	3.9 (2)	0	0	0	0	6	1.2 (1)
No	30 (18)	57.5 (23)	3.5 (1)	38.3 (18)	6.7 (3)	11.1 (2)	17.3 (9)	50 (22)	19.8 (17)	12.2 (10)	22.2 (32)	1 55	24.4 (14)
Inaudible	1.7 (1)	0	3.5 (1)	4.3 (2)	2.2 (1)	5.6 (1)	9.6 (5)	4.6 (2)	1.2 (1)	8.5 (7)	12.5 (18)	39	4.9 (4)
No Idea	0	0	0	0	0	0	0	0	0	0	0.7 (1)	1	0.1 (0.1)
I Can't	0	0	0	0	0	5.6 (1)	0	0	0	0	0	1	0.5 (0.1)
Total	60	40	29	47	45	18	52	44	86	82	144	647	100 (61.2)

Other responses which were not discussed in this dissertation but revealed in this study were unclear (2.7%), incomplete (4.3%), repeated (1.2%), inaudible (4.9%), no idea (0.1%) and I can't (0.5%) responses. An unclear response is an answer that lacks clear explanation. This could either be correct or partly correct, or incorrect or partly incorrect. An incomplete response is a response to a question that is not complete; a partly correct response; or a response to a question that is interrupted by the teacher. A repeated response is a response that has already been provided by another student. An inaudible response is a response that is not clearly heard by the teacher and the rest of the students in the classroom. A no idea response is when a student utters "No Idea" in response to a question, and finally I can't response is when a student utters "I can't" in response to a question.

4.2.4.1 Teacher response behavior to students' correct answers and student feeling

(a) Video and interview

It was observed in the video that the teachers used both verbal and nonverbal rewards, asked students to write correct answers on the chalkboard, wrote correct answers on the chalkboard, and sought for the correct answers again (Table 4.48).

Table 4.48 Observed teacher response behaviors to students' correct answers in selected junior high schools in Ghana

Behavior	Category /% (N)	Theme
Repeats CA	Encouraging 86.9 (370)	Self-confidence
Use of positive reinforcement (Examples: Exactly, asking class to clap for the student, "Good", "I like that and everybody should try, okay", "That is it, a good try", "Exactly, you have heard her", "Very good", "You are very fast", "Sit down, you have done well", "Well done", That is good", "Good, good you are there", "you've all done well", you do remember, you've all done well", "You do remember, that is good", "Yes")		
Repeats CA and asks class to clap for student		
Ask class to clap for student		
Asks a student to write CA on chalkboard		
Asks whether students heard CA		
Confirms CA		
Spells CA with students and writes it on chalkboard		
Repeats CA with students		
Writes CA on chalkboard		
Ask class to repeat CA		
Repeats CA and writes CA on chalkboard		
Accepts CA		
Repeats question to elicit same CA		
Seeks for CA again		
Explains CA with daily life experiences		
Elaborates on CA		
Explains CA		
Repeats CA and explains		
Modifies/reframes CA		
Ask a student to read CA written on the chalkboard by another student		
Saying "I know some students like such topics"		
Probes CA to find the reason behind answer	Judging 2.8 (12)	Self-Learning
Asking the class to judge the correctness of answers		
Probes CA		
Asks student to proof CA on chalkboard		
Asks students "Are you sure of the response"		
Seeks alternate name for CA	Finding out 0.5 (2)	
No teacher response	Ignoring 9.4 (40)	Shy-Timidity
Not commending student who used his own words to construct a definition (Teacher say this is correct, and is from your own words, I like it, that is good but "I want somebody to give me the definition that I gave you. Tells the student I like what you said but want to know if students prepared what he taught them)	Rejecting 0.5 (2)	
Repeats CA but is still not satisfied		

The students also reported that their teachers mainly verbally and non-verbally rewarded their efforts (Table 4.49).

Table 4.49 Teacher response behaviors to students' correct answers reported by students in selected junior high schools in Ghana

Behavior	Category % (N)	Theme
Verbal rewards like very good, excellent, not too bad, thank you, good, you have done well, you are good, good boy	Encouraging 96 (48)	Self-confidence
Nonverbal rewards like clapping, shinning		
He is satisfied		
Behaves well		
Will be happy		
Uses the response and add more in developing the lesson		
No TRB	Ignoring 4 (2)	Shy-timidity
Sometimes the teacher does not say anything		

Furthermore, the video also revealed that 2.8% and 0.5% of teacher responses were judging and finding out response behaviors respectively (Table 4.48). There was no behavior that made students uncomfortable in either the reported or observed data. These responses were categorized as encouraging, judging, finding out, ignoring, and rejecting, and three main themes namely self-confidence, self-learning, and shy-timidity emerged from these categories.

Naturally, teachers are happy when students are able to correctly respond to questions so it is normal that they tend to encourage students' answers and efforts. All the science teachers interviewed reported that they motivated their students after giving a correct answer through verbal means like praising the students and nonverbal means like clapping and the use of facial expression (Table 4.50).

Table 4.50 Teacher response behaviors to students' correct answers reported by teachers in selected junior high schools in Ghana

Behavior	Category % (N)	Theme
Through complimentary remarks and emphasis on the correct answers given	Encouraging 100 (17)	Self-confidence
Reward learners verbally like very good		
Praise them for correct answers given like Very good		
Appraisal – praising them in class		
Good, well		
By commending them as a form of motivation		
I ask the class to clap for the person		
Praise them like clapping		
Sometimes I give them toffees		
Positively		
Give them gifts (from my own pocket)		
At times use of body gestures		
facial expression		
In good mood		
Encouragement		

Although, the science teachers reported that they neither rejected nor disregarded students' correct answers, the video revealed that 0.5% and 9.4% of the observed teacher responses were correspondingly rejecting and disregarding teacher response behaviors (Table 4.48).

Furthermore, 4% of the reported teacher responses by the students were disregarding teacher response behaviors. It must be noted that rejecting teacher response behavior to a correct answer was exhibited by only one teacher in camera. This teacher did not commend a student who used his own words to construct a correct answer. The teacher responded that "this is correct, and is from your own words, I like it, that is good but I want somebody to give me the definition that I gave you". Upon a second attempt by the student, the teacher again responded that he liked what the student said but wanted to know if students prepared what he taught them. However, the teacher asked the class to clap for different student who used exactly the same words used by the teacher for the definition. The fact that both students, one using his own words and the other using the teacher's words to correctly answer the teacher's question but the teacher commending only the latter will not promote development of student views and ideas. Teachers should rather encourage students to use their own words and understandings to promote meaning-making in the development of scientific knowledge. Disregarding students' correct answers will also discourage students from engaging in classroom discussion so science teachers need to at least commend students for their efforts and correct answers.

(b) Students' feeling after teacher response behavior to students' correct answers

The students felt happy and motivated to answer more questions after teacher response behavior to their correct answers. One student reported that "I feel happy because I have answered correctly and he has used my answer"; and others also said that "I become happy and is able to keep the answer in my head" and "I feel better and the answer sticks to my head" (Table 4.51).

Table 4.51 Students' feeling after science teachers respond to students' correct answers reported by students in selected junior high schools in Ghana

Behavior	Category % (N)	Theme
I feel happy because I did not get it wrong	Encouraging 100 (34)	Self-confidence
I feel very happy		
It makes me learn harder		
I become happy		
I become motivated		
I feel better and the answer sticks to my head		
I feel encouraged because if the answer is wrong he will know it is wrong and the teacher will encourage you to have more ideas		
I feel very excited		
I feel happy because I have answered correctly and he has used my answer		
I feel happy and comfortable		
I become happy		
I feel fine		
I become free and I feel good		
I feel happy		
I feel good		
I feel fine		
I become happy		
I feel happy		
I feel that my answer is good		
I feel happy		
I become happy and is able to keep the answer in my head		
I feel happy that I have answered a question and it is correct		
I feel good		
I feel cool		
I feel happy		
I feel very comfortable		
I feel to be always answering questions		
I become happy		
I feel that I know something		
I become happy		
I feel well		
I feel happy because when a teacher teaches and I perform I know that I am performing		
I feel happy		

The teachers also reported that the students "feel accepted and encouraged", "feels to be part of the class and encouraged to answer questions in class", and it "makes them feel good" and "gives them the confidence to talk or interact in the classroom" (Table 4.52). These tend to enhance classroom discussion.

Table 4.52 Students' feeling after science teachers respond to students' correct answers reported by science teachers in selected junior high schools in Ghana

Behavior	Category % (N)	Theme
Feels involved and satisfactory	Encouraging 100 (17)	Self-confidence
Motivated		
It makes them feel good		
It gives them the confidence to talk or interact in the classroom		
Feels to be part of the class and encouraged to answer questions in class		
Happy and encouraged		
The person feels happy and motivated to answer more questions. Even when the answer is wrong they try to bring their ideas		
They feel good		
Students feel accepted and encouraged		
At times I feel very happy. They also feel motivated to answer		
It helps some of them. They feel proud that they have been able to answer		
They feel good		
Feels good, feels happy		

4.2.4.2 <u>Teacher response behavior to students' incorrect answers and student feeling</u>

(a) <u>Video and interview</u>

The teachers reported exhibiting mainly encouraging teacher response behavior to students' incorrect answers. Examples of encouraging teacher response behaviors to students' incorrect answers include teachers giving hints, using verbal cues like "not exactly" or "you have tried", and teachers reframing questions (Table 4.53).

Table 4.53 Teacher response behavior to students' incorrect answers reported by science teachers in selected junior high schools in Ghana

Behavior	Category%(N)	Theme
Accept answer	Using 10 (2)	Self-learning
Link answer to topic		
Find out reason	Judging 5 (1)	
Make corrections	Encouraging 50 (10)	Self-confidence
Allows others to bring their views		
Gives Hint/clue		
Gives student another chance to answer		
Help reframe answer		
Reframe question		
Says "you have tried"		
Says "Not exactly"		
Use gestures like shaking the head	Rejecting 25 (5)	Shy-timidity
Responds "No"		
Says "answer is wrong"		
Call another person		
Provide answer	Ignoring 10 (2)	
Ask the same question to those who know		

Twenty-five per cent and 10% of teacher response behaviors that sum up to 35% reported by the teachers were rejecting and ignoring teacher response behaviors respectively (Table 4.53). On the contrary, the students reported that 43.6%, 18% and 2.6% of teacher response behaviors totaling 64.2% were rejecting, ignoring and discomforting teacher response behaviors in that order (Table 4.54).

Table 4.54 Teacher response behaviors to students' incorrect answers reported by students in selected junior high schools in Ghana

Behavior	Category %(N)	Theme
Gives Hint	Encouraging 35.9 (15)	Self-confidence
Advise me to learn		
Says "keep on learning"		
Says "learn hard"		
Says "Try to get it correct next time"		
Says "Try again"		
Makes us think and come out		
Says "Not exactly, but think about it"		
Says "That is not the answer, try again, try another idea		
Does not do anything to disgrace me		
Corrects me		
Tells me to pay attention		
Ask me to listen to the correct answer		
Gets angry	Rejecting 43.6 (18)	Shy-timidity
Says "Answer is wrong" or shakes the head		
Says "No"		
Calls/appoint another person to respond		
Provides correct answer	Ignoring 18 (7)	
No teacher remark		
Says "Sit down"		
Uses canes on me	Discomforting 2.6 (1)	

The students reported that teachers using gestures like shaking the head or saying "answer is wrong", telling the student to sit down or not passing any comment, and the caning of students are examples of rejecting, ignoring and discomforting teacher response behaviors correspondingly. Furthermore, the video showed that 26.2% and 40.2% of teacher response behaviors that totaled up to 66.4% (Table 4.55) were rejecting and ignoring teacher response behaviors respectively.

Table 4.55 Observed teacher response behavior to students' incorrect answers in selected junior high schools in Ghana

Behavior	Category / % (N)	Theme
Give extra information	Encouraging 25.2 (27)	Self-confidence
Directs student to what the question demands		
Talks about the content of the previous question to link it to the question		
Asks a related question		
Asks simpler related question		
Interrupts and reframes question		
Reframes question		
Repeats question		
Says "That is a good try" but does not write WR on chalkboard		
No verbal response but teacher makes a sound to recognize ICA		
Repeating ICA in a jovial way		
Tells student that ICA is the correct answer for another question	Using ICA 2.8 (3)	Self-learning
Uses ICA to elaborate the question		
Repeating ICA in a questioning way		
Ask for the reasons behind ICA	Finding out 1.9 (2)	
Jovially accepts ICA and tries to explain the reason behind it		
Questions whether the response is correct or wrong	Judging 3.7 (4)	
Says "Are you sure"		
Use of verbal negative reinforcement:	Rejecting 26.2 (28)	Shy-timidity
Provides ICA		
Repeats WR and says No		
Says "If this was an examination you would have deviated"		
Says "Don't deviate the question"		
Says "It means that you did not understand the lesson"		
Interrupting ICA and repeating question		
Says "What in a loud voice"		
Says "Did you get the question"		
Appointing another person to respond		
Asking another student to help the student who provided WR		
No TRB	Ignoring 40.2 (43)	

These teacher response behaviors prevent students from responding to teacher questions. It is seen that although 65% of teacher response behaviors toward students' incorrect answers reported by the science teachers were encouraging, using and finding out response behaviors, 64.2% of teacher response behaviors reported by the students were rejecting, ignoring, and discomforting response behaviors. The students' version was corroborated by the video since 66.4% of the observed teacher response behaviors were rejecting and ignoring response behaviors.

The video also revealed teacher response behaviors that judge, find out and use students' incorrect answers like teachers questioning whether students' answers are correct or incorrect, asking for the reasons behind students' incorrect answers, and using students' incorrect answers to elaborate the question

(b) Students' feeling after teacher response behavior to students' incorrect answers

Although, majority (56.3%) of the reported responses by the teachers were actions that made the students feel encouraged after a teacher's response towards students' incorrect answers, only 23.5% of the reported responses by the students claimed that they were actually encouraged (Table 4.56).

Table 4.56 Students' feelings after TRB respond to students' incorrect answers in selected junior high schools in Ghana

Student Feeling	Teacher Response			
	Reported by Teachers		Reported by Students	
	Example	%/(N)	Example	%(N)
Dependence	The reaction from the teacher will determine his mood; depends on the question, some answers are very near to the correct answer; depends on the way I respond;	18.8 (3)	-	0
Encouragement	Feels he needs to be corrected since its part of learning; some of them realize they have to do their homework well before answering questions; not so bad since correction is made; they don't feel bad; they look uncertain till further explanation from the teacher, some go further to defend their answers even when they are wrong; always corrected and encouraged; bring out his/her idea for early correction; others do not mind; just listen to the correct answer from the teacher and sometimes their colleagues;	56.3 (9)	I feel good because when my answer is wrong my teacher will not insult me; I don't feel bad because I was trying; I continue learning so that I get it right another time; I don't feel very bad because maybe someone had the same answer so my answer will influence him; I don't feel anything; I try to answer next time; I need to keep the correct answer from the teacher; I feel that next time I will get it correct	23.5 (8)
Discouragement	He/she looks sad; they do not always feel well; sometimes they are down; at times they show some sign of surprise when teacher disapprove their wrong answer;	25 (4)	I become sad; I feel very sad; I feel very shameful; I am not happy; I don't feel happy; I don't feel fine; I feel to say something again but the teacher calls another person to answer; I feel bad; I feel so bad; I don't feel better; I don't feel well; I feel ashamed	64.7 (22)
Shyness	-	0	Sometimes I feel shy; I feel shy	11.8 (4)

The students stated reasons such as I feel good because when my answer is wrong my teacher will not insult me, I do not feel anything, I feel that next time I will get it correct, I feel to say something again but the teacher calls another person to answer, I do not feel bad because I was trying, and I do not feel very bad because someone also has the same answer so my answer will influence him. However, whereas 25% and none (0%) of the reported responses by the teachers discouraged the students and made them shy respectively, 64.7% and 11.8% of the reported responses by the students themselves asserted that they felt discouraged and shy respectively after the teacher's response towards their incorrect answers (Table 4.56). Some of their responses were: I become sad, I feel very shameful, I am not happy, I do not feel fine, and I feel bad. Others were: I do not feel well so I sit up and study, and I feel shy. In addition, 18.8% of the responses from teachers revealed that the feeling of the students also depends on how teachers respond to students' incorrect answers, and the type of students' answers.

4.2.4.3 Teacher response behavior to students' no responses and student feeling

(a) Video and interview

It was observed in the video that the science teachers mainly practiced encouraging teacher response behavior to students' no responses. The observed encouraging teacher response behaviors were mainly positive verbal cues such as repeating the question, asking a simpler question, reframing the question, saying "try again", "say it", and "should I give it to you as homework" (Table 4.57).

The other strategies that encouraged the students were engaging students in a quick exercise, asking them to sit down and advising them, not allowing a student who previously answered a question correctly to respond, and appointing a student to respond. Moreover, the science teachers, to a little extent responded in ways that enhanced self-learning among students by adopting finding out teacher response strategy such as asking whether students understand the meaning of a particular English term in the question, asking students how they understand the question in their own words, asking students whether they know one of the expected responses, asking the class whether they know what he is talking about, and showing students strategies for answering questions correctly (Table 4.57).

Table 4.57 Observed teacher response behavior to students' no responses in selected junior high schools in Ghana

Behavior	Category /% (N)	Theme
Repeats TQ	Encouraging 71.7 (170)	Self-Confidence
Ask a simpler question		
Reframes TQ		
Says "Try again"		
Says "say it"		
Asking a student to stand up properly		
Engages students in a quick exercise, ask them to sit down and advices them		
Provides one CA & invites multiple responses from students		
Provides some information on TQ		
Asks students to use their everyday life experiences to answer TQ		
Tell student to try to answer		
Repeats question to the same student		
Ask someone to read the question on the chalkboard for the class		
Provides CA and invites another response		
Not allowing a student who previously answered a question correctly to respond		
Calls a student and repeats question		
Calls a student and reframes TQ		
Appoint a student		
Repeats previous CA		
Invites a response		
Explains using other responses		
Saying "Should I give you as a homework"	Finding out 2.5 (6)	Self-Learning
Asks whether students understand the meaning of a particular English term in TQ		
Ask students how they understand TQ in their own words		
Asking students whether they know one of the expected responses		
Ask class whether they know what he is talking about		
Showing students strategies for answering questions correctly		
Calls another student to respond	Ignoring 19.4 (46)	Shy-timidity
Calling another student and repeating TQ to him		
Provides CA		
Explains CA		
Gives CA and ask class to repeat		
Immediately providing CR without giving class the chance to respond		
Appointing another student to respond to a question just after one second		
No TRB		
Teacher says "No"	Rejecting 5.5 (13)	
Saying "It means you did not understand"		
Saying "then you are not a woman" to a girl who could not respond to a question on female sexual characteristics		
Says "Some of you will never talk"		
Saying that "It means that you don't understand English"		
Says you don't know this one"		
Says "Some of you will not raise your hand"		
Saying sit down, sit down in an unfriendly voice"		
Saying "You didn't hear anything"		
Says "Just recently you have forgotten all these things, why"		
Says "you don't know"		
Says "form 1" to remind them that they learnt that in form 1		
Says "are you lost"		
Tells students "Keep standing, you are becoming inactive"	Discomforting 0.8 (2)	
Tells student to keep on standing		

Furthermore, the science teachers mainly reported practicing encouraging teacher response behavior (61.5%) (Table 4.58) but according to the students, 37.5% and 5% of teacher response behavior were encouraging and finding out response behaviors respectively (Table 4.59).

The science teachers reported in the interview that they mainly motivated students by encouraging them to respond like asking them to sit down and calling them after the class to advise them, cheering them to be active in class and advising them to learn hard, creating a scenario relating to the question and guiding the student to share what he/she has as far as the scenario is concerned, and asking students to write the answer in their books (Table 4.58).

Table 4.58 Teacher response behavior to students' no responses reported by teachers in selected junior high schools in Ghana

Behavior	Category %(N)	Theme
Should write the answer in his/her book	Encouraging 61.5 (8)	Self-confidence
Sometimes I let them sit down and after the class I call them because some of them have their peculiar problems		
Encourage them to be active in class and to answer questions		
Sometimes I call them after the class and I talk to them when I find out that it happens a lot		
Create a scenario relating to the question and guide the child to share what he/she has as far as the scenario is concerned		
Encourage him/her to learn to know more		
I always encourage them to talk. Usually if they do not talk I intentionally call them		
Sometimes I feel they are absent minded. Sometimes there are problems in the house. I let the person sit down and tell them to pay attention and call other person.		
I ask another student to answer	Ignoring 23.1(3)	Shy-timidity
I shift the question		
By calling another person to answer		
To stand up to enable him/her to pay attention	Discomforting 15.4 (2)	
I ask them to keep standing and ask another person		

Table 4.59 Teacher response behavior to students' no responses reported by students in selected junior high schools in Ghana

Behavior	Category %(N)	Theme
She will ask me whether I don't understand or I were not here the content was taught	Finding out 5 (2)	Self-Learning
Sir asks me why or don't I understand what is being taught		
The teacher will keep on saying something in the past (hint) so that you can remember the answer	Encouraging 37.5 (15)	Self-confidence
I should sit down and think about it		
He will say think about it		
He will tell you to talk or share your idea		
She says I should say something		
My teacher waits till I respond		
She repeats the question		
She asks another person to answer then ask whether I understand. If I did she then asks me to repeat the answer		
Try to say what you know		
Sir tells them to learn hard		
He will give that person some time to try to express his opinion		
He asks the person to sit down and teach that person what he was expecting him/her to say		
He explains to me		
He will tell you the answer		
Tells me to sit up and learn		
Call another person	Ignoring 15 (6)	Shy-Timidity
She later appoints someone to answer after the silence		
He will say when you are asked a question and you don't know you should say I do not know	Rejecting 25 (10)	
He tells you to sit down		
If the question is about something that has just been taught the teacher will say that I have just taught this and you should know		
Teacher will sometimes get angry with you because the teacher feels that when we are playing we do a lot of things		
She will ask me don't you know, then she will ask the whole class for someone to answer so that I understand		
He will ask the person to sit down and appoint another person to answer		
If you cannot answer sit down		
Think before you stand up to talk but not stand before thinking		
He also ask me to stand up till I am able to say something	Discomforting 17.5 (7)	
At times he says stand up and if he ask another question he will call you again		
He sometimes cane me		
Teacher forces the person to talk		
If the teacher forces the person and the person does not talk she canes the person and tells him to learn when he goes home		
Canes the person and then later explain the content		

Involving students who do not talk in class by calling them by their names and asking them to read their answers (Tobin and Fraser, 1990) after writing them down is an exemplary practice that promotes the development of science teaching and learning. They also said they sometimes exhibit actions that make students feel ignored and uncomfortable like calling another student to respond and asking students to stand up respectively.

The teachers also reported that 30.8% and 15.4% (total of 46.2%) of teacher responses towards students' no responses were ignoring and discomforting response behaviors respectively, and the students reported that 25%, 15% and 17.5% (total of 57.5) of teacher responses were rejecting, ignoring and discomforting response behaviors. The students stated examples like telling students to sit down, calling another student to respond, and asking the student to stand up till he/she is able to say something as rejecting, ignoring, and discomforting teacher response behaviors respectively (Table 4.59).

Furthermore, the video showed that 5.9%, 19.4% and 0.4% (total of 25.7%) of the teacher responses were rejecting, ignoring and discomforting teacher response behaviors respectively. This observed teacher response behaviors (25.7%) is due to the video recording of one lesson taught by each teacher, but the teacher response behaviors reported by the teachers (46.2%) and students (57.6%) are based on teachers' and students' experiences over many lessons. Furthermore, the reported data is a pool judgment of the teachers and students interviewed in this study. This means that the science teachers generally exhibited rejecting, ignoring and discomforting response behaviors towards students' no responses. Teacher behaviors like saying "no" or "sit down" in an unfriendly voice, no teacher response or calling another student to respond to teacher questions, and telling the students to keep standing increase students' propensity to refrain from responding to teacher questions, and make them shy and timid. One probable cause for these teacher actions could be that science teachers' questions did not seek for students' ideas but mainly checked students' knowledge so the teachers were disappointed when students could neither respond nor provide correct answers. Teacher questions need to elicit student ideas so that they will be encouraged to contribute their views during discussion.

(b) Causes of students' no responses to teacher questions

The students on one hand reported that 56.9%, 15.9% and 27.3% of the factors that prevent them from not responding to teacher questions were student, teacher and psycho-social based respectively. The teachers on the other hand attributed 56.3%, 6.3% and 37.6% in that order to these factors. Student aptitude, student characteristics, students thinking or having no idea about the answer, and the verbal intelligence of the students emerged as student factors, and teaching strategy (unclear question/lesson content), and teacher response behavior to students' answers were cited as examples of teacher factors (Tables 4.60 and 4.61). Additionally, the social background or home, extra-curricular activity, class behavior and shyness were also reported as preventing students from speaking out in response to teacher questions.

Table 4.60 Causes of students' no responses to teacher questions reported by students themselves in selected junior high schools in Ghana

Factor	Category	Theme %(N)
It is because of the language or the word that I do not know; sometimes also they think that the English that they are coming to use is wrong; cannot speak English	Verbal intelligence 6.8 (3)	Student 56.9 (25)
The person knows but is reluctant to open his mouth; depends on the mood of the person, maybe the person is quarrelling with someone and is angry so when he is asked to respond he keeps quiet; because I did not learn; maybe my mind is not on what sir is teaching; maybe my friend is talking to me; maybe the person was not paying attention; maybe when they give them notes, when they go home they don't revise; at times when the person talks the voice is low; others also feel proud they know that they know if so they don't want to answer so that when it comes to examination they will be able to write; some prefer to write down their answers during exercises	Student characteristics 27.3 (12)	
Maybe the person is thinking about what to say	Thinking about question 2.3 (1)	
Sometimes I do not know/ Sometimes the thing they don't know; sometimes I have no ideas; have no idea to answer the question	Do not know the answer 20.5 (9)	
It might be that the teacher canes very much. If he canes very much I will be afraid of talking; afraid to be caned when he/she gets the answer wrong; some of them are afraid of the teacher,	Teacher response behavior 6.8 (3)	Teacher 15.9 (7)
Maybe the person does not understand the question or the content; maybe I did not understand what she taught, and I also did not tell Madam that I did not understand so she will not know; maybe I don't understand the content so in this case I do not understand it is difficult to answer; maybe they do not understand the question	Teaching strategy (unclear question/lesson content) 9.1 (4)	
I am an athlete and train every morning so I am sometimes late so when I am asked a question it is difficult to answer since I do not follow the lesson	Extra-curricular activity 2.3 (1)	Psycho-social 27.3 (12)
Sometimes I fear to talk because when my answer is wrong the class laughs at me; if the person did not know the answer he will keep quiet otherwise when he speaks out the class will laugh at him; sometimes they feel that if their answers are wrong they will laugh at him; are afraid that when the answer is wrong others will laugh at them	Class behavior 13.6 (6)	
Sometimes they feel shy; maybe the person is tense	Shy 11.4 (5)	

Table 4.61 Causes of students' no responses to teacher questions reported by teachers in selected junior high schools in Ghana

Factors	Category	Theme %(N)
Lack of communication skills(English language); lack of English language proficiency; major problem is the English language; cannot express themselves well in English	Verbal intelligence 25.0 (4)	Student 56.3 (9)
Not paying attention during the lesson; not learning; as a result of forgetfulness	Student characteristics 18.8 (3)	
Depends on individual learning ability; others also may understand and cannot use it to recall	Student aptitude 12.5 (2)	
Lack of understanding of the question	Unclear question 6.3 (1)	Teacher 6.3 (1)
Child may have a peculiar problem (at home, hunger, etc.)	Home 6.3 (1)	Psycho-social 37.6 (6)
They don't like to be humiliated, they would feel that when they give wrong answers they will be rejected Some feel that when they are wrong others will laugh at them	Class behavior 12.5 (2)	
Most times they are shy/shyness; timidity; some are introverts	Shy 18.8 (3)	

(c) Students' feeling after teacher response behavior to students' no responses

Although, the majority of the reported responses by the teachers and video data revealed encouraging teacher response behaviors after a no response from a student, more than 50% of the reported responses by both the teachers and the students affirmed that the students felt discouraged after TRB (Table 4.62). For example, the teachers claimed that the students: feel sorry, feel that the question is difficult, and feel bad when they are standing, especially, the girls. In addition 8.8% of the reported responses by the students asserted that the students were felt shy. For instance, the students reported that "I feel very shy" and "I sometimes feel shy because the teacher has taught me and I have forgotten".

Table 4.62 Students' feelings after science teachers' respond to students' no responses in selected junior high schools in Ghana

Student Feeling	Teacher Response			
	Reported by Teachers		Reported by Students	
	Example	%/(N)	Example	%(N)
Dependence		0		0
Encouragement	He or she feels absent minded in the class and that he or she should be active in class; he will feel part of the class, not rejected; motivated and encouraged; some feel alright when they are standing, especially the boys; I respond positively, that is commend them to motivate them, and they feel good	46.2 (6)	I feel excited because the teacher did not ignore me; I become satisfied; I feel that my teacher is helping me to always be part of the class; I feel it would have been better to say something, get it wrong for him to correct me; when the teacher canes me I feel happy; when the teacher asks me to stand up I also pay attention; I feel I should learn from my friend; I feel good; I feel fine; I will feel good because I could not answer the question; I perform I feel good; the person will feel to learn hard so that he or she can answer and ask questions in class; feel better; and I keep it in my head and I feel comfortable.	32.4 (12)
Discouragement	They feel sorry; they feel that the question is difficult; feels bad but adjusts to the situation; sometimes they feel that I am worrying them; at times some students feel unhappy when they cannot give an answer to a question; some feel bad when they are standing, especially, the girls;	53.8 (7)	If what he has taught us and I have forgotten I will feel bad because he has taught us; I feel unhappy because the teacher will k now that as for me I can answer the question so if I am not able to answer the question the teacher will also not be happy; I don't feel happy; I am not happy after caning; I will not be happy; I do not feel good; bad; I feel bad; I will be sad; I become sad; I feel ashamed; I feel bad; I feel ashamed; I become sad; I will feel sad; feel bad; and I will be ashamed	59.5 (22)
Shyness		0	I feel very shy; I sometimes feel shy because the teacher has taught me and I have forgotten; and I feel shy.	8.1 (3)

4.2.4.4 <u>Summary of findings of teacher response behavior</u>

(a) <u>Teacher response behavior to students' correct or answers, and no responses</u>

All the teacher responses towards students' correct answers reported by the teachers themselves and 96% of reported teacher responses by the students were encouraging teacher response behavior (Table 4.63). This was supported by 86.9% of the observed teacher responses.

Regarding teacher responses towards students' incorrect answers, the teachers reported that 5%, 10% and 50% of the teacher responses totaling 65% were finding out, using and encouraging teacher response behaviors respectively, but on the part of the students encouraging teacher response behavior was the only category of response behavior reported (35.9%). However, the video showed that 3.7%, 1.9%, 2.8% and 25.2% response behaviors that totaled up to 33.6%

were judging, finding out, using and encouraging teacher response behaviors in that order. These categories of teacher response behaviors motivate students in class and sustain student interest in lessons, and are exemplary actions.

Table 4.63 Teacher response to students' correct or incorrect answers and no responses in selected junior high schools in Ghana

Teacher Response		Category of Response/ %(N)						
		Judge	Find out	Use	Encourage	Reject	Ignore/ Disregard	Discomfort
Towards correct answer	Observed	2.8 (12)	0.5(2)	0	86.9(370)	0.5 (2)	9.4 (40)	0
	Reported by teachers	0	0	0	100.0 (17)	0	0	0
	Reported by Students	0	0	0	96.0 (48)	0	4.0 (2)	0
Towards incorrect answer	Observed	3.7 (4)	1.9(2)	2.8(3)	25.2(27)	26.2(28)	40.2(43)	0
	Reported by teachers	0	5.0 (1)	10.0 (2)	50.0 (10)	25.0 (5)	10.0 (2)	0
	Reported by Students	0	0	0	35.9 (15)	43.6 (18)	18.0 (7)	2.6 (1)
Towards no response	Observed	0	2.5 (6)	0	71.7 (170)	5.5 (13)	19.4(46)	0.8 (2)
	Reported by teachers	0	0	0	61.5 (8)	0	23.1 (3)	15.4 (2)
	Reported by Students	0	5.0 (2)	0	37.5 (15)	25.0 (10)	15.0 (6)	17.5 (7)

It was observed that 71.7% and 2.5% (total of 74.2%) of teacher responses towards students' no responses were encouraging and finding out teacher response behaviors respectively. Furthermore, 61.5% of reported teacher responses by the teachers were encouraging response behavior, and 37.5% and 5% of teacher responses reported by students that sum up to 42.5% were encouraging and finding out response behaviors.

(b) <u>Causes of students' no response to teacher questions</u>

The causes of students' no responses are student, teacher and psycho-social factors (Table 4.64). Student factors include students' characteristics, aptitude and verbal intelligence, students' thinking about the questions, and students who genuinely do not the answer. Teacher factors are mainly teacher response behaviors and unclear lesson content and questions. Psycho-social factors include home, extra-curricular activity, class behavior and shyness.

Table 4.64 Causes of students' no responses

Category	Teachers /%(N)	Students /%(N)	Theme
Verbal intelligence	25.0 (4)	6.8 (3)	Student
Student characteristics	18.8 (3)	27.3 (12)	
Student aptitude	12.5 (2)	0	
Thinking about question	0	2.3 (1)	
Do not know the answer	0	20.5 (9)	
Teacher response behavior	0	6.8 (3)	Teacher
Teaching strategy (unclear question or lesson content)	6.3 (1)	9.1 (4)	
Home	6.3 (1)	0	Psycho-social
Extra-curricular activity	0	2.3 (1)	
Class behavior	12.5 (2)	13.6 (6)	
Shy	18.8 (3)	11.4 (5)	

(c) Students' feeling after teacher response behavior to students' correct or incorrect answers, and no responses

Generally, the students were encouraged after teacher response behavior to their correct responses (Table 4.65). However, whereas the teachers claimed that the students were encouraged after TRB (56.3%), the students mainly reported that they were discouraged (64.7%) and sometimes felt shy (10.8%). In addition, both the teachers and students reported that students mainly felt discouraged after TRB.

Table 4.65 Students' feeling after science teachers respond to students' answers in selected junior high schools in Ghana

Teacher Response Behavior		Student Feeling/ %(N)			
		Dependence	Encouragement	Discouragement	Shy
Towards Correct answer	Reported by teachers	0	100 (17)	0	0
	Reported by students	0	100 (34)	0	0
Towards Incorrect answer	Reported by teachers	18.8 (3)	56.2 (9)	25 (4)	0
	Reported by students	0	23.5 (8)	64.7 (25)	11.8 (4)
Towards no response	Reported by teachers	0	46.2 (6)	53.9 (6)	0
	Reported by students	0	32.4 (12)	59.5 (22)	8.1 (3)

4.2.4.5 Factors that shape classroom discussion

Teacher responses towards students' correct or incorrect answers and no responses were generally verbal and non-verbal, and put under three factors namely 'self-confidence', 'self-learning', and 'shy-timidity'. Teacher response behaviors that promote these factors influence classroom discussion.

Teacher response behaviors that encourage students were classified as self-confidence factor. Using incorrect responses, finding out about students' answers and responses, and using students to judge answers lead to self-learning, and teacher responses like ignoring and rejecting student answers, and those that cause discomfort to students were also put under shy-timidity factor.

4.2.4.6 Participants' views about science teaching, classroom discussion and contexts

(a) Students' views

It emerged from the students' views that teaching strategy and attitudes about teaching, students' attitudes towards learning, and educational management and administration need to be considered towards improving science teaching, classroom discussion and contexts. For example, regarding teacher response behavior, some of the students reported that "Teachers should give recognition to students' answers", "teacher should give equal opportunities for every student to answer questions", "I want teachers when students are asking questions they should allow them to ask", and "sometimes when I answer question, teacher does not write but refers to the one in textbook: I feel teachers should accept our responses; What the teacher says, the school children should also bring their ideas so that they will share" (Table 4.66).

Table 4.66 Students' views about science teaching, classroom discourse and its contexts in selected junior high schools in Ghana

View	Category	Theme
I want every teacher who teach science to speak English when he or she comes to class because words in science are in English	Language of teaching 3.9 (2)	Teaching strategy and teachers' attitude about teaching 39.1 (20)
Should try to use English more than Fante (local language) so that it will not be difficult for us during speaking		
Sometimes when a science teacher teaches I don't understand so it is difficult to do my homework	Teaching method 2 (1)	
When students don't understand teachers should explain it further for them	Understanding lesson content 7.8 (4)	
Should give us notes that we will understand after reading		
Should also explain the notes to us		
Teachers should teach us to know		
Teachers should help us to improve our learning through extra classes	Extra tuition 2 (1)	
Teachers should give recognition to students answers	Teacher response behavior 7.8 (4)	
Teacher should give equal opportunities for every student to answer questions		
I want teachers when students are asking questions they should allow them to ask		
Sometimes when I answer question, teacher does not write but refers to the one in textbook. I feel teachers should accept our responses. What the teacher says, the school children should also bring their ideas so that they will share		
Every lesson there must be practical work	Practical work 3.9 (2)	
Teachers must continue doing experiments and observation		
There should be quizzes and student activities to entertain us so that we will learn more and be part of it	Interesting activities 3.9 (2)	
The teacher has to always do something to impress us so that we can learn		
Teachers should try to complete the syllabus before the BECE	Adequate lesson content 3.9 (2)	
The science should be more/Teachers should teach more science		
Teachers play with students too much and this makes them lose respect so they should have their limit and cane them accordingly	Teachers' attitudes 3.9 (2)	
Teachers should also go to class, and use their periods		
When a teacher is not in class we must take our notes and read	Students' private studies 13.7 (7)	Students' attitudes about learning 35.4 (18)
Students should be very serious with science. They should learn when they go home. They should learn according to the subjects they have the next day.		
The students should learn hard		
Students should learn both at home and at school. Should not play too much but learn very hard		
Students should learn		
Students should learn hard		
Students should learn hard/well		
During teaching students should keep quiet and listen to the teacher.	Attentiveness in class 5.9 (3)	
During lessons we should all pay attention		
Students should pay attention in class		
When we don't understand we should ask the teacher	Questioning Behavior 11.8 (6)	
Students should ask questions when they do not understand during lessons		
Those who do not understand should raise their hands for the teacher to explain again		
Students should also ask questions in class if they really want to know/acquire knowledge		
Sometimes when a question is asked and I am about to answer students say you don't know you should sit down		
When we are asked a question, we should be able to answer correctly		
When the teacher explains the work and I don't understand I become very quiet	Shy 2 (1)	
When one does not understand something the person should see his friend after the lesson for further explanation since the teacher may have another lesson in a different class	Peer Consultation 2 (1)	

Table 4.66 (Continued) Students' views about science teaching, classroom discourse and its contexts in selected junior high schools in Ghana

View	Category	Theme
By giving us teachers who can teach the subject well and explain it well so that we can understand	Teacher quality 3.9 (2)	Educational management and administration 25.6 (13)
We need better science teachers		
By providing textbooks	Teaching and learning support resources 15.7 (8)	
Providing enough textbooks to use		
Provision of science teaching and learning materials and equipment		
Teaching and learning materials/science equipment		
We need science textbooks		
Need experimental equipment		
Teaching and learning materials		
Books/textbooks		
I am begging that the government should increase their salary	Teachers' salary 2 (1)	
Should bring us the new syllabus on time so that we can learn it on time	Policy implementation 2 (1)	
Government should organize street children to go to school	Out of school age children 2 (1)	

(b) Science teachers' views

On the part of the teachers, this study revealed that, teaching strategy and attitudes about teaching, and educational management and administration play a major role at improving science teaching, classroom discussion and contexts. For instance, the teachers reported that "science teaching in the primary schools is not attractive to the children so they feel that science is difficult to learn", "science should be made easier for the children", "primary school teachers should engage children in practical work, science work so that they will continue to enjoy", "teaching of science should be made more practical than pouring out knowledge for students, that is, child-centered", "lessons that involve practical work should be done in groups to encourage individual involvement", and "science should be more practical than theoretical" (Table 4.67).

Table 4.67 Science teachers' views about science teaching, classroom discourse and its contexts in selected junior high schools in Ghana

View	Category	Theme
No TLMs	Teaching and learning support resources 40 (6)	Educational management and administration 40 (6)
There should be a number of science laboratories in every district		
Provisions of TLMs		
More resources (like round bottomed flask, flat bottomed flask, materials for basic electronics and computers) should be provided so that they become practical based		
More reference materials and science books for children		
GES should provide apparatus		
Science teaching in the primary schools is not attractive to the children so they feel that science is difficult to learn	Interesting activities 13.3 (2)	Teaching strategy and teachers' attitudes about teaching 53.4 (8)
Science should be made easier for the children		
Primary school teachers should engage children in practical work, science work so that they will continue to enjoy	Practical work 26.7 (4)	
Teaching of science should be made more practical than pouring out knowledge foe students, that is, child-centered		
Lessons that involve practical work should be done in groups to encourage individual involvement		
Science should be more practical than theoretical		
Science should be taught in English for easy understanding	Language of teaching 6.7 (1)	
Children should be made to have extra classes in their homes to support classroom work	Extra tuition 6.7 (1)	
Some topics are difficult to teach like Basic Electronics in B.S. 7. 8 & 9	Difficult topics 6.7 (1)	Curriculum 6.7 (1)

(c) Head teachers' views

The head teachers mainly considered educational management and administration as the focal point of science teaching, classroom discussion and contexts (Table 4.68).

Table 4.68 Head teachers' views about science teaching, classroom discourse and its contexts in selected junior high schools in Ghana

View	Category	Theme
They learning of science in Ghana has not been learner centered, most of the time it is teacher centered so I think the vice versa will do us more good	Teaching method 6.7 (1)	Teaching strategy and teachers' attitudes about teaching 13.4 (2)
Once a term a teacher should evaluate his teaching. Ask students to evaluate the teacher on a plain sheet. Do not ask them to write their names	Reflective teaching 6.7 (1)	
Some topics from the senior secondary schools have been moved to junior secondary school	Revision of syllabus 6.7 (1)	Educational management and administration 80.1 (12)
Science lessons should take place at the laboratory	Teaching and learning support resources 40 (6)	
No science equipment		
No science lab		
We do not have the materials for experiments		
Because in most cases we do not have the concrete objects to facilitate the learning Children needs to feel the objects not just see the chart		
No equipment for practical work Because there is no fund it is difficult to provide these TLMs Equip one school in an area with science equipment so that others can share during science practical work		
There is the need for teachers with very good science background to handle the science lessons	Teacher quality 20 (3)	
During the posting of the teachers, managers should consider the background of the teachers		
Lack of qualified/specialized science teachers		
The science periods on the time table is not sufficient so there is the need for extra time for science lessons	Lesson time 6.7 (1)	
The school atmosphere and environment is very important because this impacts both positively and negatively on teachers and how they relate to the pupils and their responses	School environment 6.7 (1)	
The psychological framework of the teacher, sometimes things outside the classroom like marital problems, financial, etc. affect teachers	Personal problems 6.7 (1)	Psycho-social 6.7 (1)

They reported that the revision of syllabus, teaching and learning support resources, teacher quality, distribution of lesson time, and school environment need to be addressed. Forty per cent and 25.6% of the reported responses by the teachers and students also touched on educational management and administration (Tables 4.66 & 4.67).

(d) Summary of participants' views about science teaching, classroom discourse and contexts

The teachers and the students were of the view that teaching strategy and teachers' attitudes was the most important factor to consider in improving science teaching, classroom discussion and contexts, but the head teachers isolated educational management and administration as the most important factor (Table 4.69).

Table 4.69 Head teacher, science teachers, and students' views about science teaching, classroom discussion and contexts in selected junior high schools in Ghana

View/comment/ideas		Teaching strategy and teachers' attitudes about teaching	Students' attitudes about learning	Educational management and administration	Curriculum	Personal problem
Towards science teaching, classroom discussion and contexts	Reported by teachers	53.4 (8)	0	40 (6)	6.7 (1)	0
	Reported by Students	39.1 (20)	35.4 (18)	25.6 (13)	0	0
	Reported by head teachers	13.4 (2)	0	80.1 (12)	0	6.7 (1)

4.2.4.7 <u>Appropriate teacher response behavior</u>

(a) <u>Appropriate teacher response behavior to students' incorrect answers and no responses</u>

The teachers reported encouraging teacher response behaviors such as teachers should be friendly towards students, teachers should use mild words like not exactly, and give students hint as appropriate to students' incorrect answers (Table 4.70).

Table 4.70 Appropriate teacher response behavior to students' incorrect answers reported by the science teachers in selected junior high schools in Ghana

Behavior	Category	Theme
The wrong answer is an answer in itself so I make them understand why it is wrong	Finding out 8.3 (2)	Self-learning
Asking follow up questions		
Should not make any derogatory remarks or discourage/reprimand learners	Encouraging 75.0 (18)	Self-confidence
Should not make discouraging remarks		
Should not reprimand learners		
Encourage them to try next time		
Friendly towards the child		
Try to bring the child closer to you		
Try to encourage the person to learn		
Do not shut the person down		
Create a friendly atmosphere. When that happens, they come out freely because they believe when they give wrong answers they will not be rejected		
Motivating and encouraging them		
Use of mild words like not exactly		
Guide them to the correct answer		
Do not abuse the child for giving a wrong answer. If the child is wrong you have to appreciate every answer given in the class		
If the child is wrong you have to appreciate every answer given in the class		
Correcting pupils		
Giving students a clue or hint		
I use wrong answers as useful tools for developing the lesson	Using 4.2 (1)	
Quietness. Keep quiet for some time to draw his/her attention that it is wrong	Ignoring 4.2 (1)	Shy-timidity
At times I write correct answers on the board so if your answer is not written on the board it suggest that the answer you gave is wrong	Rejecting 8.3 (2)	
Use of gestures like Shaking of the head		

Additionally, the students also cited encouraging teacher response behavior like urging students to try again and going over the lesson content to ensure clear understanding by students as appropriate response behavior (Table 4.71).

Table 4.71 Appropriate teacher response behavior to students' incorrect answers reported by the students in selected junior high schools in Ghana

Behavior	Category	Theme
Teacher should ask whether you understand or not	Judging 2.6 (1)	Self-learning
I want my teacher to remind me something	Encouraging 55.3 (21)	Self-confidence
I don't want my teacher to insult me when I give wrong answers		
Teacher should say try again. Then I will think about it as the teacher calls another person		
I want him to say that we should keep on learning		
Not exactly what you think, think about it, another idea		
Encourage you to learn/tell the person to learn at home		
Should try hard to answer correctly next time		
Teacher should encourage us by saying that the answer is wrong but try to answer again		
He should ask me to sit down and try again later		
Sir should force us to try again		
Sir can ask me to try again		
Teacher should tell the person "okay sit down" but next time you have to make sure that you will learn before coming to school		
He should tell them to pay attention in class		
The teacher should call him privately and teach him/her because maybe the person does not know		
Teacher should correct me		
He should try to teach you the right thing		
Should go through the lesson again		
Teacher should tell us the answer	Rejecting 31.6 (12)	Shy-timidity
Explain it to us		
Teacher should let your friend answer		
The teacher should call another person to answer the question		
She should explain well and provide the answer so that I can commit to memory		
Teacher should say the answer is wrong		
He should allow/ask me to stand up	Discomforting 10.5 (4)	
Teacher should cane me		

The head teachers further reported that teachers should not be emotional towards wrong answers but rather have a composed disposition towards the answer, prompt the students, and use related experiences to guide or draw the student's mind to the topic (Table 4.72).

Table 4.72 Appropriate teacher response behavior to students' incorrect answers reported by the head teachers in selected junior high schools in Ghana

Behavior	Category	Theme
Throw the answer to other children for their views	Judging 4.2 (1)	Self-learning
You do not shut the person down	Encouraging 83.3 (20)	Self-confidence
Ask the person who got the wrong answers to repeat or take note of the answer		
First of all do not dismiss any answer given.		
There is no foolish/wrong answer		
It's a good try, someone should help		
Every answer is accepted. Allow the children to come out		
Develop atmosphere for students to give answers		
Create an environment for everybody to be free to say anything		
Science teachers should not be emotional towards wrong answers. They should have a composed disposition towards answer		
Motivation (You have done well, but you could do better; You nearly had it; You have tried; You are not far from the answer; You are about getting it)		
Ask the child have another chance.		
Think well to answer to come out with a correct answer		
Guide to child towards the correct answer		
Prompt the child		
If the teacher says wrong outright the introverts will never open up Can't you think of another answer?		
Teacher should use related experiences to guide child/draw child's mind to the topic		
Not the best to say wrong out rightly, will embarrass the child		
When a child gives a wrong answer you do not have to say No		
Allow many answers and the correct one comes out		
Ask other students the same question until you get the correct answer from the class		
Ask the class who can help this person	Rejecting 8.3 (2)	Shy-timidity
Teacher calls the correct answers for pupils to repeat		
Ignore the person and move on	Ignoring 4.2 (1)	

In addition, 8.7% and 4.3% of the teacher response behaviors that were finding out and using teacher response behaviors were considered to be appropriate by the teachers (Table 4.70). Examples of finding out and using teacher response behaviors judged appropriate are making students understand why the answer is wrong and perceiving wrong answers as useful tools for developing lessons. Besides 2.6% and 4.2% of teacher response behaviors that were judging teacher response behavior were believed to be appropriate towards incorrect responses from students by the students and head teachers correspondingly (Tables 4.71 and 4.72). Teacher response behavior such as teachers asking students whether they understand the question or not and teachers throwing the wrong answer to other students for their views were cited as examples of judging teacher response behavior.

Surprisingly, 8.7%, 31.6% and 8.3% as rejecting teacher response behavior were judged by the teachers, students and head teachers respectively as appropriate towards students' incorrect answers (Table 4.70, 4.71 and 4.72). Teachers using gestures like shaking the head, teachers saying the answer is wrong, and teachers asking the class who can help the student who incorrectly answered the question are examples of recommended rejecting teacher response behaviors. Furthermore, 4.2%, 10.5% and 4.2% as ignoring, discomforting and ignoring teacher response behaviors respectively (Tables 4.70, 4.71 and 4.72), were also considered as appropriate by the teachers, students and head teachers in that order. Keeping quiet for some time after an incorrect answer, letting the student who provided an incorrect answer to stand up or using canes on that student, and ignoring the student who gave the incorrect answer are examples of ignoring, discomforting and ignoring teacher response behavior respectively believed to be appropriate.

Regarding teacher response behavior towards students' no responses, 91.5%, 43.2% and 60% as encouraging teacher response behavior and 9.5%, 13.5% and 30% as finding out teacher response behavior were believed to be appropriate by the teacher, students and head teachers respectively (Tables 4.73, 4.74 and 4.75).

Table 4.73 Appropriate teacher response behavior to students' no responses reported by teachers in selected junior high schools in Ghana

Behavior	Category	Theme
During the lesson you ignore the child and later call her/him after the lesson to find the problem	Finding out 9.5 (2)	Self-learning
Look for the causes/reasons		
It is sometimes good to give them probing questions with gestures and sketches	Encouraging 91.5 (19)	Self-confidence
Ask the pupil to write answer in his/her book		
Friendly		
Patience		
Repeat the question		
Try to explain it further		
Make them group leaders during discussions so that during presentations they do		
Let them represent their rows during quizzes		
Explain the content again, then ask the question again		
Adaptiveness		
At times some of them have not understood the question so reframe the question		
Urge the student to try his or her best		
You always have to call them until they start talking or answering		
Give them more chances, this will enable them to prepare before coming to class		
They need to be encouraged. Make them feel that they are part of the lesson, do not from		
Make them feel that they are part of the lesson, do not from		
Motivate them		
Discourage those students who laugh/mock at students who give wrong answers		

Table 4.74 Appropriate teacher response behavior to students' no responses reported by students in selected junior high schools in Ghana

Behavior	Category	Theme
The teacher should ask whether I know the answer or not	Finding out 13.5 (5)	Self-learning
Should ask whether you understand or not, and further ask the part that you do not understand so that she can explain further		
Should ask me why		
He should ask them if they understood what was taught		
Teacher should ask him that why is it that he has no answer but he stood up		
The teacher should remember the person	Encouraging 43.2 (16)	Self-confidence
I want my teacher to say that you can answer it so try and don't rush		
The teacher should try to help him/her to bring/come out with the answer		
He should encourage me to talk		
I should keep on learning		
Should tell me to learn		
Sir should advise him to learn at home		
By advising them to sit down and learn		
Some do not pay attention so when they are asked a question they are in trouble. Teacher can ask such students not to do that again		
Should tell them that they should learn at home and stop roaming about		
Teacher should always keep on asking you questions so that when you go home you make research and ask and give answers to questions		
And ask you to repeat what a friend said		
She should explain well and provide the answer so that I can commit to memory		
Teacher should teach me to understand		
Maybe the person did not learn in the house so the teacher would have to go over the lesson again		
Teacher should ask another person to come out with his/her answer and if he realizes that the answer is wrong the teacher will know that we did not understand what he taught us and will have to teach again		
The teacher would have to wait for the person to think about it and come out with an answer		
He should allow us to stand up and call another person to respond	Discomforting/ Ignoring 37.8 (14)	Shy-timidity
He should ask the person to sit and cane the person		
Teacher should ask you to stand up and call others to answer then later tell you that you were absent minded during the lesson		
Ask you to keep standing		
If the teacher has treated the topic, he should punish the person		
Cane me		
Some do not copy notes, some do not come to school. Teacher should inspect notes and cane those who do not copy notes or do not attend class		
Should cane me and then later explain		
Sir should punish the person		
Some do not pay attention so when they are asked a question they are in trouble. Teacher can sack them		
I will like my teacher to tell me to sit down because I don't know	Rejecting 5.4 (2)	
She should ask the class for the person who can tell the answer so that I can learn from it		

Table 4.75 Appropriate teacher response behavior to students' no responses reported by head teachers in selected junior high schools in Ghana

Behavior	Category	Theme
You will have to find out why. May be the person is normally intimidated at home and that has made him that way, so you find out after the lesson	Finding out 30 (3)	Self-learning
Leave the person alone because genuinely he may not have the answer; try to find out about the background information about the child. Maybe he did not come to school or has not copied the notes. Sometimes check from class notes for children who are reluctant and query the child. Try to find out the cause and depending on the findings you can advice or counsel		
The teacher must be friendly and find out the students problem		
Go on explaining the subject being taught and let the child try to come out with an answer by demonstration and other ways	Encouraging 60 (6)	Self confidence
Maybe the question did not go down well so try to explain further and if still not getting on pass it on to another person		
Involve the child in other activities like during science lessons, ask students to show to their colleagues and try to break(get him to talk) Teachers should be creative and innovative and should put the child at the center of the learning experience and facilitates, Alright come and handle this for your friends to talk about this. This will make him feel happy and confident		
Best way is to motivate them to talk, encourage them, ask them some questions		
Group those students who do not provide a response together and have special tuition for them		
The teacher must be friendly encourage him/her to talk when asked a question in class		
You should call another person	Rejecting 10 (1)	Shy-timidity

However, 5.4% and 37.8% as rejecting teacher response behavior, and discomforting/ignoring teacher response behavior respectively were also considered appropriate by the students (Table 4.74). In addition, 10% of the reported teacher response behavior towards students' no responses thought to be appropriate by the head teachers was rejecting teacher response behavior (Table 4.75).

This study also revealed that all the teachers recommended encouraging teacher response behavior as appropriate for stimulating inactive students to respond to teacher questions (Table 4.76). In addition, 93.7% and 6.3% as appropriate teacher response behavior reported by head teachers were encouraging and finding out response behaviors respectively (Table 4.77). Furthermore, 82.9%, 8.6% and 8.6% of teacher response behaviors recommended by students as appropriate were encouraging, finding out and discomforting response behaviors respectively (Table 4.78).

Table 4.76 Appropriate teacher response behavior for encouraging inactive learners to answer questions in class reported by teachers in selected junior high schools in Ghana

Behavior	Category	Theme
Encourage them to sit by active learners	Encouraging 100 (17)	Self-confidence
They should keep on trying		
They should be mixed with the very active ones (seating according to ability)		
Friendly		
Motivation		
Ask questions intermittently and mention names randomly		
Give them more work		
call them more often		
Let them repeat correct answers said by their own friends		
Create scenarios to give them ideas		
Patience		
At times I call them by their names whether their hands are up or not to answer questions		
If it is an activity lesson you call them and involve them in the activity so that they also become part of the class		
Call them to answer questions		
You always have to call them until they start talking or answering		
Give them more chances, this will enable them to prepare before coming to class		
Intentionally ask them, call them to do activities, intentionally throw questions to them		

Table 4.77 Appropriate teacher response behavior for encouraging inactive learners to answer questions in class reported by head teachers in selected junior high schools in Ghana

Behavior	Category	Theme
Know your class, know your pupil (my philosophy in teaching).	Finding out 6.3 (1)	Self-learning
Make time for them, may be after school. You let them stay for about 15 minutes, group them an counsel them	Encouraging 93.7 (15)	Self-confidence
Spontaneously throw the question to the students. Do not specifically target any student		
Call them by force to answer. They are very good so force them to answer		
Should not promote sitting according to ability.		
There is no child who is dull and daft. Let them feel free.		
Create an atmosphere in class that removes intimidation		
During teaching involve them		
Clap for them whenever they answer questions		
motivate them with gifts or good response		
Reward the active ones to encourage the inactive ones to strive for a reward		
During teaching guide them to answer questions, drag them along		
Sometimes teachers should guide them to answer, give them guided answers, especially the weak ones		
Give them very simple questions within their means		
Prior to that talk to the class, tell them we are all equal, not perfect, we are still learning		
Caution them/students against students who laugh at others whose answers are wrong. When s student laughs at a friend, teacher should caution him		

Table 4.78 Appropriate teacher response behavior for encourage inactive learners to answer questions in class reported by students in selected junior high schools in Ghana

Behavior	Category	Theme
If they are not many teacher should call them at the office and ask them why they don't answer questions in class	Finding out 8.6 (3)	Self-learning
She should ask those who don't understand		
He or she must ask them if they understand the question well or not so the teacher can explain further for them to understand		
The teacher must call such persons everyday	Encouraging 82.9 (29)	
When the teacher ask questions he can call those students not only those who answer questions to answer		
Always ask them questions		
He should call them to answer questions so they can compare their learning		
He must continue calling them		
Teacher should ask me to answer questions unaware since it is possible that I was not paying attention		
Teacher should call them to answer questions in class		
The teacher should ask them		
Teacher should appoint them to answer questions		
Teacher should call those people to answer questions in class		
Sir should ask them to contribute their ideas during lessons		
Throw questions to them		
He should always try to ask them questions		
He must teach very well so that they can understand and also take part		
This will depend on the teaching		
Teacher should teach me very well		
She should explain further to them		
Should teach them again and ask the questions		
Teacher should explain question in low level so that they can understand		
Teacher should tell them that if they are asked a question and they do not know, they should at least say something		
Teacher should help them by using the students. Students should help one another		
He should tell them to say whatever that they know		
He should tell them to stop all that they are doing and pay attention (some do different things in class)		
Teacher should encourage them to learn		
Teacher should talk to them for them to pay attention in class and contribute accordingly		
He should advise them		
Maybe teacher stands at one place (corner) so they will not hear so teacher should go to all the places		
Sir should call them and interview and advise them. He has even called me before		
The teacher would have to wait for the students to think about it and come out with an answer		
Teacher should punish them by giving them canes	Discomforting 8.6 (3)	Shy-timidity

(b) Summary of appropriate teacher response behavior

Encouraging teacher response behavior is the most appropriate to exhibit to students' incorrect answers or no responses, and for inspiring inactive students to verbally take part in science lessons. This is because this study revealed that 73.9%, 55.3% and 83.3% of the reported responses by teachers, students and head teachers in that order were encouraging teacher response behavior (Table 4.79).

Table 4.79 Appropriate teacher response behavior in selected junior high schools in Ghana

Teacher Response		Category of Response/ %(N)						
		Judging	Finding out	Using	Encouraging	Rejecting	Ignoring/ Disregarding	Discomforting
Towards incorrect Answer	Reported by teachers	0	8.3 (2)	4.2 (1)	75.0 (18)	8.3 (2)	4.2 (1)	0
	Reported by Students	2.6 (1)	0	0	55.3 (21)	31.6 (12)	0	10.5 (4)
	Reported by head teachers	4.2 (1)	0	0	83.3 (20)	8.3 (2)	4.2 (1)	0
Towards no response Answer	Reported by teachers	0	9.5 (2)	0	91.5 (19)	0	0	0
	Reported by Students	0	13.5 (5)	0	43.2 (16)	5.4 (2)	37.8 (14)	
	Reported by head teachers	0	30 (3)	0	60 (6)	10 (1)	0	0
Encouraging inactive students	Reported by teachers	0	0	0	100 (17)	0	0	0
	Reported by Students	0	8.6 (3)	0	82.9 (29)	0	0	8.6 (3)
	Reported by head teachers	0	6.3 (1)	0	93.7 (15)	0	0	0

CHAPTER 5

DISCUSSION

5.1 Science Teaching

5.1.1 Science teachers' time spent on different school activities

The small number of hours spent by science teachers in this study in Ghana compared to the other countries could be due to the fact that the science teachers might be doing another job like teaching extra classes for personal gains in order to raise more income. This could also be attributed to the time allocation specified by the curriculum. The reason why science teachers in Ghana reported spending many hours teaching other classes may be due to the fact that there are inadequate teachers in the basic schools in Ghana so they are compelled to teach other subjects.

Science teachers in Ghana, like their colleagues who participated in TIMSS 1999 video study, reported spending the least average number of hours on meeting with other teachers to work on curriculum and planning issues, mainly because they are not involved in curriculum development and planning issues. The local and regional offices of the GES and the school administration should greatly involve teachers in issues relating to curriculum and planning. This, when practiced, would cultivate the habit of meeting with other teachers to work on issues regarding the relevance of the content in curriculum.

Japanese science teachers spend the highest number of hours on other school related activities because they are generally involved in extra activities like class and grade activities, home room responsibilities, teaching period of integrated studies, and moral education.

5.1.2 Science teachers' decision to select lesson content

Curriculum guidelines, mandated textbooks and external examination greatly influence decision to select lesson content among the science teachers in this study in Ghana because science teachers mainly use curriculum materials specified by the government like science syllabuses, mandated textbooks and B.E.C.E. past questions. For instance, every teacher uses the science syllabus to determine the lesson content to be taught because the syllabus has specified objectives, activities and assessment procedures to serve as a guide for the teacher.

Science teachers in Ghana also use mandated textbooks because these are the primary source of information for both the teachers and students. Hence, the science teachers rely heavily on them for familiarity with the content. Additionally, B.E.C.E. past questions greatly influence the instructional practices of teachers. Generally, science teachers in Ghana are highly stressed because they have to prepare their pupils to pass the national exit examination (that is, B.E.C.E) at the end of the compulsory basic education. Therefore, science teachers teach according to the nature of the B.E.C.E past questions. The fact that the exit examination is used as criteria for selecting students to pursue their education in the senior high schools in Ghana encourages the science teachers to prepare their students towards passing this examination. As a result of this, the teaching and learning of science shapes pupils' behaviors towards passing the examination. However, science teaching need to focus on the development of knowledge among pupils so science teachers should be autonomous and innovative rather than relying heavily on curriculum guidelines, mandated textbooks and B.E.C.E. past questions. Besides, they need to have adequate assessment of their students' interests or needs to enable them to diagnose students' weakness and strengths. Adequate knowledge about students' interests, thinking, difficulties, needs, weaknesses and strengths will enable teachers to select appropriate content and plan desirable activities.

5.1.3 Background information of the science teachers

5.1.3.1 <u>Science teachers' education preparation</u>

Many of the science teachers in this study in Ghana possessed certificates below undergraduate degree because they mainly went through a 3-Year Post Secondary Teacher Training College education. Most of them completed 9 years of basic education, 3 years of high school education and finally enrolled in the teacher training colleges where they spent 3 years. On the other hand science teachers in Australia, Czech Republic, Japan, Netherlands and USA pursued the science disciplines in the universities.

In Ghana, the 3-Year Teacher Training College that the science teachers in this study attended did not prepare them in specific science disciplines like life sciences, physics, chemistry and earth science. They were mainly nurtured in general science and other subject areas. However, a teacher's education preparation potentially shapes teacher capacity which determines teacher productivity.

A teacher's deep knowledge in science content will help in classroom questioning practices, especially, regarding the cognitive and knowledge dimensions of teacher questions. For instance, this study revealed that the major at college and a teacher's higher qualification influences teacher questions that focus on knowledge and cognitive dimensions (Tables 4.39, 4.40, 4.41 & 4.42).

Therefore, science teachers need to have deep knowledge in the various science disciplines so it is necessary to upgrade the teacher training colleges so that they can offer degree and diploma programs in education and related fields. Although, the teacher training colleges have been upgraded to Colleges of Education that offer diploma programs (since 2004), this is still inadequate since most of the tutors at post in the colleges do not have qualifications that befit the status of a diploma awarding institution. This makes it imperative for the University of Cape Coast to which the Colleges of Education are attached to play a major role in training the students, and building the capacity of the tutors. The University of Cape Coast need to collaborate with the University of Education, Winneba, to provide human resource to the Colleges of Education, and at the same time, help in the professional development of the tutors in these institutions.

5.1.3.2 Professional development opportunities

The universities need to establish a strong link with basic schools and conduct collaborative research in science teaching at the grassroots level. This will cultivate the seed of research in science teaching among science teachers across the country and open up professional development opportunities for them. The research and professional development activities could focus on diverse activities like cooperative group instruction, interdisciplinary instruction, standards-based teaching, teaching higher order thinking skills, teaching students from different cultural backgrounds and with limited proficiency in English language, education technology, classroom management and organization, and lesson study.

Professional development is the key to improving the quality of science teaching. Both pre-service and continuing professional development activities prepare teachers to upgrade and improve their content and pedagogical knowledge and skills. Therefore, teachers at the grassroots require very active and pragmatic in-service training activities to enable them to maintain and improve their knowledge and skills in their subject areas. School-based in-service training that involves a teacher observing the lesson of a teacher colleague and vice versa need to be promoted in the schools. The fact that the teachers did not major in specific science disciplines in the teacher training colleges, makes it necessary for the science teachers to attend regular in-service training activities to learn more about science and share their experiences and ideas.

5.1.3.3 <u>Science teachers' learning goals for science lessons</u>

The difference in the learning goals of science teachers among science teachers in this study and those who took part in TIMSS 1999 video study could be due to the fact that the science teachers in Ghana and those in the other countries have different socio-academic backgrounds and working conditions. For instance whereas majority of the science teachers in Ghana usually do not have the first university degree, all the science teachers in the countries who participated in TIMSS 1999 video study have at least the first university degree. Furthermore, the science teachers in those countries like Japan have access to well-equipped facilities in the schools but, science teachers in Ghana have limited access to equipment and facilities. Furthermore, the science teacher in Japan spends almost the whole day at school but his counterpart in this study in Ghana spends about half of that time at school. Therefore, there is the need to create a social environment and working conditions that will promote science instruction in Ghana.

Furthermore, science teachers in Ghana need to emphasize understanding of scientific ideas and concepts during science lessons. Although, 21% of the science teachers in this study in Ghana reported that they focus on creating awareness of the usefulness of science in life, the understanding of science concepts and ideas is paramount. Without the understanding of science concepts, patterns, theories and ideas, children may be aware of the usefulness of science but cannot make use of scientific knowledge in their everyday life activities. Therefore, science teachers need to focus not only on knowing (as revealed in this study) but also understanding of science; doing science such as carrying out scientific experiment, project or activity, developing generic thinking skills, learning laboratory thinking skills, and using scientific inquiry skills; and context of science like awareness of the usefulness of science in life, collaborative work in groups, and independent work

5.1.3.4 <u>Learning environment and extent of access to available resources</u>

Learning environment plays an important role in the teaching and learning process. The lack of either a science room or a science laboratory and the inadequacy of both commercial and natural products to aid teaching and learning will restrict opportunities available for students to engage in active learning processes. Furthermore, the lack of educational technology will also hinder the teaching and learning process. Generally, the cognitive entry behaviors, affective entry characteristics, general and verbal intelligence, and the socio-economic and cultural backgrounds of students are different so a multidisciplinary approach needs to be used during instruction. The use of computers and specialized visual technologies would allow individuals to learn at their own pace.

The Ghana Education Service needs to improve the learning environment of science teaching, classroom discussion and contexts. This will enable science teachers to have access to available resources that will support the teaching and learning process.

5.1.3.5 Attitudes about teaching

Science teachers in Ghana should continue to engage in activities that will professionally develop their career. School based in-service training and personal effort to develop ones potential should be encouraged. Science teachers should have a strong background in both science content and pedagogy, so the GES should strengthen the foundations for teaching and learning of science in senior high schools and teacher training institutions. In addition, the GES need to put in place a mechanism to attract a cream of the citizens (top ten percent of senior high school graduates) to be teachers.

The Ghana Education Service should also form strong partnership with the industry to develop science education in the country to make science education more practical and relevant to everyday life activities. It appears there is a gap between science education and industry because "industry and education continue to be seen as separate entities with distinctive functions with the only linkage occurring at the time industry employs school leavers" (Anamuah-Mensah, 1999 b, p. 88). Science teachers know very little about industrial processes and the raw materials for daily products like paper, soap, plastics, cement and toothpaste (Anamuah-Mensah, 1999 b) so engaging in industrial attachment will provide opportunities for them to learn about industrial processes. This will cement their knowledge in science and help them to be able to link science and industry during classroom instruction. An understanding of the linkage between science and industry will influence science teachers' practices in class, and make pupils appreciate the usefulness of science in everyday life activities and experiences.

Although, the science teachers from Ghana in this study, generally, agreed to the statement "I have a strong background in the subject areas I teach", they in fact slightly agreed to this statement (Table 4.10). This may be due to the fact that their major areas at college were not in specific science disciplines.

The science teachers, mainly, have positive attitudes towards teaching so head teachers, students, parents, community and the GES should continue to give them recognition and appreciate their dint of hard work. This will intrinsically motivate them to become more dedicated to their work. The quality of thinking and the level of understanding of different ability, high ability and low ability students are different, so science teachers need to use appropriate methodologies and strategies during instruction. Pre-service and in-service training should also focus on these methodologies and learning behaviors of these categories of students. Although science teachers in this study in Ghana generally agreed that they prefer to teach low, high and mixed ability students, majority of them strongly agreed to prefer to teach high and mixed ability students, and the minority strongly agreed to prefer to teach low ability students. It is very important not to leave any child behind in education so professional development activities should equip teachers with knowledge in dealing with low ability learners and skills in handling them. They should give equal attention to all pupils in class to provide each one of them with equal learning opportunities (MOE, 2007).

5.1.4 Instructional organization of lesson time

5.1.4.1 Public talk and time spent on studying science

Spending most of the lesson time on public talk and science instruction is an indication that science teachers in this study in Ghana are doing their best to maximize the contact hours of instruction. This is in line with the models of school learning put forward by Caroll (1963) and Bennett (1978) that link success in school learning to the amount of time spent on a learning task. At the same time, the content of what students spend their time on is important so science teachers need to organize lesson time on productive learning activities.

However, spending very little time on science organization implies that they rarely involve learners in classroom administrative and discussion activities that are linked to science study. These activities enable students to complete science instruction activities and prepare for follow up activities that support science instruction. Although there is no obvious science instruction taking place during this time, students' engagement in such organizational activities complement science instruction.

5.1.4.2 <u>Lesson organization for different instructional purposes</u>

Developing new content is needed to increase students' scientific knowledge base. However, developing new content without reviewing of previous content, assessing student learning, assigning homework and going over assessment will not yield the desired learning outcome. Science teachers need to devote appropriate part of the lesson time to assigning homework, going over homework, assessing student learning in the classroom, and going over assessment. Assessment procedures like class tests, class exercises and homework are necessary to monitor learning outcomes. Science teachers in Ghana "are expected to use class exercise and homework as processes for continually evaluating pupils class performance and as a means of encouraging improvement in learning performance" (MOE, 2007, p. xviii). Assessment procedures provide avenues for science teachers to get feedback from learners and monitor their learning. Homework and in-class assignment reinforce learning, assess learning outcomes, and promotes inquiry among learners during instruction, so these should form an integral part of science instruction.

Science teachers in Ghana need to cultivate the habit of assigning homework and giving in-class assignment during every lesson. They should use many assessment procedures to realize their lesson objectives, and provide feedback about assessment to the learners. This will promote self-evaluation practices among learners and the science teachers will also have the opportunity to monitor learning outcomes through getting feedback from learners. They need to formally assess pupils' learning, and keep the records. The contents of assignment and assessment should be directly linked to the subject matter content of the lesson.

Therefore, science teachers in Ghana need to spend appropriate lesson time on these pedagogical function structures, as well as others like reviewing previous knowledge and administrative work. This will again help them to easily monitor the learning, behavioral patterns of individual pupils, and keep students alert in the teaching and learning process.

5.1.4.3 Lesson organization for whole-class and independent work, and practical and seatwork activities

Generally, science teachers in this study in Ghana engaged learners more in whole class work than independent work. This could be due to the nature of the classroom learning environment. They spend more time on seatwork activities than practical activities. The seatwork activities are mainly whole class seatwork activities. The students, have very limited time and opportunity to engage in group work or work in pairs during independent seatwork and independent practical work activities. This greatly limits scientific inquiry and is in contrast to what the science syllabus expects from them in teaching each of the topics. The syllabus requires them to use practical activities and discussion for most of the topics, and brainstorming and discussion for the others (MOE, 2007). In view of this, science teachers need to spend appropriate time on whole class practical work, and independent practical work and seatwork activities with students working in groups or in pairs.

Furthermore, seatwork activities should be made motivating and be cognitively demanding, involve adequate reading activities, mathematical calculations and operations, making graphs and diagrams and interpreting them, and writing down answers to in-class assignments.

5.1.4.4 Science content of the lessons

(a) Science disciplines and topics addressed in the lessons

Science teachers in this study mainly prefer to teach life sciences than disciplines such as chemistry and physics because of the general perception that chemistry and physics are more difficult than biology. Furthermore, students prefer biology because it mainly involves reading to chemistry and physics that involve calculations.

(b) Types of science knowledge in the lessons

Generally, science teachers in this study in Ghana, develop canonical knowledge in class, and also used real life illustrations. Developing canonical knowledge only will not promote the acquisition process skills among learners. Science lessons should also contain a high content of practical work to equip students with experimental and process skills. Science teachers, again, need to spend appropriate part of the lesson time on developing procedural and experimental knowledge, real life issues, real life issues used to develop canonical knowledge, classroom safety, nature of science, and meta-cognitive knowledge.

The behaviour of the science teachers in Ghana does not reflect what is demanded by the teaching syllabus. In the syllabus, "the dimensions for teaching, learning and testing in Integrated Science at JHS and their respective weights are as follows: Knowledge and Comprehension (20%), Application of Knowledge (40%), Experimental and Process Skills (40%)" (MOE, 2007, p. x). Although, they are expected to emphasize experimental and process skills, this study revealed a low practical content of the lessons. Furthermore, no time was organized for classroom safety knowledge, although observation of safety measures has been clearly stated in the syllabus, and meta-cognitive knowledge in class.

The science teachers also need to avoid spending time on blank segments/activities since this does not offer learning opportunity for students to learn science but rather distribute this time to developing the other types of knowledge. The verbal resource of the teacher should be very clear and specific when giving out instructions and for classroom management purposes. Digression from the lesson content and non-public talk during whole class settings should be discouraged.

5.1.4.5 Developing science content

The high number of science lessons (87%) in Ghana that contained at least 15 public canonical ideas could be due to nature of classroom instruction in Ghana. Science lessons in Ghana are dominated with whole class seatwork activities, public teacher presentation of facts, and developing mainly canonical knowledge and new content. Additionally, the exit examination also exerts an influence on the science teachers to cover many topics in class. Therefore, science teachers present many facts in order to cover all the topics in the syllabus at the expense of ensuring clear understanding of concepts by students. This also explains why the sources of science content are mainly science teachers and textbooks. Science content needs to come from more than one source that includes students themselves. When students are aware that their contributions and views form part of the science content they will be motivated to broaden their knowledge base through reading and from other sources.

The content of science lessons is generally developed by acquiring facts and definitions, with making little connections through inquiry and no connections through applications. Therefore, students tend to learn content with weak or no conceptual links. Besides, it is very difficult to conceptually connect many public canonical ideas within a science lesson so science teachers need to focus on a small number of canonical ideas and stress understanding and strong conceptual links. They need to use more science terms than highly technical science terms during teaching for easy understanding and communication. They should address various types of knowledge like canonical, real-life, procedural and experimental, classroom safety, and meta-cognitive knowledge. They also need to devote appropriate lesson time to both independent and whole class seatwork activities and practical work, and devote appropriate lesson time to developing new content, reviewing students' prior knowledge, assigning homework, assessing students learning, and going over homework and assessment.

Goal statement by science teachers is as important as summary statement. Whereas goal statement gives an overview of the expected lesson content and prepares students in a receptive framework for the lesson, summary statement concretizes and reinforces student learning. These should therefore constitute part of every lesson. In addition, the science content should be more of basic and challenging, and challenging content, than just basic content.

5.1.4.6. Using evidence to develop science content

The use of first-hand data, phenomena and visual representations concretizes and reinforces learning. Everyday life activities, examples and illustrations, simple demonstration of phenomena, 3-dimensional models, graphic organization, diagrams and formula should be integrated in the teaching of science. Science teachers need to use more than one piece of the various types of evidence in developing the main ideas in a lesson. As much as practicable, they need to also support every main idea with first-hand data, phenomena, and visual representations.

5.1.4.7. Collaboration and communication

Socrates describes learning as searching for knowledge and according to Dewey, knowledge can be discovered in practice. Discovering knowledge by learners themselves means allowing thinking together, working together, and sharing ideas and experiences. This makes it imperative to promote interaction among learners during instruction.

Learners should be encouraged to cooperate during the instructional process. Discussion among learner groups and between them should be encouraged in class. The use of the snowballing technique during discussion will also greatly enhance interaction among learners. During instruction, teachers can continue to merge small groups and engage them in discussion till there is only one group, that is, the whole class, and then have a class discussion.

The use of group work is necessary to ensure collaborative learning among the students, and this enhances both verbal and physical interaction, and cooperation among learners. Teachers need to use this strategy to actively involve the students during instruction. Children tend to learn easily from their peers, so the groups should be formed such that each group is made up of children with mixed abilities.

Additionally, organizing more time for teacher presentation than discussion will not promote critical thinking among learners, and sharing of views on a topic among them. Science teachers need to spend more time on discussion to promote verbal exchange of ideas and experiences among learners. This, however, is a big challenge since the verbal facility of the students is not adequate to freely allow them to engage in classroom discourse because the home language is different from the language of instruction at school.

Furthermore, independent work on graphs, diagrams and mathematical calculations need to be promoted in the teaching and learning of science. But this need to be followed by communicative activities likes classroom presentations and discussions to verbally engage the students. The making of graphs and diagrammatic representations by students will prepare them to effectively communicate their ideas when they engage in such activities. Encouraging mathematical calculations will also develop students' thinking and creative skills.

5.2 Classroom Discussion and Contexts

5.2.1 Students' cognitive involvement in discussion

The finding that students' answers are mainly a demonstration of knowledge could be due to the nature of questions asked by science teachers. The science teachers' questions were mainly to check students' knowledge rather than drawing out student thinking and understanding.

Students' responses that are non-verbal, non-physical, teacher-led, and a demonstration of knowledge do not promote the development of knowledge. Teacher questions need to be constructed in such a way that they elicit student thinking. The use of teacher questions that elicit reasoning and stimulate questions from students need to be promoted. Furthermore, science teachers need to regularly invite questions from students and encourage questions or responses from students to other students.

5.2.2 Knowledge and cognitive dimensions in teacher questions and students' answers

The analysis of science teachers' questions or statements, and students' answers to determine their knowledge dimensions and cognitive processes reveals their quality. This is important because it shows the profile of teacher questions or statements and students' answers, and sensitizes science teachers to construct questions or statements to nurture the desired knowledge dimensions and cognitive processes. The finding that the science teachers in this study place much emphasis on factual knowledge (72.1%) followed by conceptual knowledge (25.1%), and downplay procedural (2.7%) and meta-cognitive (0.1%) knowledge on one hand, and also stress remember cognitive process instead of high order cognitive processes on the other hand, will be a resource for improving the quality of teacher questions or statements in class.

For instance, the statement "name any part of the male sexual organ" that elicited recall of factual knowledge can be reformulated into a new statement; "differentiate between any two named parts of the male sexual organ?" in order to stimulate student thinking. In this new question, the verb differentiate signifies a cognitive level of analyzing knowledge, and the subject contains and nurtures factual knowledge.

The quality of students' answers, to a large extent, is nurtured by the type of questions or statements science teachers use in class. Teacher questions or statements should not only emphasize factual knowledge dimension and remember cognitive process, but also place appropriate emphasis on understanding, applying, analyzing, evaluating, and creating cognitive processes as well as conceptual, procedural, and meta-cognitive knowledge dimensions. This would elicit student thinking and make them very responsive and creative in developing scientific knowledge.

However, it must be noted that factual knowledge is the foundation for understanding, applying, analyzing, evaluating and creating (developing) conceptual, procedural and meta-cognitive knowledge. For instance since observation is theory-driven, students need to have a factual knowledge base before they can carry out meaningful observations to develop conceptual, procedural and meta-cognitive knowledge. Therefore, nurturing factual knowledge is legitimate. But, this should not be overly stressed at the expense of other knowledge domains.

The purpose of teacher questions or statements should mainly elicit student thinking in order to promote productive learning. Teacher questions or statements need to be directed towards developing student thinking by incorporating all the cognitive processes in them, and eliciting factual, conceptual, procedural, and meta-cognitive knowledge dimensions.

It is seen that science teachers in the developed countries as revealed by TIMSS 1999 video study, to some extent, weighted meta-cognitive knowledge during their lessons. Additionally, they stressed canonical knowledge as well as procedural and experimental knowledge. According to Roth et al. (2006), "while canonical knowledge can be thought of as the products of scientific inquiry, procedural and experimental can be thought of as the knowledge used to arrive at these products" (p. 49). Therefore, it is important to emphasize procedural and experimental knowledge, and meta-cognitive knowledge in science lessons. The fact that science teachers in this study disregard procedural and experimental knowledge, and meta-cognitive knowledge, means that learners will find it difficult to know the 'hows' of arriving at the products of science. Furthermore, they will not be empowered in developing scientific knowledge by themselves. This is probably due to the goal for science lessons perceived by the science teachers.

The goal for science lessons in Ghana is mainly to know about science information (Beccles, 2010). However, the science goals for developed countries such as Japan, Australia, Czech Republic, Netherlands and United States are spread over knowing and understanding science, doing science, and the context of science (Roth et al., 2006). For instance, Japan and Australia lay great emphasis on the understanding of scientific ideas (ibid.). Understanding of scientific ideas will help students to make good use of scientific knowledge. This is because the application, analysis, evaluation, and creation of scientific knowledge, depends on how much one understands it. In addition, the above named developed countries make it a goal to do science during lessons. In this respect, they aim at carrying out scientific experiments, projects or activities, developing generic thinking skills, learning laboratory skills, and using scientific inquiry skills (ibid.).

The science teachers in the developed countries also actively engage in diverse professional development activities such as classroom management and organization, cooperative group instruction, interdisciplinary instruction, science instruction techniques, and standards-based teaching. The rest are teaching higher order thinking skills, teaching students from different cultural backgrounds, teaching students with limited proficiency in their national language, and the use of technology. However, this is different in the African setting where professional development is mainly focused on limited disciplines. For example, professional development is chiefly focused on science instructional techniques in Ghana, and does not even target teaching students with limited proficiency in the language of teaching (Beccles, 2010), although, this is not the home language but rather English language. Professional development of teachers needs to focus on the diverse activities outlined above.

The fact that high order questions or statements generally elicited a small number of responses from students revealed that students may have resorted to low thinking when these questions were asked. This could be due to a number of reasons such as teacher remarks to students' incorrect answers (Beccles & Ikeda, 2011), classroom activities, traditional setting, unclear lesson content, students' poor scientific knowledge base, unclear questions or how questions are worded, and language barrier. The wording of questions and students' verbal intelligence are important because in Ghana, English language, the medium of instruction from primary grade 4, is the students' second language so they are obliged to study it for school education. The verbal competence of the students is generally low in the primary and junior high schools so it is possible that most students did not understand the content of the questions. Besides, it is also possible that the students who might have understood the questions did not have the appropriate vocabulary to express their ideas.

Furthermore, the level of thinking by students also depends on the knowledge base of students. Students need to cultivate the habit of reading many books at home and in the library. Science teachers should encourage students to read and go to the public libraries. They could also create a bulletin board in the classroom where informative materials could be displayed. Once in a week, teachers could also photocopy materials on contemporary issues in science and distribute to the students to read and make presentations on them. This will help build their scientific knowledge base. A rich reservoir of knowledge is a condition that yields creativity (Kagan, 1967a) and fertilizes student thinking, so students need to be exposed to scientific knowledge. Student thinking, in a way, will be a product and reflection of what they know, so a rich knowledge base could potentially develop their thinking skills and make them active and responsive during classroom discussions.

Another entrenched probable cause of the low response could be the fact that traditionally, students are of the view that science teachers normally present knowledge to them. Teacher questions to them are simply aimed at retrieving and evaluating what students know. Students perceive themselves as receivers of knowledge so they are not motivated to engage in thinking processes to develop scientific knowledge. As a result of this, students may not be used to responding to questions that elicit student thinking. This cultural setting may also be the probable cause of why most of the science teachers' questions or statements focused on factual knowledge memorization. However, since culture is dynamic, cultural norms that promote factual knowledge memorization need to be changed.

Science teachers need to present themselves as co-learners in class. There should be a paradigm shift to professionally use questions to create a classroom atmosphere where teaching and learning are in a symbiotic association such that the teacher teaches and learns from the student and the student learns and teaches the teacher. Classroom authority needs to be equally shared between both teachers and students. Teachers need to change the pattern of questioning from the traditional way of checking students' knowledge to frequently asking high cognitive value questions that enhance student thinking in class. They need to give more room for various responses from students, respect and accept students' answers whether viable or not. The use of person-centered questions to elicit students' views and thinking rather than questions that demand only correct answers will encourage students to engage in argumentation and share their views. Science teachers need to make group work, subsequent student presentations, and discussions a core part of their lessons. Therefore, students need to be encouraged to freely participate in such activities and willingly express their thoughts. Their efforts should be consequently appreciated and positively reinforced. This, however, will take time since cultural settings have strongly influence pedagogy from the past and will, therefore, require a pragmatic revolution from policy level, teacher preparation, in-service training, and attitudinal change.

In addition, the questions used in the exit examination greatly influence the instructional behavior of teachers. Generally, teachers teach according to the nature of past questions. The fact that exit examination are used as criteria for selecting students to pursue their education in the senior high schools in Ghana encourages the science teachers to prepare their students towards passing this examination. As a result of this, the teaching and learning of science shapes pupils behaviors towards passing the examination. Therefore, science teaching focuses on knowledge acquisition by pupils. Teachers tend to tailor instruction to allow their students to pass the exit examination by relying heavily on these past questions, than equipping them with both scientific knowledge and skills. In view of this, the questions used in the exit examination should incorporate all the cognitive processes and lay emphasis on the various knowledge dimensions. The pattern of the questions should change from focusing mainly on recall of factual knowledge to higher cognitive processes and conceptual, procedural and meta-cognitive knowledge dimensions.

The results of this study like that of Matsubara (2009) reveal students' cognitive involvement in science lessons. Whereas this study uncovers the cognitive processes: remember, understand, apply, analyze, evaluate, and create, being nurtured in students in class, Matsubara (2009) lesson analysis method shows students' cognitive involvement in lessons and whether it is either being initiated by teachers or by students themselves. Students' cognitive involvement in science lessons is important in the development of scientific literacy among students. Classroom activities that make students' thinking, thoughts and ideas visible need to be promoted and well investigated. In view of this, discussion sessions that reveal the cognitive processes, knowledge dimensions, and the level of cognitive involvement of students in science lessons should be the lens for improving the teaching and learning of science. Matsubara (2009) lesson analysis method and the method used in this study which reveals students' cognitive involvement and the cognitive processes respectively, will inform science teachers to use cognitively demanding questions in class.

However, the nature of pedagogy in Africa is such that there is very little opportunity for students to engage in discussion sessions. This is because apart from the little time devoted to discussion, the language of teaching is essentially English or French which is not the students' home language. The students are more proficient in their home language than their second language. Therefore, they are incapacitated to verbally express their ideas and thoughts during discussion sessions. This is a major problem in both Anglophone and Francophone countries in Africa.

5.2.3 Teacher intentions behind questions

Teacher intentions influence the quality of questions and serve as a guide in realizing instructional objectives. Science teachers can formulate teacher questions to elicit student thinking and at the same time check students' focus in the lesson. For example, instead of using statement(s)/word(s) that elicit either Yes or No responses such as “are you with me”, “do you understand” and “okay”, the teachers can ask specific content questions to elicit student thinking and focus concurrently.

In addition, instead of having an intention to check science content knowledge, daily life experiences, observation, reading and drawing abilities, science teachers need to develop the intention of using teacher questions to elicit a demonstration of students’ understanding of science content knowledge, daily life experiences, observation, and reading and drawing abilities. The act of continually checking students’ knowledge will not encourage students to construct their own meanings and explanations in demonstrating understanding.

Teacher intentions need to also elicit procedural and experimental knowledge. This knowledge dimension is vital in science education because science process skills are regarded as daily life skills. Therefore, these skills should be developed in schools to enable them to use them outside schools. Generally, teacher intentions need to be aligned towards eliciting student thinking and understanding.

5.2.4 Teacher response behavior

5.2.4.1 Teacher response behavior to students’ correct answers, incorrect answers and no responses, and student feeling

Generally, during classroom discussion, science teachers in this study, use positive verbal cues to commend students’ correct answers and to motivate students when they do not raise their hands to respond to a question or when a student called upon to respond does not talk (Tables 4.49, 4.50 & 4.52). These actions build confidence in the students and consequently motivate them to engage in the classroom discussion.

However, regarding incorrect answers from students, majority of the science teachers in this study, either used negative verbal cues or passed no comment (Tables 4.58 & 4.59). Although, the science teachers reported that they mainly engage in response behavior that promote self-confidence and self-learning (Table 4.57), it was revealed by the video and students that the science teachers, mainly, respond to students’ incorrect answers in a way that breed shy-timidity traits in students (Tables 4.58 & 4.59). A teacher’s use of negative verbal cues and passing no response or remark on students’ incorrect responses tend to make students become shy and timid.

For example, “ignoring an answer, being critical, sarcastic or dismissive will deter pupils from answering” (Amos, 2002, p. 12). These practices dampen the learning spirit of students and allow them to withdraw from contributing to classroom discussion since they experience an unpleasant feeling within them. Consequently, students become shy psychosocially, and passively engage in both mental and physical activities in the class because “the most frequent and prepotent reaction to an expectancy of failure is decreased involvement in the task and subsequent withdrawal” (Kagan, 1967 b, pp. 155-156). Invariably, “the fear of being incorrect which represents the fear of disapproval by social community, acts as a permanent insulation against the discovery of new mental combinations” (Kagan, 1967 a, p. x), thus, affecting the development of thinking skills and learning. Therefore, “it is important that the teacher does not ignore or play down incorrect answers as this has the effect of sanctioning them, and sending confusion messages to pupils (Kagan, 1967 b, p. 12). Generally, students take a high risk when they raise their hands and they have tentative ideas and opinions, and a low risk when they are confident of their answer (Amos, 2002). According to Wellington (2000), “most answers mean that the student has given some attention and perhaps some deep thought to the question” (p. 91), so teachers should appreciate student effort and “turn wrong answers into learning experiences” (ibid.). They “need to create an environment in which pupils feel encouraged and supported, and one of the most important factors in this is how the teacher responds to questions” (Amos, 2002, p. 11).

Disregard for students’ feelings during classroom questioning discourse, especially, how they feel after a teacher’s response to students’ incorrect answers, will not yield appropriate feedback to the teacher about students’ understanding and interest in the lesson. This area has not been explored in studies involving classroom discussion. In this study, the students, generally, felt happy and motivated after a teacher’s response to their correct answers (Tables 4.53 & 4.54), but at the same time, majority of them reported that they felt discouraged and shy after the teacher’s response towards their incorrect answers and no responses (Table 4.60). Armed with information about students’ feeling after teachers’ responses towards students’ answers, science teachers need to consider learners’ perspectives seriously and appropriately respond to students’ answers in order to elicit further contributions from them.

In view of this, there is the need for a change in teacher response behavior to promote self-confidence and self-learning traits among students. Students are motivated when the challenge of responding to a question and the effort are recognized and appreciated. Although the content of the response may be incorrect, the challenge put up and the effort needs to be valued by science teachers. Teacher response behaviors, revealed in this study, like encouraging student effort, using incorrect answers, and probing incorrect answers to judge and find out the reasons behind them need to be promoted to enhance self-confidence and self-learning traits.

5.2.4.2 Causes of students' no responses

Students' no response to teacher questions is a resource that science teachers can use to develop science lessons. In this regard, science teachers need to play a major role in eliciting responses from students. Students' responses to teacher questions depend mainly on students' understanding of lesson content and teacher questions so lesson content should be well explained to the level of understanding of students. This can be done by explaining main ideas in different ways, and appealing to the sense of sight to cater for the various student aptitude levels and different student characteristics. Science teachers need to associate the main ideas of lessons to students' prior experiences and everyday life activities and experiences.

In addition a teacher's question should be as clear as noonday sunshine in order to elicit many appropriate responses. The question must be within the reach of the students. Science teachers need to confirm students understanding of teacher questions before eliciting responses from students, and the functional language can be used to ensure that students completely understand teacher questions and lesson content.

Furthermore, since students' responses depend on their verbal intelligence, the teacher needs to promote the use of the functional language in class so that students' who cannot clearly express their ideas will have the opportunity to speak out during lessons. Flexibility in the use of language in class will stimulate to facilitate classroom discussion since students will have the freedom to express themselves in class using a mixture of English and their home language.

Teacher response behavior to students' answers in class will also determine whether students will engage in subsequent classroom discourse or not. Teacher response behaviors such as ignoring and rejecting students' answers are likely to make students not wanting to respond to teacher questions in class. For instance if teacher response behavior encourages the class to laugh at a student who gives an incorrect answer, that particular student, and others who are not sure of their answers would neither raise their hand nor speak out to respond to teacher questions when appointed. Additionally, a no response from a student could mean that the student is still thinking about the question at that time so science teachers need to increase the wait-time, and respond appropriately to the student in order to elicit a response rather than responding in a way that will lower the spirit of the student.

5.2.4.3 Factors that shape classroom discussion

Classroom discussion is influenced by self-confidence, self-learning and shy-timidity factors. Teacher response behaviors that promote these factors among students shape classroom discussion. Self-confidence and self-learning stimulate and support classroom discussion but shy-timidity does not. Therefore, science teachers need to engage in response behaviors that develop self-confidence and self-learning traits among students and limit the development of shy-timidity tendencies.

5.2.4.4 Participants' views about science teaching, classroom discussion and contexts

Educational management and administration, teaching strategy and teachers' attitudes about teaching, and students' attitudes about learning were considered as important in improving science teaching, classroom discussion and contexts in Ghana. Educational management and administration emerged as a common view among the participants. Factors such as teacher quality, teaching and learning support resources, teacher's salary, policy implementation, out-of-school children, revision of syllabus, lesson time and school environment that are under the umbrella of this view need to be addressed by the GES. Among these factors, the majority of the participants isolated teaching and learning support resources (Tables 4.67, 4.68 & 4.69) as the main area that needs to be improved. For example, the students reported that the government should provide textbooks, experimental equipment and other teaching and learning materials, and the science teachers claimed that there are no reference materials and science books for the children. Furthermore, the head teachers said that science lessons should take place in the laboratories but there are no science equipment and science laboratories in the schools. The science teachers also suggested that there should be a number of science laboratories in every district to serve the junior high schools in the districts.

Therefore, the GES need to develop the classrooms into a science room with a few more science facilities to allow students to engage in some level of practical work. Such a room should have a large teacher's desk at front of the classroom. This desk needs to have access to electric power, water and gas. In addition, the students' desk should be easily movable.

In addition, teaching strategy and teachers' attitudes that emerged as a common view between science teachers and students revealed the language of teaching, teaching method, understanding lesson content, extra tuition, teacher response behavior, practical work, interesting activities, adequate lesson content, and teachers' attitudes as influencing science teaching, classroom discussion and contexts in Ghana. Therefore, pre-service and continuing professional development could target these areas with the aim of improving teacher capacity.

Understanding lesson content and the use of practical work were highly stressed by the students and science teachers respectively. The students reported that when they do not understand the lesson content, teachers should give further explanation. Besides, they required science teachers to teach them 'to know'. The teachers buttressed the students' view by reporting that primary school teachers should engage children in practical work so that the pupils enjoy science. They also suggested that the teaching of science should be made more practical than pouring out knowledge for students, and lessons that involve practical work should be done in groups to encourage individual involvement and enhance student learning.

Although, practical work is only one way to ensure effective teaching and learning, science instruction involving practical-based activities have the tendency to enormously enhance the understanding of scientific concepts. The "experience of 'doing science' through carrying out an investigation which has a degree of open-endedness" (Harlen, 1999, p.18) will promote investigative and inquiring skills among pupils. Besides, the propensities in pupils to exhibit behaviors like playing together, collecting things, and inquisitiveness are tapped through practical work. Engaging pupils in practical work need to be an integral part of science lessons to promote both mental experiences and physical activities. Teachers need to organize regular in-class practical work and outside-classroom practical work, depending on the nature and level of sophistication of the activities. In the absence of a science laboratory, the classroom environment could be developed to serve as a substitute. Outdoor science activities should also be encouraged to enable the students to interact with nature.

Finally, the students were the only participants who attributed the development in science teaching, classroom discussion and contexts to students' attitudes. Students' attitudes are determined by factors such as students' private studies, attentiveness in class, questioning behavior, shyness, and peer consultation. Among these factors, the students mainly chose students' private studies as the most important attitude. They reported that students need to learn hard both in the school and at home (Table 4.67). This revelation is a resource science teachers can use to meta-cognitively engage them in learning. Therefore, science teachers need to guide students to take responsibility for their own lifelong learning.

5.2.4.5 Appropriate teacher response behaviors

In the classroom, every student needs a compliment as a means of recognition. Therefore, encouraging, using, judging, finding out teacher response behaviors are appropriate to manage students' incorrect answers, no responses, and for encouraging inactive learners to answer questions in class.

Encouraging, judging, using and finding out teacher response behaviors positively reinforce student behavior in responding to teacher questions. These are very good and suitable for science teachers to practice in class. Encouraging teacher response behaviors to students' answers strengthen students' self-confidence, and judging, using and finding out teacher response behaviors promote self-learning in students. Self-confidence in students is a result of teacher actions like recognizing students' effort at attempting to answer questions, motivating students for their efforts, and using positive reinforcement. Science teachers need to verbally reward students' efforts, and always recognize and use both correct and incorrect answers from students. This act will make the particular student and others with the same view feel accepted and understand why answers are either correct or incorrect, and gradually build their self-confidence. The teachers should respond to students' answers in ways that promote their self-confidence. The philosophy that every answer, viable or not, is useful should guide teachers in handling students' answers. Students' incorrect answers are still answers in themselves, so teachers need to make students understand why particular answers are not viable, and use them as resources in developing science lessons. An incorrect answer may not be viable in one way or the other but viable in another context or situation so teachers need to probe them to unveil students' reasons behind them. This will help teachers to understand students' conceptions and perceptions about science content and their environment.

Furthermore, science teachers need to promote 'self-learning' among students in class. They have to teach them how to learn through meta-cognitive approaches. For instance, they must teach students strategies for answering questions in class. Besides, their questions should have a high content of meta-cognitive knowledge dimension and higher levels of cognitive processes. It is necessary for science teachers to promote 'self-learning' through probing students' answers and allowing students themselves to judge their answers to be either viable or not with reasons. Science teachers need to understand students' answers or no responses, and appropriately respond to them because there are reasons behind them. For instance, an incorrect answer or no response to teacher questions could be due to student factors such as language competency, understanding of lesson content or teacher question, level of interest in the lesson or subject, and student characteristics. The verbal intelligence of both teachers and students will also determine whether students understand the lesson content or teacher questions. The low level of the verbal intelligence of the students, especially, in public schools, require science teachers to be very competent at English language and use vocabulary familiar to the students. The science teachers must also be verbally versatile in explaining lesson content and reformulating questions. Teacher questions must be well framed (correctly worded) and simple, and lesson presentation should be supported with gestures, sketches and linked to everyday life activities. Using examples of daily life activities will clarify lesson content and instill enthusiasm in students. Furthermore, science teachers need to make their lessons interesting and devise means to capture and sustain students' interest in lessons. Students tend to be absent minded or inattentive in class if they do not have interest in the lesson or subject.

It is also useful for teachers to know student characteristics like general aptitude, cognitive entry behaviors and affective entry characteristics. Knowledge of student characteristics will enable teachers to know the background of student thinking and guide them to appropriately respond to students' incorrect answers or no responses, and elicit correct responses from them. Teacher responses to students' incorrect answers or no responses and the consequent psycho-social environment in class are also causes of students' incorrect or no responses to teacher questions. The way science teachers respond to students' answers or no responses will either positively or negatively reinforce students' responses to teacher questions. Teacher response behaviors that promote self-confidence and self-learning positively reinforce students' active responses to teacher questions whereas teacher response behaviors that endorse shy-timidity negatively elicit no response to teacher questions. Shy-timidity is cultivated in students when teachers use negative verbal cues, ignore and reject students' answers in class. Moreover, teacher responses that make students feel uncomfortable like caning and asking students to keep standing when they are not able to either respond to a question or give incorrect answers make them feel shy and timid. Shy-timidity suppresses self-confidence and self-learning in students and potentially affects student participation in discussion. Therefore, Teacher Response Model (TRM), which requires teachers to put themselves in the place of students and try to understand student thinking is recommended as appropriate for managing students' answers and no responses. This model for managing students' answers or no responses to teacher questions is informed by teacher response behaviors that promote self-confidence and self-learning in students.

5.2.5 Teacher Response Model

TRM is a facilitative approach by teachers to manage students' answers and no responses. Teacher facilitation involves five levels (Table 6.1). Levels 1, 2 and 3 require that science teachers recognize, commend, and use students' correct and incorrect answers as valuable contributions in developing lesson content respectively. Level 4 allows teachers to strategically probe students' correct and incorrect answers, and level 5 calls for teachers to modify teacher responses or be flexible in responding to students' incorrect answers or no responses. Appropriate teacher responses toward students' correct answers involves the first four levels of this model and science teachers are required to use all the 5 levels in responding fittingly towards students' incorrect answers. However, teacher response behaviors suitable towards students' no responses involve only level 5.

Table 6.1 Teacher Response Model

Level	Teacher Response Behavior	Correct Student Response	Incorrect Student Response	No Student Response
1	Recognize student response	✔	✔	✕
2	Commend student response	✔	✔	✕
3	Use student response	✔	✔	✕
4	Probe student response	✔	✔	✕
5	Modify teacher response	✕	✔	✔

This approach enhances the socio-psychological environment surrounding discussion sessions, and sustains the interest and participation of students in classroom discussion. It also uncovers students' thought processes, conceptions, misconceptions, perceptions, and naive ideas. TRM is underpinned by teachers' conception of students' answers, and knowledge development by students themselves. The theoretical underpinnings of teachers' conception of students' answers are:

(1) an answer from a child is his or her idea about something
(2) an answer is the result of the interaction between students' thinking and the surroundings
(3) every answer is useful
(4) an answer is either desirable/viable or undesirable/not viable
(5) there is no incorrect answer
(6) an incorrect answer is an answer in itself
(7) incorrect answers are resources for developing lesson content

Furthermore, knowledge development by learners themselves is underpinned by the fact that students do not learn by means of direct instruction, but rather build their own knowledge through experience (Hassard, 2005). Knowledge cannot be directly imparted from one individual to another (Edelson, 2001; Von Secker & Lissitz, 1999), because the knowledge structures in everyone reflect his or her unique experiences (Edelson, 2001). It is actively constructed by the learner (Von Secker & Lissitz, 1999). Furthermore, "knowledge is attained when people come together to exchange ideas, articulate their problems together from their own perspectives, and construct meanings that make sense to them" (Gordon, 2008, p. 324). Students need to interact with objects and events through their senses and engage in verbal exchange of ideas. When this interaction results in an activity with a purpose effective learning, and for that matter, knowledge development takes place (Dewey, 1916).

In this model, the teacher must first recognize (Level 1) students' correct or incorrect responses by acknowledging students' effort and accepting their answers. Acknowledging student contributions (Chin, 2006; Anderson, Rourke, Garrison, & Archer, 2001) supports student thinking in class. However, it should be noted that endorsement of students' effort after given an incorrect answer need to be professionally done in such a way that is clearly different from an endorsement of a correct answer. Teachers must be very clear on how they treat incorrect answers because to some students, take into account that students have different general and verbal intelligence levels, and learning abilities, "positive teacher response" or "endorsement" of incorrect answers in any way may imply that the answer is correct for that particular question to some students. Therefore, there should be a clear and an unambiguous strategy of treating incorrect answers to ensure that students end up not "trapped".

Recognition of students' correct or incorrect answers is followed by commending (Level 2) students' effort. The use of verbal and non-verbal means by teachers to reward students' effort sustains student engagement in the lessons. Teachers need to avoid ignoring or rejecting incorrect answers but rather use them to stimulate discussion. The "view that new knowledge must be constructed from existing knowledge" (National Research Council, 2000, p. 10) requires "that teachers need to pay attention to the incomplete understandings, the false beliefs, and the naive renditions of concepts that learners bring with them to a given subject" (ibid.).

Teachers need to use (Level 3) correct or incorrect answers after commending students' efforts. This is done through a number of ways like explaining correct answers with daily life experiences, using incorrect answers to elaborate teacher questions or lesson content, converting an incorrect answer into a question or repeating incorrect answers in a questioning way, linking student responses to lesson content, and interpreting answers. Tobin and Fraser (1990) reported that exemplary teachers involved weaker students in class and later used their answers for discussion. Furthermore, good teachers elaborate students' previous answers (Wolff-Michael, 1996), and link students' responses to lesson content.

The use of students' correct or incorrect answers is followed by probing (Level 4) student answers. Probing children's responses helps them to "recognize when they understand and when they need more information" (National Research Council, 2000, p. 12). It uncovers a student's incorrect strategy and helps teachers to clearly understand student thinking (Frank et al., 2009). It also allows students to give alternative correct answers and helps them to discover information/knowledge. Teachers need to seek information from students that will guide teaching strategy through actions such as tasking students to judge the correctness or incorrectness of student answers, asking students for the reasons behind their answers, requesting students to validate their answers; soliciting from students their understanding of the question or lesson content; and finding out about their prior knowledge. Probing or using follow-up questions tests students' ability to think about the question. If after probing, students are still unable to come out with a correct answer, then the teacher need to modify teacher response behavior.

The last stage is modifying teacher response behavior (Level 5) to students' incorrect answers or no responses through reformulation of questions, providing hints or clues, teacher initiation, and using meta-cognitive approach. Reformulation of questions is done through reframing or rephrasing questions (Tobin & Fraser, 1990; French & MacLure, 1983), asking simpler, related or previous questions; using person-centered questions (Alpert, 1987; Amos, 2002); and using gestures and sketches to ask questions. Teachers need to provide hints through explaining the question to the reach of students' verbal ability level, providing little or extra information, repeating previous answers to related questions, talking about the content of previous questions, and explaining lesson content again. Teachers can also initiate an answer with the aim of igniting student thinking in response to the question. Meta-cognitively, teachers need to help children take control of their own learning by teaching them strategies for learning and answering questions. Teaching students generalized learning to learn abilities (Glaser, 1976) will help students to be independent and creative.

5.2.6 Validity

Cook & Lincoln (1979) in Trochim & Donnely (2008) reported that "the framework of validity in the quantitative tradition involves evidence for internal validity, external validity, reliability and objectivity". However, according to Guba & Lincoln (1981), the framework of validity involve the verification of truth value or credibility (internal validity), applicability (external validity or generalization), consistency (reliability), and neutrability or confirmability (objectivity) of the data, interpretation and findings.

The interview guides were content validated by two experienced science teachers, three science education specialists, and six science education graduate students and piloted for five days in February, 2009, in Ghana before the actual data collection. Five students, two science teachers, and two head teachers were interviewed during the pilot study to ensure consistency in asking the questions, familiarity with the items, and standardizing the instrument and the process. This also enabled the researcher to get familiarized with the interview process and to refine its focus. The instruments were subsequently modified and finalized after the preliminary testing. The researcher also checked students' understanding of the items by asking them to explain the meaning in their home or functional language during the actual collection of data. The researcher used semi structured interviewing with the same format and sequence of items in order to standardize the interviewing process. The interview items, mainly open ended, were asked in the same wording to the respondents. There were no leading questions that influenced the response from the participants. Filter questions were used to know the exact stand of the respondents.

The video recording of the science lessons was entirely continuous without gaps. Completely unedited video and verbatim transcripts of the science lessons were used for the analysis to preserve the content of the classroom verbal interactions captured. All the videotaped lessons were taught in English, and were transcribed by two science teachers of basic school in Ghana. The researcher together with the two raters later viewed the science lessons to come to agreement on the spoken words by both the teacher and the students in the lesson transcripts to ensure verbatim transcription of the interaction.

In addition, four raters were involved in: identifying teachers' questions, students' answers, and teacher's evaluation remarks; categorizing data; putting the categories under themes; and the code development process. The researcher and the raters initially worked independently and later compared their analysis. The researcher, together with the raters identified agreements and disagreements, and then discussed dispassionately and in details the disagreements and agreements that occurred by chance until an agreement was reached.

The researcher also made direct classroom observation and noted events that were not captured by the video as part of the field notes. The data gathering process was also complemented by interview data from science teachers, head teachers and students. Miller and Zhou (2007) reported that individual experiences are more influential than the experience of an entire class. Furthermore, "vivid stories of personal experience are more persuasive than statistical evidence" (ibid., p. 322). Therefore, the interview data clearly expressed the true feelings and views of the participants. The researcher neither had any misperceptions of what the respondents said nor sought responses that supported preconceived notions (Cohen, Manion & Morrison, 2007). The views of the science teachers, head teachers and students were cross-checked with the video data. Questionnaires were also used to solicit for the views of the science teachers and students based on their experiences over many lessons and this was cross-checked with the interview data. This makes the findings more credible since "triangulation forces the observer to combine multiple data sources, research methods, and theoretical schemes in the inspection and analysis of behavioral specimens" (Denzin, 1971, p. 177). Furthermore, using Q analysis to put the categories into themes is analogous to cluster-analytic and factor-analytic devices used in statistical analysis (Miles & Huberman, 1994).

Furthermore, the data and the findings were taken to the sources from which they were drawn (Lincoln & Guba, 1985) to verify their truth value. The researcher and the raters also intended "to check that their findings are dependable" (Cohen, Manion, & Morrison, 2007, p. 149) because since "the purpose of qualitative research is to describe or understand the phenomenon of interest from participants' eyes, the participants are the only ones who can legitimately judge the credibility of the results" (Trochim & Donnely, 2008, p. 149). The participants responded to items on credibility (Appendix 5) and confirmed the data to be what was collected and reported that they agreed with the findings. They stated reasons such as "the report gives the information as to what happens in class during teaching, especially how teachers respond to students' correct or incorrect responses"; "the results of this project should be made available to schools in Ghana"; "I agree with the results in this report because it has really shown the kind of science teachers we said we are, and has also shown what we ought to do to improve the standard of science teaching"; and "because teachers respond in that way to students answers" (Appendix 5). They also reported that the results reflect how science teachers respond to students' answers, and declared that "this project should be encouraged to have a great impact on classroom teaching and learning of science"; "not all but most science teachers respond to students' answers as the research has shown"; and "mostly that is how teachers respond to correct, incorrect and no idea answers".

They also reported that the results of the study are applicable to other schools in the country with reasons like: "schools in Ghana use the same curriculum, same textbooks, and have little or no teaching and learning materials"; "science teachers in Ghana almost adopt similar methods of teaching and for that matter questioning"; and "we were all trained under the same umbrella in the teacher training colleges where we learnt the same methods of teaching".

Besides, the data, findings and interpretations were taken to different districts and discussed with other science teachers from different schools who did not take part in the study. These science teachers also responded to items on applicability of the findings (Appendix 6) and avowed that the findings and interpretations were what pertain in their classrooms. Some of their responses were: "I respond to questions almost the same way"; "the methods applied during their lessons are mostly applied by me when I am having a lesson with my students"; "most of the responses are used by me in my science lessons"; "I use similar techniques in my lessons" and "I can say almost all other schools (99%) in Ghana display the results filed in this report" (Appendix 6). In addition, they declared that: "from my experience most science teachers are the same including (me), and similar methods are adopted by most science teachers nationwide"; "the results of this report is a general practice of what goes on in various science classrooms in Ghana"; "what the researcher went through with the students is exactly what goes on in my school"; "the results in this report is what is happening everywhere in our education in this country, and it will help students in answering questions"; and "majority of the science teachers in Ghana respond the same as the report has shown". Furthermore, they claimed that: "that is how most science teachers respond to student answers and also it is not only science teachers alone sometimes all teachers"; "this is applicable since the same type of children are in my school and behave the same way as these pupils under the study"; "the examples of the responses are used in almost every school in Ghana"; "as stated in the report, most of the time these results from the study can be seen in my school"; and "it clearly reflects what is happening in my school". Nevertheless, two science teachers reported that "some of the science teachers' responses to students' answers differ from the report", and "it does not necessarily reflect how all teachers ask questions but most teachers in my school follow this pattern".

Although the results of this study cannot be generalized to reflect teacher response behavior of all science teachers in the country, it can be transferred to other samples within the population having similar generalizability contexts or with proximal similarity patterns (Trochim & Donnely, 2008) such as same curriculum for pre-service and in-service teacher training, comparable teacher characteristics, cultural pattern of teaching and learning, and cultural backgrounds of both teachers and students. The fact that people from different places at different times reported that they exhibit similar teacher response behaviors due to similar settings like schools having the same curriculum, and undergoing the same teacher education programs means that a proximal similarity model that relate the study context to other potential context along the gradient of similarity of place, time, people, and settings can be postulated to transfer the results of this study to other places with similar context (ibid.). This is because the measure of utility of results from a qualitative study is the transferability of the results (Marshall, 1996). Furthermore, Firestone (1993) points out that most generalizations in qualitative studies are case-to-case transfer, and sometimes analytic but not from sample-to-population.

5.2.7 Limitations of the Study

One limitation of using video to study classroom interactions is that logistical constraints did not allow the researcher to use probability sampling to cover all the regions in the country. As a result the behavior of the science teachers selected for this study show actions and teaching practices of some science teachers in selected basic schools in Ghana, and thus, cannot be generalized for the whole country.

In addition, the analysis of science lessons in video studies depends on the quality of the recording. For instance sound quality is a critical factor to consider when studying classroom processes (Jacobs et al., 2006). However, the fact that microphones were not used may have affected the sound quality and clarity. This explains why some of the verbal interactions could not be well transcribed.

It must also be noted that the scientific community uses and evaluates video differently (Goldman, 2007). According to Clark (2004) “the methodological challenge is how to document and analyze the fundamental differences in how each participant experiences any particular social (classroom) situation” (p. 1) during the investigation of classroom interactions. There are no universally established standards for collecting and evaluating video data. A major challenge in video study is the quality of the data collected since evaluation and analysis mainly depends on what has been recorded. What happens to classroom events that take place outside the camera? Classroom events that took place outside the camera could not be analyzed. For instance some student-student interaction and private talk between students could not be well captured since the student camera was principally stationary and did not cover the entire students in the classroom.

In addition, according to Erikson in Goldman (2007) just as "no one person reads a text in the same way" (p.14), "we read the video streams quite differently when we are in the process of analyzing them (ibid, p.14). This might have affected intra-rater reliability control measures carried out. It is also possible that the presence of the videographer, camcorders and accessories may have affected the behaviors of both the science teachers and the students. Certain student behavior might have been limited and others overly expressed in the study. For example, some students were shy because of the presence of the video and therefore, did not speak loud or at all, and others were over active in class. Barron (2009) reports that "although it is possible that the video camera may have influenced student behavior, it is difficult to predict in which direction".

Moreover, since science teachers teach differently depending on the science contents and concepts video recording of lessons should take place throughout the whole academic year (an academic year in Ghana is divided into three terms) to reflect the teaching of different topics in each term. However, the fact that data was collected in the first term limits analysis to the teaching of few science topics.

In addition, many other educational conditions and problems such as school organization, administration, finance, home, community believed to affect school learning were not covered in this study.

CHAPTERS 6

CONCLUSION

6.1 Science Teaching

6.1.1 Science teachers' time spent on different school activities

The organization of science teachers' time on different school activities is important in the development of science teaching. Science teachers in Ghana need to organize their time effectively on various school activities such as teaching science, meeting with other teachers to work on curriculum, planning issues, and activities related to teaching science in the school or home, and engaging in other school-related activities.

6.1.2 Science teachers' decision to select lesson content

In Ghana the decision to select lesson content by science teachers is greatly influenced by factors such as: curriculum guidelines, mandated textbooks, and external examination and standardized tests. Therefore, the content of the science syllabuses, teacher's manuals, students' textbooks and workbooks, and other reference materials need to be carefully selected by authors in consultation with the Curriculum Research and Development Division (CRDD) in Ghana, Ghana Education Service, experienced science teachers, policy formulators and implementers, retired educationists, and science teachers in the colleges of education and the universities to ensure appropriateness and adequacy.

In addition, the B.E.C.E. questions should have a high content of questions that elicit understanding, application, analysis and evaluation of factual, conceptual and experimental knowledge. The questions need to also draw out students' experiential knowledge.

6.1.3 Background information of the science teachers

Many of the science teachers in this study in Ghana went through a 3-Year Post Secondary Teacher Training College education where the curriculum is designed to train students to be able to teach all subjects in the basic schools. They had an overall average teaching experience of six years, and were exposed to professional development opportunities.

The science teachers learning goals were focused on knowing science information which was followed by awareness of the usefulness of science in life. However, they placed the least emphasis on the understanding of scientific ideas and doing science. But, understanding scientific ideas, concepts, and the nature of science is the cornerstone for making use scientific knowledge. Therefore, science teachers need to focus science teaching on knowing and understanding science, doing science through inquiry, laboratory work, experimental work, hands-on activities, minds-on experiences, and the contexts of science like awareness of the usefulness of science in life, collaborative work in groups, and independent work.

The science teachers teach in an environment where the students usually wear uniforms and have textbooks and notebooks. Lessons are conducted in a regular classroom with a blackboard and limited commercial and natural products.

The science teachers in this study in Ghana have positive attitudes towards professional development, teaching science, encouraging boys and girls and students of different ability levels, and are satisfied with their students' thinking processes. They are of the view that their work is appreciated by society by society and have enough opportunities at school to collaborate with colleagues about science. However, they reported that they spend a small amount of time (3 hours) in a week on curriculum and planning issues. Therefore, science teachers need to spend more time in a school day to make use of the opportunities they have to collaborate with their colleagues about science teaching. In view of this, the Ghana Education Service needs to define the school day for a teacher to be from 8 a.m. to 5 p.m. to enable teachers have more time to work on curriculum and planning issues.

6.1.4 Instructional organization of lesson time

Science teachers spend most of their time on science instruction, whole class work, seatwork activities, teacher presentation, developing new content, and public talk. There is very little time spent on non-science, science organization, independent work, practical activities, discussion, assessment procedures, reviewing previous content.

The science teachers in this study mainly developed life sciences and addressed canonical and real life issues. They developed science content primarily by making connections through inquiry and unidentified approaches. They did not make connections through applications. Most of the learning content had weak or no conceptual links. Only a small number of the learning contents were strongly linked to concepts. Procedural and experimental knowledge, and classroom safety knowledge were rarely addressed in the lessons.

Furthermore, whereas many of the science lessons had goal statements, only few of the lessons had summary statements. Many of the lessons in this study contained basic content with a few challenging content. In addition, very few of the lessons incorporated first-hand data and phenomenon but slightly more than half of the lessons incorporated visual representations. These were either diagrams or other visual representations.

A smaller percentage of the lessons supported all main ideas with more than one set of first-hand data, phenomenon, and visual representation. Furthermore, the science teachers rarely used multiple types of evidence that is first-hand data, phenomenon, and visual representations, to support all main ideas. They also rarely included independent work on graphs, diagrams and mathematical calculation.

But the aforementioned instructional activities in unison contribute towards achieving quality teaching and learning. Therefore, lesson time need to be appropriately organized for effective science teaching.

6.2 Classroom Discussion and Contexts

6.2.1 Students' cognitive involvement in classroom discussion

Generally, the development of scientific knowledge in students depends on students' cognitive involvement in science lessons, especially, classroom discussion where the students have the chance to express their ideas. The expression of students' ideas and views will be meaningful when students are able to demonstrate reasoning and pose questions to their colleagues and teacher.

However, students' answers to teacher questions in this study were mainly a demonstration of knowledge, Yes or No responses that are teacher-led, and non-verbal non-physical responses indicating a low cognitive involvement in classroom discussion. Therefore, science teachers need to elicit student responses that demonstrate reasoning in classroom discussion. Teacher questions that require students to think and stimulate students to pose questions to the teacher and colleague students would raise the level of students' cognitive involvement in class.

6.2.2 Knowledge and cognitive dimensions in teacher questions and students' answers

In this study, procedural and meta-cognitive knowledge are rarely developed during science lessons. Furthermore, the science teachers place greater emphasis on eliciting factual knowledge rather than conceptual, procedural and meta-cognitive knowledge. Besides, they stress recall and play down higher order cognitive processes. Thus, most of the students' answers were directed at recall of knowledge. Furthermore, high order questions or statements generally elicited a low response rate from students. Teacher questions and/or statements need to equally emphasize all cognitive processes, and directed at eliciting factual, conceptual, procedural information, in addition to the exploration of meta-cognitive knowledge dimension.

6.2.3 Teacher intentions behind questions

The intentions behind teacher questions determine the kind of teacher questions posed to students and the nature of the corresponding answer or response from students. Teacher intentions revealed in this study that checks students' focus/attention in lessons and students' prior knowledge will limit the development of scientific knowledge during classroom discussion.

Students' procedural and experimental knowledge, students' understanding, and eliciting student thinking teacher intentions need to be promoted during classroom discussion. These teacher intentions will empower students to freely engage in classroom discussion to share their ideas about scientific knowledge.

6.2.4 Teacher response behavior

(a) Teacher response behavior to students' correct answers, incorrect answers and no responses, and student feeling

Teacher responses to students' answers and no responses were encouraging, using, judging, finding out, rejecting, ignoring, and discomforting response behaviors. Encouraging response behaviors are actions that motivate students to respond to teacher questions. Using and judging response behaviors are using students' responses to develop the lesson, and probing responses to evaluate them respectively. Finding out response behaviors are probing for information that will guide teaching strategy and help students to develop knowledge. Rejecting, ignoring and discomforting teacher response behaviors are not accepting students' responses, not passing a comment on students' responses or telling the student to sit down, and physical actions that do not make a student comfortable in that order.

Generally, the students mainly felt discouraged and sometimes encouraged. They also reported that students' feeling depends on the nature of teacher response behaviors to students' incorrect answers or no responses. Science teachers are required to factor students' feelings and be sympathetic in responding to students' answers.

(b) Causes of students' no responses

The causes of students' no responses to teacher questions were put under three main themes namely, student factors, teacher factors and psycho-social or home based factors. The student factors were aptitude, characteristics, thinking or having no idea about the answer, and verbal intelligence, and the teacher factors were teaching strategy (unclear question/lesson content) and teacher response behavior to students' answers or no responses. Psycho-social based factors reported were the social background or home, extra-curricular activity, class behavior and shyness.

(c) Factors that influence classroom discussion

Self-confidence, self-learning and shy-timidity emerged as the factors that influence classroom discussion. Teacher response behaviors that promote shy-timidity are mainly practiced by science teachers in this study in Ghana. This makes students inactive during classroom discussion and limits the development of scientific literacy.

Therefore, teacher response behaviors that build self-confidence and self-learning in students need to be promoted in class. Science teachers should engage in response behaviors that stimulate students to take active part in classroom discussion and freely share their ideas and experiences.

(d) Participants' views about science teaching, classroom discussion and contexts

Educational management and administration, teaching strategy and attitudes about teaching, and students' attitudes towards learning emerged from the views of the participants as influencing science teaching, classroom discussion and contexts. This means that improving science teaching, classroom discussion and contexts will call for active contributions from educational managers (head teachers, district and regional educational managers, Director-General of Ghana Education Service and the Minister of Education, Ghana), science teachers and students. For example, the educational managers need to ensure effective instructional management by proving: adequate and appropriate teaching and learning support materials; adequate and well trained teachers; and regular school-based in-service training opportunities. They need to put in mechanisms to have effective school-community relations, and administrative, personnel, school building and facilities, and financial management. They should also ensure that the CRDD develops effective curriculum materials.

The science teachers need to also use effective teaching methods and approaches to ensure that students understand lesson content and organize lesson time in such a way as to cover adequate content. In addition, they should use appropriate teacher response behavior to students' answers and no responses, and have positive attitudes about teaching and learning. They need to also organize practical work and engage students in interesting classroom activities, and use vocabulary that is understood by the students.

The students need to also devote quality time to studying and pay close attention in class. Paying close attention in class will help them to concentrate deeply in lesson. A high student concentration power during lessons could be linked to high learning outcomes since students will absorb and understand the lesson content. Students should also feel free to ask questions in class when they do not understand lesson content or teacher questions and want to clarify their understandings.

(e) <u>Appropriate teacher response behavior</u>

A Teacher Response Model (TRM) for managing students' answers to teacher questions, guided by teacher response behaviors that promote self-confidence and self-learning in students, is recommended as appropriate for classroom teachers. This model is based on the conception that every answer (correct or incorrect) is a useful tool for developing lesson content. TRM has five levels. Levels 1, 2 and 3 require that teachers recognize, commend, and use students' correct and incorrect answers as valuable contributions in developing lesson content. Level 4 allows teachers to strategically probe students' answers, and level 5 calls for teachers to modify teacher response behavior or be flexible in responding to students' incorrect answers or no responses.

6.3 Conclusion

(a) Science Teaching

The study revealed that science teachers in Ghana: spend a small amount of time on all teaching and other school related activities; mainly possess a 3-Year Post Secondary TTC Cert A; have professional development experience; mainly focus learning goals on knowing science information; have positive attitudes about teaching; and have limited access to available teaching and learning resources. Furthermore, curriculum guidelines, mandated textbooks and external examination influence science teachers' decision to select lesson content, and the science teachers do not organize lesson time for effective classroom practices.

The government and the stakeholders in education need to address these factors in productive ways, manage science education effectively, and capacitate science teachers in every district by either supporting programs or acquiring resources aimed at improving the quality of science teaching.

(b) Classroom Discussion and Contexts

Science teachers stressed recall of factual knowledge rather than eliciting high order cognitive processes and conceptual, procedural and meta-cognitive knowledge dimensions. The quality of students' answers and thinking to some extent is a reflection of teacher questions, so cognitive processes and the various knowledge dimensions need to be equally weighted during classroom discussion. Furthermore, teacher questions depend on teacher intentions behind the questions. Therefore, the intentions behind questions are linked to the type of questions used by science teachers which in turn will determine the level of students' cognitive involvement in classroom discussions.

In this study, teacher response behavior to students' answers and no responses are encouraging, using, judging, finding out, rejecting, ignoring, and discomforting response behaviors. The students generally felt discouraged after teachers respond to their incorrect answers. Self-confidence, self-learning and shy-timidity were identified as factors that influence classroom discussion.

Teacher response behaviors to students' incorrect answers that lead to shy-timidity among students are mainly practiced by the science teachers in this study in Ghana. Usually, science teachers only require mere correct answers, reject or ignore incorrect answers, and sometimes engage in actions that make students uncomfortable. These lead to low involvement of students in classroom discussion. On the other hand, teacher response behaviors that nurture self-confidence and self-learning among students seem to be more important, but are lowly practiced among Ghanaian science teachers in this study. Self-confidence and self-learning traits in students will empower them to easily and freely share their ideas during classroom discussion. Consequently, science teachers need to engage in response behaviors that promote self-confidence and self-learning in students, and avoid those that breed shy-timidity. They need to understand students' answers, especially, incorrect ones, the reasons behind these answers, what the meanings of the answers are to the students, and use them as a resource to develop lesson content. Therefore, TRM is recommended for managing students' answers.

The goals of science education in Ghana will be affected by factors that promote shy-timidity. When students are shy and timid they recoil into their shells in class and either do not participate in classroom activities at all or passively take part in them. This may lead to a low interest in classroom activities and schooling in general with a possible consequence of dropping out from school, and invariably have a negative effect on the development of scientific literacy and culture among the students and their capabilities to deal with challenges in their everyday life activities. Furthermore, a low development of scientific literacy and culture coupled with school dropouts would affect the quality and number of competent professionals to carry out research and development at the highest level.

However, factors that enhance self-confidence and self-learning would promote the realization of the goals of science education in Ghana. Students are motivated when their efforts are appreciated, recognized, commended, used and probed. This deepens their interest in learning and schooling, and develops their thinking ability. School-age children will tend to complete their schooling and climb the education ladder. Science teachers need to promote factors that develop self-confidence and self-learning in school-age children.

Therefore, these findings would help science teachers to innovate the culture of science teaching in Ghana from teacher presentation of facts to a more active verbal interaction and engagement of students since students minds are not empty vessels to be filled but fire to be ignited. Thus, science teachers need to tap what is in the minds of students because “the empires of the future are the empires of the mind “(Winston Churchill).

6.4 Recommendations

6.4.1 Pre-service and in-service professional development

This study recommends that pre-service and in-service professional development need to focus on clear explanation of lesson content, teacher response behavior to students’ answers and no responses, and teaching students from different cultural backgrounds and with limited proficiency in English language.

Science teachers need to clearly explain lesson content to the ability level of every student in the class. This can be done by making very strong impressions of lesson content on students’ mind and through association of lesson content with multiple types of evidence. For example, science teachers need to restate important ideas in different ways to allow students with different aptitudes to form vivid impressions of the main ideas. This is a way of repeating lesson content to reinforce student understanding and also to ensure that every student understand the lesson content. Furthermore, the science teachers need to appeal to the sense of sight through the use of diagrams, sketches, charts, and concrete teaching and learning support materials. This will allow students to learn through association and concretize their understanding of lesson content. It is easy for students to associate lesson content with a concrete image than to associate lesson content with an abstract image as is with the case when teachers teach in abstract. In addition, science teachers need to support main ideas with at least more than one piece of visual representation, phenomena, and first-hand data (multiple types of evidence). Examples of visual representations are using 3-dimensional models, graphic organizers, formula, diagrams, and computer simulations. The use of multiple types of evidence helps students to easily associate lesson content with concrete images.

The understanding of lesson content by students also depends on teacher response behavior to students’ answers and no responses. This is because teacher response behavior that promotes shy-timidity among students will deter them from answering teacher questions. The teacher will have very little feedback or none from the students to guide teaching and to know whether students understand the lesson content or not. However, teacher response behavior that builds self-confidence and self-learning in students will motivate students to be expressive in class.

Consequently, students will freely answer teacher questions which will be a resource for teachers to diagnose students' weaknesses and to know students' understanding levels to guide teaching. In this regard, the study recommends Teacher Response Model to be part of the content of professional development to improve science teaching, classroom discussion and contexts.

This study also recommends that science teachers need to be trained to understand the cultural, linguistic, and academic backgrounds of students and how to use this information as a resource for teaching. Ghana is a country that is defined by many tribes so science teachers are dealing with students from a diverse environment. They need to consider the background of students, especially, proficiency in English in science teaching. Therefore, science teachers need to be trained in how to teach in such an environment by using the functional language to make lesson content and teacher questions clearer to students, and at the same time afford students the opportunity to clearly express their ideas in class.

6.4.2 Local association of science teachers

It is also recommended that there should be a formation of an association of science teachers in the locality of junior high schools in all the districts across Ghana. This association can meet once every month to discuss about science teaching, classroom discussion and contexts. In addition, the science teachers need to engage in research in science teaching at the grassroots level through collaboration with the universities and the colleges of education. It is time a Ghanaian science teachers' journal is launched to communicate the research findings in science teaching in the junior high schools across the country.

6.5 Future Studies

1. Comparative study of teacher response behavior using TIMSS 1999 publicly released video of science lessons
2. Development of a teacher response behavior manual for science teachers in Ghana
3. Investigating the views of science teachers about Teacher Response Model in Ghana

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Appendices

Appendix 1: Modified TIMSS 1999 video study science teacher questionnaire items

TIMSS item		Slightly modified TIMSS item/Item used in Ghana	
1a	What was your undergraduate major field of study?	1c	What was your major field of study in the Teacher Training College?
1b	What was your major field of study at post graduate level?		
3a	During the last two years, how many university courses have you taken in science or science education?	3b	During the last two years, how many university courses have you taken in science or education?
4a	During the last two years, have you participated in professional development activities or taken courses in any of the following?	4b	Have you participated in professional development activities or taken courses since you started teaching in any of the following?
5a	Which of the following played a role in your decision to teach this content?	5b	Which of the following played a role in your decision to teach this content? The option of one of the items focusing on the factors that influence the teacher's decision to select lesson content was changed from 'national, state, or school curriculum guidelines' to 'national curriculum guidelines', and the option 'Basic Education Certificate of Education past questions' was added to the other options for the same item.

Appendix 2: Interview Schedule for Science Teachers

Demographic and Background Information

Take note of the following

- Date: __________________________
- Time: __________________________
- Place: ____
- Interviewee's name: ____
- Position: ____
- Highest educational background
  (Take note of science teacher with both teacher training college and university experience):

  ____

  ____
- When did you first start teaching? ____
- Which town(s) and school(s) have you been posted to teach since then?

  ____

  ____
- Please specify the type of school? ____
- Take note of any special conditions that may affect the interview:

  ____

  ____

Section A

- My name is Chris Beccles, and I am a student of Hiroshima University pursuing my doctoral degree
- Thank you for allowing me to conduct this study
- The study is aimed at identifying teacher behaviors that are best for handling incorrect answers, no idea or I don't know responses and no response by learners in science lessons. This will isolate both good and bad practices of handling such utterances, and recommend teacher behaviors that are best for promoting classroom discourse. (Bring some written material to leave at the end for that purpose. Provide a twenty-five words or less description).
- The purpose of this interview is to find out how your teacher responds to your answers, specifically incorrect answers, "no idea" or "I don't know" responses, and when a pupil called upon to answer a question does not respond at all in class
- I assure you that you are being interviewed confidentially, and that your participation is voluntary.

Section B

Part I

1. Do your students like asking questions in class?

____

2. Why do your students like asking question? (Why don't they like asking questions?)

____

3. Do your students like answering questions in class?

____

4. Why do your students like answering questions in class?(Why don't they like answering questions in class?)

____

5. How do you respond to correct answers from your students?

____

6. How does a student feel after your response to a correct answer?

____

7. Are your students' answers always correct?

____

8. How does a student feel when he/she gives a wrong answer to a question?

____

9. How do you respond to a wrong answer from a student?

____

10. How does a student feel when you respond to a wrong answer from him/her?

____

11. How do you respond to a "No Idea" or "I Don't Know" response from a student?

____

12. How does a student feel when you respond to a "No Idea" or "I Don't Know" response from him/her?

____

13. How do you respond to a student when he/she does not give an answer to a question?

____

14. How does a student feel after your response when he/she does not give an answer to a question?

____

15. What do you think prevents the student from talking?
(What prevents the student from not giving an answer to the question?)

____

Part II

16. Which teacher behaviors are best for handling wrong answers in class?

____

17. Which teacher behaviors are best for handling "No Idea" or I Don't Know" responses in class?

____

18. Which teacher behaviors are best for handling students who do not provide a response to a question in class? (Those who do not talk when called upon to answer a question)

____

19. Which teacher behaviors are best for encouraging inactive learners to answer questions in class? (Those who do not take active part in lessons)

____

20. Which teacher behaviors are best for controlling learners who try to answer every question in class even without the teacher calling them?

____

21. Which teacher behaviors are best for handling absurd/foolish answers from students or answers intended to cause amusement?

____

22. Do you have any other comments/ideas/topics you would like to talk about?

____

<u>Section C</u>

Please check the quotations, to make sure they are exactly the way you said them
Ask permission to use the quotes if the need arises
Thank you very much for participating in this study.
May I contact you if there is the need to clarify any other point or ask additional questions?
I will send you a copy of the final results at the end of the study

<u>Remarks</u>

Comments and observations
Write notes after interview that detail your feelings, interpretations and other comments

Appendix 3: Interview Schedule for Students

Demographic and Background Information

Take note of the following

- Date: ____________________________
- Time: ____________________________
- Place: ____
- Interviewee's name: ____
- Position: ____
- Class/Grade: _________________________
- Age: _________________________________
- Take note of any special conditions that may affect the interview:

____

____

Section A

- My name is Chris Beccles, and I am a student of Hiroshima University pursuing my doctoral degree
- Thank you for allowing me to conduct this study
- The study is aimed at identifying teacher behaviors that are best for handling incorrect answers, no idea or I don't know responses and no response by learners in science lessons. This will isolate both good and bad practices of handling such utterances, and recommend teacher behaviors that are best for promoting classroom discourse (Bring some written material to leave at the end for that purpose. Provide a twenty-five words or less description)
- The purpose of this interview is to find out how your teacher responds to your answers, specifically incorrect answers, "no idea" or "I don't know" responses, and when a pupil called upon to answer a question does not respond at all in class
- I assure you that you are being interviewed confidentially, and that your participation is voluntary.

Section B

Part I

1. Do you like asking questions in class?

   ____

2. Why do you like asking question? (Why don't you like asking questions?)

   ____

3. Do you like answering questions in class?

   ____

4. Why do you like answering questions in class? (Why don't you like answering questions in class?)

   ____

5. How does your teacher respond to a correct answer from you?

   ____

6. How do you feel after your teacher's response to a correct answer from you?

   ____

7. Are your answers always correct?

   ____

8. How do you feel when your answer is wrong?

   ____

9. How does your teacher respond to your wrong answer?

____

10. How do you feel after your teacher's response to your wrong answer?

____

11. How does your teacher respond to "No Idea" or "I Don't Know" response from you?

____

12. How do you feel after your teacher's response to "No Idea" or "I Don't Know" response from you?

____

13. How does your teacher respond to you when you don't give an answer to a question? (When you do not talk)

____

14. How do you feel after your teacher's response when you don't give an answer to a question?

____

15. What prevents you from talking? (What prevents you from not giving an answer to the question?)

____

Part II

16. How would you like your teacher to respond to wrong answers in class?

____

17. How would you like your teacher to respond to "No Idea" or "I Don't Know" response in class?

____

18. How would you like your teacher to respond when you are not able to give an answer to a question? (When you do not talk when called upon to answer a question)

____

19. How can your teacher encourage inactive learners to answer questions in class? (Those who do not take active part in lessons)

____

20. How can your teacher control learners who try to answer every question in class even without the teacher calling them to respond?

____

21. How would you like your teacher to treat absurd/foolish answers from students or answers intended to cause amusement?

____

22. Do you have other ideas to share?

____

Section C

Please check the quotations, to make sure they are exactly the way you said them
Ask permission to use the quotes if the need arises
Thank you very much for participating in this study.
May I contact you if there is the need to clarify any other point or ask additional questions?
I will send you a copy of the final results at the end of the study

Remarks

Comments and observations
Write notes after interview that detail your feelings, interpretations and other comments

Appendix 4: Interview Schedule Head Teachers

Demographic and Background Information

Take note of the following

- Date: ___________________________
- Time: ___________________________
- Place: ____
- Interviewee's name: ____
- Position: ____
- Highest educational background:
  (Take note of science teacher with both teacher training college and university experience):

  ____

  ____
- When did you first start teaching? ____
- Which town(s) and school(s) have you been posted to teach/head since then?

  ____

  ____
- Please specify the type of school? ____
- Take note of any special conditions that may affect the interview:

  ____

  ____

Section A

- My name is Chris Beccles, and I am a student of Hiroshima University pursuing my doctoral degree
- Thank you for allowing me to conduct this study
- The study is aimed at identifying teacher behaviors that are best for handling incorrect answers, no idea or I don't know responses and no response by learners in science lessons. This will isolate both good and bad practices of handling such utterances, and recommend teacher behaviors that are best for promoting classroom discourse (Bring some written material to leave at the end for that purpose. Provide a twenty-five words or less description)
- The purpose of this interview is to find out how your teacher responds to your answers, specifically incorrect answers, "no idea" or "I don't know" responses, and when a pupil called upon to answer a question does not respond at all in class
- I assure you that you are being interviewed confidentially, and that your participation is voluntary.

Section B

Part I

1. How many times do you observe lessons in a month?

____

2. How many times do you observe science lessons in a month?

____

3. How many minutes do you normally spend during science lesson observation?

____

4. How often do your teachers observe a colleague teacher teaching an entire science lesson?

____

5. How often does the circuit supervisor observe lessons in your school?

____

Part II

6. Which teacher behaviors are best for handling wrong answers in class?

____

7. Which teacher behaviors are best for handling “No Idea” or I Don’t Know” responses in class?

____

8. Which teacher behaviors are best for handling students who do not provide a response to a question in class? (Those who do not talk when called upon to answer a question)

____

9. Which teacher behaviors are best for encouraging inactive learners to answer questions in class? (Those who do not take active part in lessons)

____

10. Which teacher behaviors are best for controlling learners who try to answer every question in class even without the teacher calling them?

____

11. Which teacher behaviors are best for handling absurd/foolish answers from students or answers intended to cause amusement?

____

12. Do you have any other comments/ideas/topics you would like to talk about?

____

Section C

Please check the quotations, to make sure they are exactly the way you said them
Ask permission to use the quotes if the need arises
Thank you very much for participating in this study.
May I contact you if there is the need to clarify any other point or ask additional questions?
I will send you a copy of the final results at the end of the study

Remarks

Comments and observations
Write notes after interview that detail your feelings, interpretations and other comments

Appendix 5: Videotape Classroom Study in Ghana

Thank you for participating in this study, and for your careful attention to this report. Kindly respond to the following questions after reading through the report by placing a tick (✔) in the appropriate *box* (☐), and giving your comments in the lines/spaces provided.

1. Do you agree with the results in this report?
   ☐ Yes
   ☐ No

   Please give your comments.

____

____

____

____

2. Does the report reflect how science teachers respond to students' answers?
   ☐ Yes
   ☐ No

   Please give your comments.

____

____

____

____

3. Do you think the results of the study could be applicable to other schools in Ghana?
   ☐ Yes
   ☐ No

   Please give your comments.

____

____

____

____

Responses from five science teachers who took part in the study

Teacher code	Do you agree with the results in this report?	Does the report reflect how science teachers respond to students' answers?	Do you think the results of the study could be applicable to other schools in Ghana?
1	Yes; results of this project should be made available to all schools in Ghana	Yes; this project should be encouraged to have a great impact in classroom teaching and learning of science	Yes; since the project was performed in Ghana, teachers in Ghana should be made aware of the impact of response to questions by children on classroom learning
2	Yes; based on the sample used, I do agree with the results in this report	Yes; basically every teacher responds to answers given by students in class but it is up to the teacher to use a response that will encourage the students to learn	Yes; majority, about 90% of schools in Ghana, since all science teachers in Ghana almost adopt similar methods of teaching and for that matter questioning
3	Yes: I agree with the results in this report because it has really shown the kind of science teachers we said we are and has also shown what we out to do to improve the standard of science teaching particularly, in central region, and Ghana at large	Yes; not all but most science teachers respond to students' answers as the research has shown. I also believe that teachers in the field of science will emulate the style of developed country's style of teaching the science	Yes; I do believe that the results of this study could be applicable to other schools in Ghana. The reason being that we were all trained under the same umbrella, Training Colleges, where we learnt the same methods of teaching. But the nature of this work, especially, when it comes to salaries does not encourage actually teachers to give out their best. I also believe that if the Ghanaian teachers should be paid like the developed counties teachers do, they can deliver to the degree or the level of the methods used by our developed counterpart teachers in the field of science
4	Yes; the report gives the information as to what happens in class during teaching, especially, how teachers respond to students' CR or IR	Yes; because science deals with more factual words and very technical ones for that matter. Therefore, teachers always come in to help pronounce correctly	Yes; because all schools in Ghana use the same curriculum, same textbooks and no or little teaching and learning materials
5	Yes; because teachers respond in that way to students' questions	Yes; mostly, that is how teachers respond to correct, incorrect and no idea answers	Yes; it will help students to be outspoken , self-confident and remove timidity

Appendix 6: Videotape Classroom Study in Ghana

Thank you for your careful attention to this report. Kindly respond to the following questions after reading through the report by placing a tick (✔) in the appropriate *box* (☐), and giving your comments in the lines/spaces provided.

1. Do you agree with the results in this report? ☐ Yes ☐ No

   Please give your comments.

   ____

   ____

   ____

2. Does the report reflect how science teachers respond to students' answers? ☐ Yes ☐ No

   Please give your comments.

   ____

   ____

   ____

3. Do you think the results of the study are applicable to your school? ☐ Yes ☐ No

   Please give your comments.

   ____

   ____

   ____

4. Do you think the results of the study could be applicable to other schools in Ghana? ☐ Yes ☐ No

   Please give your comments.

   ____

Responses from 16 science teachers in different districts who did not take part in the study

Teacher code	Do you agree with the results in this report?	Does the report reflect how science teachers respond to students' answers?	Do you think the results of the study are applicable to your school?	Do you think the results of the study could be applicable to other schools in Ghana?
1	Strongly agree because I use similar methods in my lessons	I respond to questions almost the same way	Because I use similar techniques in my lessons	Because science teachers use similar methods in their lessons
2	The behavioral pattern of students and their ability groupings normally determines the kind of teacher response	Students who are always attentive in class will receive encouraging response and vice versa	Teachers who will want to achieve the lesson's objectives within specified periods will not comment on incorrect responses of students	To ensure completion of the syllabus, on the part of teachers and promotion of analytical thinking on the part of students
3	The results of this report is a general practice of what goes on in various science classrooms in Ghana	This is how science teachers respond to answers given by students especially when they are inexperienced on the field	We have a teacher who is more experienced in the teaching of science but since sometimes may be handicapped in some areas, such things sometimes may occur	Because most of the schools in Ghana do not have the science resources to enhance the teaching and learning of the subject leading to the teachers inadequate preparation before lesson delivery
4	I do agree with the results filed in this report	Most times; it reflects how science teachers respond to answers from students	As stated above, most of the time these results from the study can be seen in my school	I can say almost all other schools (99%) in Ghana display the results filed in this report
5	The results of this study is acceptable because it was obtained through an action research	In most cases when a child gives a correct response the teacher must not repeat but has to write it on the chalkboard	It does not necessarily reflect how all teachers ask questions but most teachers in my school follow this pattern	This research is really applicable in almost all schools in Ghana, especially, in all private schools where most teachers are not professionals
6	It is quite true that the response to students' answers may encourage or discourage the student in answering another question and even in their studies	Yes, the report definitely does but these usually happen because science is sometimes dogmatic and has rules to be followed. These make the teachers to reject or ignore students' answers	In most cases some of the things or studies in science especially diffractions are usually definite and students must produce them as such	From my experience most science teachers are the same including (me). Similar methods are adopted by most science teachers nation wide

7	This is because what the researcher went through with the students is exactly what goes on in my school	Science teachers respond pupils' answers as reported by the researcher	This is applicable since the same type of children are in my school and behave the same way as these pupils under the study	This is because we don't have trained in my school in Ghana teaching. Some of the teachers may be pupil teachers
8	The methods applied during their lessons are mostly applied by me when I am having a lesson with my students	Because most of the response are used by me in my science lessons	How my students feel after my response to their answers whether correct response, incorrect response or no response are all observed in your report of study	The results reflects on the interaction which normally happens between students and science teachers during science lessons
9	The results in this report is what is happening everywhere in our education in this country, and it will help students in answering questions	Because that is how most science teachers respond to student answers and also it is not only science teachers alone sometimes to all teachers	Because the science teachers in our school comes in to answer questions when a student is not able to answer or give correct answer	Because the results will be helpful…
10	Science as you know is full of activities for these reasons teachers need to involve the children through questioning and answers	Science teachers asks questions calls pupils for answers, a correct answer is re-emphasized by the teacher	It is really applicable here in my school because this is how teachers, science teachers for that matter respond to pupils answers	It could be applicable because this is a very good way for asking questions and answering them. This helps for better understanding of the subject
11	The report is the true reflection of the effective teaching of science	When students answer questions correctly the other students are made to clap for such students who answer correctly	Science is all about discovering	Since all schools are examined by one examining body, yes
12	Teachers response towards students sometimes promote learning and also retard learning when the incorrect answers were not responded to	Teachers normally encourage students who give correct answers to questions and discourage the incorrect answers from students	Students who give correct answers to their teachers questions are being motivated and they are the students who normally pass the subject at the expense of those who give incorrect answers	Because if the teachers study the results critically and change their way of discouraging other students who answer the questions wrongly and encourage all students, the subject will become interesting to all students and they will all pass

13	Majority of the science teachers in Ghana respond the same as the report has shown	Some of the science teachers respond to students answers differ from the report	-	The results of the study show exactly many science teachers response to student answers
14	Teachers respond towards students correct or incorrect answer in one way or the other motivate them	It is not all the ways teachers are able to handle students incorrect answers appropriately	when students answers are handled in the right order, it encourages learning	Science teachers in Ghana at times handle students answers in the wrong way and they should find the best way in handling students answers in order to instill intrinsic motivation in them
15	Science is an activity oriented subject. Teachers have to take into consideration the total development of the students	Based on the relevant previous knowledge of the students, the students is guided to do the right thing	Due to the training the science teachers receive from training all the methodology applicable to effective teaching of science is considered	Since all schools in Ghana are examined by one examining body (WAEC) the results could be applicable to other schools in Ghana
16	It clearly shows what is happening in various schools in Ghana	The examples of the responses are used in almost every school in Ghana	It clearly reflects what is happening in my school	The same responses could have been arrived at in my school also