Classroom discourse with both student-led questions and feedback: Enhancing engagement and attainment of students in a Learner-centred Key Stage 3 science classroom

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DECLARATION

"I certify that this work has not been accepted in substance for any degree, and is not concurrently being submitted for any degree other than that of Doctorate in Education being studied at the University of Greenwich. I also declare that this work is the result of my own investigations except where otherwise identified by references and that I have not plagiarised the work of others"

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SIGNATURE (SUPERVISOR) ………………… DATE ……………

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ABSTRACT

This study focuses on the use of student-led questions and feedback to improve students' engagement and attainment in Key Stage 3 science. My interest in Assessment for Learning has arisen from working as a science teacher for over 9 years in several secondary schools in London and Kent. My aim has been to support Key Stage 3 science students to improve their engagement and attainment by means other than the use of science practical. The purpose of this study is to find out how students' awareness of questions and feedback can be used to improve their engagement. This includes examining students' contribution to the classroom discourse through developing their own questions and giving peer feedback, and assessing how this has improved their attainment. This study also sought teachers' perceptions on the role of questions and feedback in engaging students in science lessons.

This mixed methods study was inspired by a constructivist paradigm approach to learning (Creswell 2011; Savasci and Berlin, 2012). The study used six techniques of enquiry for data collection to support triangulation of my data. The students were involved in problem solving activities which led to developing their own questions using Bloom's taxonomy question prompts and giving feedback to other students. The interaction was audio recorded to examine the quality of questions and feedback in order to ascertain how this has led to an improvement in their engagement and attainment, in addition to other data collection methods used.

This study found that students were capable of developing high level questions and giving constructive feedback that will move other students' learning forward just like their teachers aim to do. There was an improvement in the high level questions developed which influenced the quality of feedback given to other students. 98% of the students were engaged in the questions and feedback which contributed to over 92% of the students achieving their target levels in the end of unit science test. These outcomes are contributions to knowledge. Other contributions to knowledge include the new model of discourse presented in this thesis, and two factors that constitute engagement in learning. Pupil voice was a dominant factor as students were in charge of the classroom discourse which was encouraged by the questions and feedback. Some recommendations are made for professional practice and further research.

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GLOSSARY OF TERMS

AfL	Assessment for learning
APP	Assessing Pupils' Progress
BEIP	Bexley Education Improvement Partnership
DCSF	Department for Children, Schools and Families
DFES	Department for Education and Skills
HSW	How Science Works
IRE	Initiation, Response and Evaluation
I-R-P-R-P-R-E	Initiation, Response, Prompts, Response, Prompts, Response and Evaluation
NoS	Nature of Science
OFSTED	Office for Standards in Education
TES	Times Educational Supplement

SI-SR-SP-SR-SP-SR-SP-SP-SP-SR-SP-SR-SP-SR-SE, where SI represents Student Initiation, SR is Student Response, SP is Student Probing and SE, Student Evaluation.

Definition of Key terms used

Learner-centred: this is a learning environment that attend to and make use of what students bring to the classroom learning situation.

Formative assessment: concerned about how the judgements about the quality of student responses (performance, pieces of work, feedback) can be used to shape and improve the students' competence. It provide informative feedback to teachers and students about the progress being made by students. It can be referred to as Assessment for Learning.

Assessment for Learning: the process of seeking and interpreting evidence for use by learners and their teachers to decide where the learners are in their learning, where they need to go and how best to get there.

Summative assessment: concerned with summing up or summarizing the achievement status of students e.g. end of unit test used in this study. It can be referred to as Assessment of Learning.

Assessment as Learning: is the development of personalised learning agenda. It is associated with metacognition and helps the learner to take more responsibility for their learning.

Interest: this is a student's repeated engagement or focused attention on an object/tasks and can be determined by their interactions.

Engagement: activities that students are carrying out in order to sustain their interests in the tasks. Engagement can be determined by the time spent on tasks e.g. questions and feedback used in this study, students' willingness to be involved in their own assessments, ability to create a supportive environment to improve students' learning.

Active learning: involves students listening and contributing to classroom discourse in science lessons.

Thinking skills: activities created to enable students to apply their thinking to the tasks for example, presenting reasons for alternative solutions, expressing their own views and state examples where reasoning is important in everyday life.

Metacognition: opportunity created to enable students to give extended explanations or justifications. It prompt them to state why they have reached a conclusion or hold a particular opinion. It is thinking about thinking.

Personalised learning: assessment process that is flexible and tailored to address the needs of pupils. This is differentiated so that all pupils can be involved and make progress in their learning.

Independent learning: ability of the students involved to lead their own learning and assessments which includes finding information for the problem solving tasks, supporting each other. Although the process is facilitated by the teacher

Students' funds of knowledge: constitutes knowledge gained on their experiences outside school which would enable them to contribute to their knowledge construction to enhance their learning and attainment.

Autonomy: students given opportunity to lead their learning and decide assessment process for example, choosing their own assessment groups and responding to other students' questions.

Constructivism: this involves students creating their own knowledge while working with others. The views of the students involved are considered towards improving their learning and attainment in science.

CHAPTER 1

1.0 INTRODUCTION

This study focuses on the use of student-led questions and feedback to improve students' engagement and attainment in Key Stage 3 secondary science. The purpose of this study is to find out how students' awareness of the use of questions and feedback can be channelled to improve students' engagement in their learning, and to examine how students' contribution to the classroom discourse through developing their own questions and giving peer feedback, can improve their attainment. This study also sought teachers' perceptions on the role of questions and feedback in engaging students in science lessons.

When students are allowed to lead their learning, it will support their understanding of scientific concepts (Windale, 2010; Ofsted, 2013) and the application of science, which can improve their engagement and attainment (Nicol, 2007; Harlen, 2009). Therefore, the idea of this study being learner-centred, supports my theoretical perspective of a constructivist approach to learning, in which students are engaged in creating their own knowledge and also working with other students (Parkinson, 2004; Adey and Serret, 2010; Creswell, 2011). However, Savasci and Berlin (2012) noted that while constructivism is embraced by science teachers, evidence from their study showed that three out of four science teachers observed did not actually practice constructivism in their lessons. Therefore, the strongest point about this study is that it should act as a model to promote constructivism in the science classroom in order to support students' engagement and attainment.

1.1 The research problem

This study took place in the science department in a secondary school in a mixed Academy in London. The reason behind this study is that some students in the science department were identified by the school as needing interventions in order to support their attainment in science at Key Stage 3. This was considered by the school as part of raising students' achievement in science. In the course of this study, I will be guided by the main research question and two subsidiary questions highlighted below.

The main research question is

- How can both student-led questions and feedback be used to enhance students' engagement and attainment in a Learner-centred Key Stage 3 science classroom?

This research question has been identified by Alexander (2008) as a main concern in using AfL strategies, especially in the area of students developing their own questions and giving feedback to each other. In line with this research problem, the ASE (2006) and Reiss and Ruthven (2011) identified students' engagement in science as a concern that needed a solution in order to support students' learning and retain their interest in the subject. The main research question has led to two subsidiary research questions which will also be considered in this study, and are listed below:

- How can student-student interaction in questioning and feedback be used to improve students' engagement in science lessons?
- What is the nature of teachers' perceptions in the use of questioning and feedback in engaging students in science lessons?

In order to justify this study and highlight its relevance in students' learning, it is important to state that Cowie, Jones and Otrel-Cass (2011) pointed out that when teachers create opportunities for interaction between students, as adopted in this study, using talk as a medium to assess students and give feedback, this will help to engage the students and support their learning.

1.2 Summary of the study

This study focuses on the use of both student-led questions and feedback to improve students' engagement and attainment in Key Stage 3 secondary science. The research paradigm adopted is a constructivist paradigm (Adey and Serret 2010) linked to my theoretical perspective based on Assessment for Learning in science. This has allowed me to create opportunities for the students involved to work in small groups, constructing their own knowledge based on the problem solving activities designed for this study. Therefore, the methods of data collection adopted have been informed by my ontological and epistemological beliefs (Scott et. al., 2007), which have been influenced by my theoretical perspective and will be discussed in chapter 3 of my methodology (3.2, page 54). This is because the focus of this study involves students creating questions and giving feedback with a view to improving their engagement and attainment.

Chapter two of this work (literature review) will focus on literature linked to Assessment for Learning strategies and their impact on students' learning and engagement. Emphasis will be placed on literature showing the contribution of questions and feedback on students' learning, and social pedagogy in the science classroom, and those factors that may constitute engagement of students in science lessons. This will also include factors that may pose as barriers to students' learning. In addition, a reflection on the Nature of Science and How Science Works (Millar, 2012; Golabek and Amrane-Cooper, 2013), will be considered as important in this study as it may reveal how students apply the knowledge gained and their prior knowledge in problem solving (questions and feedback). The literature review will be informed by themes that emerge from the literature search (appendix 16).

In chapter three (Methodology), a mixed method was used to collect data through the means of lesson observations by the teachers involved in the study. The data collection methods used were audio recording of students' questions and feedback; end of unit science test results pre- and post-data collection; scoring of students' presentations based on some success criteria; field notes; questionnaires and interviews. More details can be seen in table 3.2 in the methodology chapter of this thesis (pages 69-70). Different data collection methods were used in order to support triangulation and ensure reliability and validity of my results. These data collection methods and analysis are shown in table 3.2 in the methodology section on pages 69-70. The students had the opportunity to use research materials such as text books, internet resources and work sheets to enhance their subject knowledge whilst solving the problems. This enabled each group of students to present their findings to the class, while the other students listened and asked questions using Bloom's taxonomy question prompts provided by the teacher. They gave student-student feedback and clarified any misconceptions in the use of scientific key words.

Chapter four (data analysis and discussion) will focus on my findings and how they support the literature in the field of Assessment for Learning, especially the contribution made by the students to questions and feedback. A focus on students' cognitive development based on the types of questions developed using Bloom's taxonomy is highlighted and its impact on engagement and attainment. Analyses of the following data is considered in making my conclusions: Questionnaires; interviews; audio transcripts of students' questions and feedback; field notes; scores from students' presentations and end of unit science test results.

Chapter 5 (conclusions and recommendations) discusses the impact of the questions and feedback on students' engagement and attainment in this study. Original contribution to knowledge and also the limitations of the study is reported. The recommendations are twofold, that is, for professional practice and suggestions for the development of future research. Finally, the impact of the study on my professional development and the teachers involved is discussed as well as the outcome from sharing these experiences with other colleagues in the science department.

1.3 Expected original contribution to knowledge

This study focuses on Key Stage 3 students (13 years old) involved in developing their own questions and giving feedback to other students, and leading the classroom discourse by taking the role of the teacher in the Initiation, Response and Evaluation (IRE) pattern of discourse (Chin, 2006), referred to as model 1 in this thesis (page 43). This is an original contribution to knowledge as an exhaustive search of literature using Swetswise; Routledge; Sage journals online; and hand searching, did not reveal any other study that has used the same age group of students. This will be discussed in detail in chapters 4 and 5. The new model of discourse presented in this thesis, which is a contribution to knowledge evolved from questions and feedback led by the students and is represented as SI-SR-SP-SP-SR-SP-SR-SP-SP-SP-SR-SP-SE, where SI is student initiation of questions; SR is student response; SP is student probing; and SE is student evaluation (SE). Engaging students in this new model of discourse was responsible for 98% of engagement of the students in the problem solving tasks, and 92% of the students achieving their target levels in the end of unit science tests. Details of this model will be discussed in chapters 4 and 5. In addition to this, two new factors that constitute students' engagement in learning are highlighted. They are Repetition/Repeat activity; and Practice. These factors were not identified during my literature search, and details will be discussed in chapters 4 and 5.

1.4 My journey

This study focuses on the use of student-led questions and feedback to improve students' engagement and attainment in Key Stage 3 secondary science. This study examines students' contributions to their own learning through questioning and feedback as part of the AfL strategies that will enhance their engagement and attainment in science. The rationale behind the use of questions and feedback to address the research problem was based on my own experience of the problems encountered in assessment of students in Key Stage 3 science. As a science teacher, I have worked as a Science Lead Professional and also have a leadership responsibility for teaching and learning, and assessment of students at Key Stage 3. During my professional career, I have always sought to know what driving factors are responsible for students' engagement and attainment in science. This is because my experience has shown that these schools were all engaged in using structured means of assessment of students' learning. However, it was apparent that they gave differing outcomes on students' attainment that may not be comparable. In one situation, both schools I worked in had similar kinds of students with the same ability ranges, and also used the same examination board and assessment materials to assess their students. Despite this, one of the schools performed better than the other in terms of their GCSE grades as well as value added scores at Key Stage 3 science assessments.

Following on from my concerns about assessment above, Millar (2012) considers that schools which perform better do so because they prioritise assessment at the top of their school improvement plan, before the curriculum. However, I consider this claim by Millar as not yet conclusive as other factors may be responsible for the difference in the performance of the students in the two schools. These factors may be regarded as barriers to learning, for example McCombs and Miller (2007) consider students' cognition and metacognition as one such barriers. This will be discussed in the literature review chapter of this thesis.

It is important to highlight that tests have been over-used as a means to measure students' abilities and attainment in science (Hosp and Ardoin, 2008) and such tests may limit some students' ability to reach their full potential due to underperformance in the test (Campbell, Abd-Hamid and Chapman, 2010). In certain cases, this may have been due to barriers to learning that may have occurred before the test or on the test day, which may not be connected to the student's ability, for example emotional and social problems (McCombs et. al., 2007). In addition to this, the use of summative assessments as the main way of judging students' attainment at Key Stage 3 science have been challenged by DCSF (2009) who argue that alternative forms of assessments such as the use of Assessing Pupils Progress (APP) criteria, as a formative assessment, can be used. More details on APP are highlighted on pages 24 and 25 of the literature review in this thesis. The idea of adopting formative assessments as a means to support outcomes from summative assessments, will challenge teachers to adopt practices in their classrooms that will encourage and improve questioning and feedback. These formative assessments will engage students in problem solving activities where they will create questions and give feedback to other students and support their own learning.

1.5 Where are we now in Key Stage 3 science assessments?

Based on my experience, the focus on improving students' learning in science, centres on using combinations of AfL strategies to support Key Stage 3 students, other than science practical work (Magaji, 2008; Wilson and Mant, 2011) which has been a source of over reliance by science teachers, hence the need to encourage the use of other AfL strategies to engage students. I am also aware that summative assessments play an important role in determining students' attainment, and have been the main means of placing students into teaching groups in Key Stage 3 until now. However, when we develop students in formative assessments (questions and feedback), this not only improves their engagement and attainment in science by improving levels of interaction among students, but it may also support them in answering questions in tests and examinations. Although, tests and examinations (summative assessments) are not the focus of this study, end of unit science test results will be used to report students' attainment. I make a case here that this study is important in terms of addressing the problems associated with talk in lessons as mentioned earlier, by encouraging students' interaction and supporting them to develop good quality, high level questions (Williams, 2011), and also encouraging them to give quality feedback to other students (Swaffield, 2008). This is because such focused assessment (questions and feedback) will help to raise standards among students and enhance their progress and attainment (Black and Wiliam, 1998; Harlen, 2009) in the tasks they are engaged with.

1.6 Studies addressing the research problem

Studies in assessing students' learning in the area of questioning and feedback to students have mainly focused on teachers, as the main source of feedback to students. This is because Gielen et. al. (2010) consider teachers to be trained to ask questions and give better feedback to students rather than students giving feedback to each other. This is an area that this study seek to address by creating awareness that students can also be engaged in questions and feedback like their teachers when they are trained to do so. Other studies have looked at students' contributions to questioning and feedback from a different perspective. However, there were some deficiencies in the studies. In one such study Aguiar, Mortimer and Scott (2010) explored interactions initiated by students in a secondary classroom which involved students generating questions and answers, with no direct instructions given to the students to ask questions. In another study, Hayes and Devitt (2008) conducted a study in the Higher Education setting aimed at supporting college students to engage in constructive discussion with the view to developing their critical thinking skills. These will form the critique section 1.7.

Still on the issue of assessment in schools, Ofsted (2011, 2013) conducted a survey and reported that when teachers use diverse assessment strategies such as questioning and feedback, they can support students' progress and understanding of scientific concepts. This means science teachers should be encouraged to use discourse in their lessons and allow students to talk and express their ideas about topics in science. In a similar study conducted by Wilson et. al. (2011) about what makes an exemplary teacher of science based on the teachers' perspective, they reported that teachers who engage students in assessments, for example through questions and feedback are better teachers. Two of the studies highlighted here, Hayes et. al. (2008) and Aguiar et. al. (2010) will act as a model to identify some deficiencies that will be addressed by my study.

1.7 Critique in similar studies related to my research problem

Hayes et. al. (2008) argue that students' critical thinking skills in science among primary and secondary school pupils have not been developed, and that more effort is required by teachers in this area to improve students' performance when they get to college. In response to this claim by Hayes et. al. (2008), engaging students in questions and feedback, as used in this study, is an important way to support the development of students' critical thinking skills. This means students are involved in assessing each other through questioning and feedback, and using prior knowledge to solve problems in some situations. A similar study conducted by Alexander (2008) shows that most students have not been given opportunities to express themselves in lessons, such as using talk and giving feedback to other students. In addition, Alexander (2008) pointed out that when talk is used in lessons and teachers fail to engage students by referring to their answers, teachers have not moved students' learning forward because they have not made the effort to clarify any misconceptions, and check students' understanding of key words and phenomenon under investigation. This means that the required progress and attainment of students will not be realised. I make a case here, and reiterate that students can also be trained to engage in talk in lessons, and check other students' answers for misconceptions in the use of scientific key words, in order to check their understanding. This is where the issue of differentiated learning will be important as able students can support the less able students.

In view of the points mentioned above, several studies based on students' perceptions of assessment in their classrooms have shown that most students have not been fully engaged in their own assessment by their teachers (Cowie, 2005; Dhindsa, Khalid and Waldrip, 2007), thereby limiting students from extending their learning and reaching the required attainment. Some other studies have shown that developing teachers' questioning skills have been given priority (Black et. al., 2003; Clarke, 2008; TLRP, 2010) over that of the students who are considered as co-assessors with their teachers. As a science teacher, I have carried a burden for developing students' questioning skills, which I feel is a subject every science teacher should consider as an area for their professional development. This is because if we want our students to become better learners, we must engage them in questioning and improve their skills in this area. This will help them to identify questions that may need elaboration in tests and examinations (although this is not the focus in this study). This study addresses the above-mentioned deficiencies and supports students in developing questions and giving feedback to other students, an element which is lacking in the Hayes et. al. (2008) study. In the study, Hayes et. al. (2008) did not involve students in developing their own questions, but rather responding to other students' ideas by challenging them when they disagreed and expanding upon the answer when they agreed.

In critiquing the study of Hayes and colleague above, it is clear that there was no strategy used to explore the type of questions the students developed, and their ideas and previous knowledge may be limited in the quality of feedback given to other students. That is why I believe that my study is very important in using Bloom's taxonomy question prompts to guide the students involved in developing varying levels of questions (Maynard, 2012), with a specific interest on students developing high level and challenging questions that will enhance their engagement and learning. Therefore, this type of study sets high challenges required to place these students in a position where they will become confident in their learning and deal with problem solving which enhances their cognition and metacognition. This makes this study an important contribution to knowledge. This study also encourages students to carry out research using materials such as textbooks, internet, and other secondary sources of information, to solve the given problems following a research model by OSLA (2012) in addition to using previous knowledge. A study conducted by Zheng et al. (2008) in the context of Higher Education, explored how Bloom's taxonomy may be used to quantify and compare levels of assessment from different examinations. This is aimed at assessing the types of questions examiners used in developing students' cognition. This study by Zheng et. al. shows that the levels of questions (low or high order) students respond to, can have an impact on their cognitive development. However, in Zheng's et al (2008) study, the students were not involved in developing questions but responding to the examiner's questions contrary to my study where students are engaged in developing their own questions and giving feedback to other students.

In line with the discussion from previous paragraphs above, the study conducted by Aguiar et. al. (2010) in Brazil was used as a model for my study and by highlighting some deficiencies and addressing those in this study it will contribute to knowledge. In the study, Aguiar et. al. (2008) did not give direct instructions to the students to ask questions, as highlighted earlier. This is because the students have been identified as those who ask challenging and high level questions in lessons anyway. The problem with this type of study, and based on my experience, is that such students cannot continually ask high level questions in every lesson and may require encouragement from their teachers (Williams, 2011) in some situations when they may not feel like engaging in the tasks. This could be due to certain barriers to learning such as emotional factors (Smith, 2007). I make a case, therefore, that the fact that the students were not given samples of question prompts to guide them, as well as encouragement from the teacher (Hodgen and Webb, 2008; Williams, 2011) to ask high level questions, may have affected their consistency in asking such challenging questions. Another argument is that, if the students are not encouraged to ask questions, this will limit the number of students engaged in asking questions, and the quality of questions developed may be compromised. That is why teachers should model questioning to students and also encourage students to ask questions in lessons. My study is designed to address this situation by encouraging students to ask high level questions using Bloom's taxonomy question prompts provided (Bergman, 2009) while the teacher facilitates the learning.

I have devised a means to check that all students are fully engaged in the questioning and feedback process. This involves using some success criteria with an idea from OSLA (2012) model of inquiry (appendix 13). These criteria were shared with the students in order to remind them of the high expectations required of them. In analysing the data obtained from their study, Aguiar et. al. (2010) decided to ignore the basic information questions developed by the students involved in the study. These basic information questions are like the Knowledge and Comprehension questions on Bloom's taxonomy (appendix 1), which may also be referred to as factual or recall questions, and do not extend students' learning. However, I have decided to include such basic information questions in my analysis as they can be used to plan for future interventions to support students' learning and improve questioning techniques. This further confirms the need for teachers to guide and support their students on how to ask high level and challenging questions, as this will also enhance quality feedback. Aguiar et. al. (2010) based their conclusion on only one source of evidence, which was obtained from the lesson observations during their study. This is in contrast to my study, where the conclusion was based on lesson observations, field notes, interviews and questionnaires, end of unit science tests and using success criteria as a formative assessment tool. These methods of data collection will support triangulation which has not been considered by Aguiar et. al. (2008) in their study. I will now consider the significance of this study for teachers and students.

1.8 Significance of the study for my chosen audience

This study focuses on the use of student-led questions and feedback to improve students' engagement and attainment in Key Stage 3 secondary science. Students' achievement can be supported by engaging them in questioning as part of the AfL strategies that will enhance their learning and questioning skills. In addition, when good questions are asked they elicit good answers (Hodgen et. al., 2008) and can influence the type of feedback generated. As a teacher, I want to embrace AfL strategies in my classroom (through questioning and feedback) to support teaching and learning. This has encouraged me to embark on this study and consider ways I can develop strategies to support students in asking high level and challenging questions. In addition to questioning, Black et. al. (1998) and ARG (2002) pointed out that feedback as an assessment strategy is important in this process because it enhances students' metacognition and social construction (Adey et al., 2010), helping them to understand the Nature of Science. Therefore, Black et al. (2006) and James et. al. (2006) consider this type of engagement, where students develop questions and give feedback as a means to encourage interaction and dialogue among students and their teachers in classrooms (Black et al., 2002; Black et. al., 2003), a tool that must be developed in science lessons.

This study will help to strengthen my professional development and other teachers in the science department, as we strive to engage our students in giving feedback to each other through peer and self-assessments (Swaffield, 2008), as this will enhance students' learning and attainment. In addition, the study will also help the teachers involved to reflect on some aspects of their teaching that may need to go through some transition and training. I make a case here that the outcomes from this study can also be applicable to other teachers in similar situations in different schools (Abrahams, 2009), who are trying to find the right combination of AfL strategies (questions and feedback) to support students' learning in science, apart from depending on the science practical. This study, therefore, engages students in formative assessments, developing their own questions and feedback to improve their engagement and attainment. Aguiar et. al. (2010) also pointed out that such questions developed by the students will provide feedback from the students to the teacher. This means the teacher will be able to assess students' learning and support them.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

This study focuses on the use of student-led questions and feedback to improve students' engagement and attainment in Key Stage 3 secondary science. Students are required to make progress in their learning and teachers have to demonstrate this for their teaching to be judged as good (Ofsted, 2011; Finney, 2013). The DFES have been in the forefront in developing science Key Stage 3 National Strategy resources and training science teachers in order to support students' progress in science (DFES, 2002). In this capacity I have been involved in training as a Science Lead Professional supporting and training colleagues on implementing the strategies in their lessons. I will argue here that using an Assessment for Learning (AfL) strategy, plays a significant role in this process and can support students' progress (Waind, Robotham and McGregor, 2012). Therefore, in order for students to be actively engaged in their own assessment and show this progress, the role of the teacher will gradually shift to becoming a facilitator of learning as in problem based learning (Hmelo-Silver, 2004; Berkel and Dolmans, 2006). Hence this study justifies the need for students to be involved in their own assessment (Blanchard, 2008; Carr, 2008; Harlen, 2009) through developing own questions and giving feedback, which may develop their skills in the use of scientific key words, while the teacher facilitates the learning process and correcting any misconceptions.

In view of the above mentioned points, it is pertinent that this study will prepare students for the new focus on literacy in science in the new National Curriculum for England in the school where this study was undertaken. In promoting literacy, Rhodes (2013) set up a literacy working party for term 1, September 2013 in her school to support students' learning. This will encourage teachers to choose and use common scientific key words and spellings in lessons which are placed on the classroom walls so that students can use them in lessons for writing, asking questions and checking understanding. I will now reflect on my research questions and draw upon literature that supports my focus.

In the course of this literature review, I will be guided by these research questions:

- How can both student-led questions and feedback be used to enhance students' engagement and attainment in a Learner-centred Key Stage 3 science classroom?
- How can student-student interaction in questioning and feedback be used to improve students' engagement in science lessons?
- What is the nature of teachers' perceptions in the use of questioning and feedback in engaging students in science lessons?

From the above questions, this study seeks to empower Key Stage 3 science students to take ownership of their learning and assessment, as argued by Nicol (2007) and Kiemer, et. al. (2014), through the use of questioning and feedback strategies to engage them with a view to improving their attainment. Hence, questioning and feedback forms the AfL focus in this study, as Harlen (2009) argues that it is not possible to implement all the AfL strategies at once in the classroom and that teachers can decide which of the strategies best suit their students and revise them as necessary. This is a view challenged by Darlington (2012) who argues that there is insufficient evidence for focussed assessment in science and that more research is required. However, in support of the views of Harlen, Black et. al. (2003) make it clear that focused assessment will have more impact on students' learning and progress in secondary school based on Black and Wiliams' (1998) work on formative assessment. In view of this, Millar (2012) argues that schools should consider assessment as a priority before curriculum and pedagogy in their school improvement plan. However, some schools promote the curriculum by organising a subject choices evening for Key Stage 3 students moving into Key Stage 4. Therefore, the benefits associated with using the right assessment strategies will be discussed later in this literature review.

In regard to assessment in science and other subjects, Turner, Ireson and Twidle (2010) and Darlington (2012) noted that students are more engaged in asking questions and giving feedback in Drama, Physical Education, English and Art lessons than in science. They are also more likely to challenge other students' views. In addition, Turner et el. (2010) made it clear that Chemistry is one subject where students may be engaged because they find the practical work interesting compared to other sciences. Practical work generally in science has been reported to engage students (Magaji, 2008; Millar, 2010; Darlington, 2012) and sustain their interest without reference to a specific topic or area in science. The argument here is that science practical may not always be a means to an end with regard to students' engagement in science as some topics do not involve practical work. This point will be discussed in detail later in this literature review. My intention is not to discredit the contribution of science practical work to students' learning but to seek alternative means to further engage our students through this study, using student-led questions and feedback, which Ofsted (2011, 2013) agree that it can support students' progress and understanding of scientific concepts. In line with this argument, Darlington (2010) encouraged the teaching of science in secondary school through drama. These strategies as argued by Turner et. al. (2010), will prevent students from losing interest in science, a view supported by Dillon (2010) and Hetherington (2010) who considered girls vulnerable to this because some of them appear not to like science practical work as much as boys.

It is important to highlight this issue of preferences in science practical between boys and girls as reference will be made to this claim at a later stage in this literature review. However, the gender issue in science is not a focus for this study. The challenge for science teachers is to seek ways to engage science students in their own assessment and learning especially in those topics that have no practical element, rather than focusing on practical work as the main means of engaging students. This is because Abrahams, Reiss and Sharpe (2011:40) reported that "practical work was found to be more effective in getting students to learn what the teacher intended about observables and phenomenon than it was in getting them to learn about scientific ideas". Abrahams and colleagues further explain that when students learn about observables intended by the teacher, they are not able to use the right scientific terminology, be thoughtful or use the correct expressions of speech when talking about objects. In addition to this, Newton and Newton (2011) argue that focusing on one kind of assessment to support students' learning which may favour only certain groups of students (either boys or girls), and be a disadvantage to others, may lead to ethical issues. Therefore, Millar (2010) and Dillon (2010) argue that when practical work is used in lessons, it should be structured so that it includes other activities to support learning, such as questioning, feedback and problem solving in order to cater for the learning needs of all students. This idea has been used in this study. This makes this study an important contribution to knowledge and may help science teachers to use discourse in their lessons and encourage students to talk and write about science (Evagorou and Osborne, 2010) which is currently promoted by the new National Curriculum in England, 2014.

The challenge now will be how to choose activities that may satisfy these purposes for our students. In line with this, Dobson (2001) and Hmelo-Silver (2004) argue that when students are involved in problem solving activities, this may enable them to ask questions and get feedback, which will improve their cognitive ability and metacognition. In order to engage students in this thinking process, teachers must support them to develop high level questions eliciting good feedback using Bloom's taxonomy question prompts (Bergman, 2009; Maynard, 2012), appendix 1, a view supported by Lord and Baviskar (2007), that it will improve students' thinking skills. However, Zheng et. al. (2008) argue that an improvement in students' thinking skills will be based on the type of questions asked which in most cases demands the high level questions to engage better thought processes among students. This arguably will enhance the type of feedback (Earl and Katz, 2008; Hayes et. al., 2008) students will get from both teachers and other students. This is an idea adopted in this study and will be discussed in detail later in chapters 3 and 4. In view of this Hayes et. al. (2008:65) pointed out that if we want to improve students' "critical thinking skills in science, it should be encouraged in primary and secondary schools as their findings suggest that such skills have not been developed among pupils".

I work in a secondary school setting and teach Key Stage 3 students. This intervention was set up to improve students' critical thinking skills in Key Stage 3, year 8 students (13 years old) in the UK National Curriculum and at the second year of their secondary education. It is important to state that this type of study can also be encouraged in a primary school setting (Key Stage 2) to improve science teaching and learning. Hence, this study is designed to be student-led at secondary school level allowing them to take control of their learning through developing questions and giving feedback, which Nicol (2007) argues will enhance their attainment. This makes the study a contribution to the existing body of knowledge. I will attempt to define what constitutes engagement in lessons at a later stage in this literature review section. The learning theories which underpin this study (Hohenstein and Manning, 2010) and Piaget's ideas on learning

(Parkinson, 2004; Adey et. al. 2010), and how it applies to this study, will also be discussed. I will highlight those factors that may constitute barriers to students' learning.

2.1 Theoretical Framework

This study focuses on the use of student-led questions and feedback to improve students' engagement and attainment in Key Stage 3 secondary science. The theoretical framework is based on Bourdieu's "cultural capital which is defined as a social relationship which comprises cultural knowledge, skills, abilities, norms and preferences of the individuals involved in a social setting, and that this cultural capital can be acquired through one's social origin (family) and through education" (Winkle-Wagner, 2010:5). The socialisation of these culturally relevant skills among students will enable them to lead their own learning and assessments. Therefore it can be argued that this study opens up an opportunity for the students involved to express and exhibit their cultural capital towards improvement in their engagement and attainment. Thus this study will examine students' contributions to their own learning through questioning and feedback led by the students, while the teacher facilitates the learning. Clarke (2005) notes that this type of study which is based on using AfL strategies fulfils a constructivist paradigm. Hence, this study is inspired by a constructivist paradigm approach to research (Gray, 2009; Creswell, 2011) drawing upon two forms of constructivism.

The first form is cognitive constructivism having its origin from Piaget (Parkinson, 2004; James et. al., 2006) which involves students creating their own knowledge. Piaget argues that students develop in stages of their cognitive abilities, which will be drawn upon in this study at a later stage. The second is the socio-cultural constructivism by Vygotsky as put forward by Brooks and Brooks (1999) and Adey et. al. (2010), which involves students creating their own knowledge while working with others. In addition to this, Blumenfeld, Kempler and Krajcik (2006) make it clear that in a class room where these forms of constructivism are used in teaching and learning, students will be engaged cognitively compared to a classroom dominated by the teacher's talk. This is a view supported by Kafai (2006) and Creswell and Plano Clark (2007) who suggest that in addition to the benefits of the constructivist approach, it will further enhance students' cognitive development as science students. Blumenfeld et. al. (2006) argue that the normal classroom (dominated by the teacher) may be based on instructionism which involves rote learning and is a common practice in science lessons, which does not give students opportunity to express their ideas. This is a practice this study seeks to discourage.

In line with my theoretical framework on Bourdieu's cultural capital, the aspect of students creating their own knowledge and leading the classroom discourse will be discussed throughout this study as the focus for improving their attainment. However, this has been challenged by Savasci et. al. (2012) in a study on science teachers' beliefs and classroom practice related to constructivism who argue that their results suggest that teachers embraced constructivism, but class room observations did not confirm implementation of these in most cases. That is why this study focuses on the use of student-led questioning and feedback to improve students' engagement and attainment in Key Stage 3 secondary science. My position, therefore, is to justify the need for teachers to create opportunities in science lessons so that students can be fully engaged in their own learning and lead the discourse so as to change the general perspectives of teachers and their behaviour in leading classroom discourse (Kiemer et. al., 2014). This arguably may contribute to progress in students' learning (Dhindsa, et. al., 2007) based on the constructivist paradigm. In addition James et. al. (2006:51) put it that:

> *"Constructivist theories focus attention on the mental models that a learner employs when responding to new information or to new problems. Learning always involves analysing and transforming any new information. Transformations of incoming ideas can only be achieved in the light of what the learner already knows and understands. Unless learners make their thinking explicit to others, and to themselves, they cannot become aware of the need for conceptual modification".*

In line with the comments above, Chin (2006) argues that in a constructivist based classroom, teachers find out what students already know and challenge them to think and express themselves in order to add to their existing knowledge. However, this study encourages students to assume the role of the teacher whilst the teacher facilitates the learning process. The research methods used in favour of the constructivist paradigm approach will be discussed in detail under the methodology section later in this thesis.

2.2 Representing the emergent themes

At this stage, I make no claims as to how to engage Key Stage 3 secondary students in questioning and feedback to improve their attainment in science. I have presented from the literature some themes which surround engagement of students in questions and feedback with a view to improving their attainment. These themes were determined from literature search using SwetsWise, Routledge, Sage journals on line, and also hand searching of key journals in Assessment for Learning, which forms part of the "systematic review" (Torgerson, 2003:24) of this study. Some of the literature which form the themes in this study are presented in appendix 16.

2.3 Assessment for Learning (AfL)

This section of the literature review justifies that the focus of this study is part of AfL strategies. It opens up the argument for its relevance in a study like this and highlights the problems of assessment. In order to engage students and support learning, it is imperative that teachers consider which combinations of AfL strategies will fulfil this as encouraged by Harlen (2009). That is why this study is based on the use of student-led questions and feedback to engage students and improve their attainment. Although this study focuses on the use of questioning and feedback as part of AfL strategies to engage students, Black et. al. (1998) and ARG (2002) argue that both teachers and students are equally involved in the learning process which may include self and peer assessments. However, this view is challenged by Earl and Katz (2008) who argue that teachers must consider the assessment strategies which can encourage students in self- assessment and self-regulation. This form of independent learning will involve students in developing their own learning goals and monitoring their progress in relation to the success criteria that are used in any problem solving task. This may also involve teachers knowing where students are in their learning and providing appropriate scaffolding to move students forward in their learning (Ruiz-Primo, 2011). For this reason, I commend this type of study as being important in helping teachers plan for assessment activities that will enable students to make progress.

In building my case further on assessment, it is important to consider teachers' perceptions in the use of questioning and feedback to support assessment. In a study conducted by Wilson and Mant (2011) on what makes an exemplary teacher of science, they claimed that teachers who encourage pupils to become active learners is the key. This means such teachers encourage the pupil's voice and create opportunities for discussion through questions and feedback. This study as earlier mentioned, seeks to achieve this by dissuading teachers from doing most of the talking in lessons, which sometimes may be the case. However, it is worth summarising that the assessment focus (student-led questions and feedback) in this type of study will help both teachers and students assess what the students know, identify any difficulties and support students to overcome them (Harlen et. al., 2012; Waind et. al, 2012). This will also help teachers to review their assessment strategies and put in place interventions to support students' learning and attainment. Therefore, the kind of dialogue created in this situation where students are involved in their own learning will improve student-student interaction and feedback (Nicol, 2007) and enhance their learning. In line with this view, James et. al. (2006) argue that the quality of the feedback is most important as a catalyst towards engaging students and enhancing their assessment. I will highlight the importance of feedback in the next paragraph.

In giving feedback to students it is helpful to point out not only the kind of errors they are making, but also what they need to do to improve (Wiliam, 2011). In addition, the feedback will help students to develop their own knowledge (Buhagiar, 2007) making them independent (Clarke, 2005; Blanchard, 2008) and responsible learners (Black et. al., 2006), which this study seeks to encourage. The case I am putting forward here by encouraging student-student interaction and dialogue does not mean the teacher's role in the students' learning will become redundant. The teacher will act as a facilitator of learning in this process. This means the students will have the opportunity to assess their learning and scrutinise the process and look at how they can improve this (ARG, 2002; Scott and Morrison, 2007). In making students aware of this process, the assessment framework we use in the school that this study took place in, allows students to state "what went well" and "even better if" when they are carrying out self and peer assessments. This is still being developed and students are currently trained by teachers to assess themselves in this way across the school. This explains why Black et. al. (1998) claimed that when formative assessment is well developed in the classroom, it can raise standards in students and enhance their progress and attainment (Smith, 2007; Earl and

Katz, 2008). Hence, the focus of this study is to use student-led questions and feedback to improve students' engagement and attainment in Key Stage 3 secondary science.

In line with the focus of this study involving Key Stage 3 students, Williams (2012) also makes it clear that assessment of students in primary science should be an issue of concern for primary schools. This is because students' "performances cannot be adequately monitored at school and national level" (p20). This is in agreement with the findings of Harlen et. al. (2012), who indicate that poor assessment in primary science is affecting students' progress, a view supported by Ofsted (2013), who argues that nearly half of the primary schools in England are not setting targets for science because they do not think that the subject is a priority. The issue highlighted by these authors on poor assessment of students in primary schools show that there is a need to consider ways in which students can be supported in learning science. Therefore, this type of study could be used in primary schools to support science teaching and learning. However, as previously stated my focus will be on strategies used for assessment for learning in secondary schools.

2.4 Strategies used in Assessment for Learning

This part of the literature review highlights the different types of AfL strategies and argues that other AfL strategies can be used in conjunction with the focused strategies (questions and feedback). It also puts forward the problems that may prevent teachers from carrying out formative assessments. The AfL strategies described by Black et. al. (1998) are feedback; questioning and dialogue; self-assessment; peer assessment (Carr, 2008; Fautley and Savage, 2008) and sharing criteria (Hallam et. al., 2004; Blanchard, 2008). The criteria referred to here could be linked to the students' learning outcomes. In comparing these strategies used in assessment for learning, Kiemer et. al. (2014) consider questioning as very important as it helps students to explore and express their own understanding, which leads to a positive experience of autonomy and competence. This is a view challenged by Black et. al. (1998) and ARG (2002) who argue that feedback is the most effective among the assessment strategies as it can help to move students' learning forward. Therefore, teachers are responsible for giving feedback to students on how to improve their work.

Further to the above comment about teachers giving feedback to students, Swaffield (2008) argues that students can also give feedback to each other through peer and self-assessments respectively. This will be discussed in the next paragraph and in more detail in sections 2.8 and 2.11. In addition Black et. al. (2003:50) pointed out that peer-assessment is valuable because it allows students to "express themselves and their understanding in their own language and accept criticism from other students which they may not take seriously if made by their teacher". Peer assessment is not the focus of this study. However, it is used to some extent as students are involved in discourse and knowledge creation. Whilst I acknowledge the work of Harlen (2009), that focusing on specific assessment strategies is more effective (such as the questions and feedback as used in this study) I have also noted that other strategies may be used to support the assessment strategies, such as self and peer assessments as in this study.

This study focuses on the use of student-led questions and feedback which have been described as the main successes associated with assessment and in line with the fact that it encourages students to talk and share ideas and give feedback to each other (Harlen, 2009; Wilson et. al., 2011; Darlington, 2012), just like they would with the teacher. The question here relates to whether or not students can be relied upon to give feedback to each other as feedback in this type of study is designed to be mostly student-led. In response to this question, Clarke (2008) suggested the use of talking partners in some cases, to encourage the feedback process which may extend students' learning (Waind et. al., 2012) and enhance how they make contribution to the discourse. In addition, Broadfoot (2007) and Hattie and Timperley (2007) argue that when students are involved in feedback, this process will help them to evaluate their learning and teachers may correct any misconceptions that may arise in the process. However, for students to be engaged in this type of learning, Black et. al. (1998:8) makes it clear that such dialogue will be "thoughtful, reflective and focused to evoke and explore understanding" which allows students to think. This is a view Marshall and Drummond (2006) considered would affect other forms of interaction in the classroom such as student-student interaction which I consider very important in this study and forms part of my research questions.

This brings to the fore, the focus of this study where students are engaged in developing questions and giving feedback to one another. In addition, Black et. al (2006) and James et. al. (2006) note that this type of engagement in science is key towards involvement of students in their own learning whilst constructing their own knowledge. Therefore, this will support assessment of students and allow their performance and progress to be ascertained (Smith, 2007) at different stages of their development. However, it is also argued that these forms of assessment will enable both students and teachers to evaluate their work (Black et. al., 2006; Blanchard, 2008) and it helps to build confidence among students and autonomy in their learning. Contrary to this, Clarke (2005) argues that despite the successes with formative assessment explained above, problems with covering the various subject content in science due to lack of time allocated within the Curriculum may prevent science teachers from carrying out different AfL strategies in their classrooms. Hence, there is the need for more time allocation to certain topics in science (Harlen, 2012) that may require extended forms of assessment to engage students other than using practical work. What this means is that formative assessment here, cannot be properly used to inform students' progress. Even when teachers are involved in assessing students, Rust, Price and O'Donovan (2003) make it clear that if students do not understand what is required of them from the assessment criteria used, it will lead to failure. That is why sharing success criteria will help students to be involved in the formative assessment process.

2.5 Formative and Summative assessments

This section of the literature review highlights the importance of formative assessments compared to summative assessments. This study focuses on the use of student-led questions and feedback as part of AfL strategies (formative assessment) to support students' learning. It is also important to talk about the benefits of summative assessment which can be used to provide information about students' attainment (Black et. al., 1998; Swain, 2010; Waind et. al. 2012). This will be discussed later. Feedback in formative assessments can be used to close the gap in students' knowledge (Hargreaves, 2005) between their current and desired performance. Therefore, Trauth-Nare and Buck (2011) argue that formative assessments should be an ongoing activity in the classroom. Formative assessment provides informative feedback to teachers and students about the progress being made (Black and Harrison, 2010) and how to move students' learning forward while improving their attainment. However, the challenge here is obvious when comparing formative and summative assessments because the final attainment of students, in most cases in schools, is measured by tests and examination results (Parkinson, 2004; Black et. al., 2006; Swain, 2010) from summative assessments.

Based on my own experience of assessing pupils in science, I believe pupils should be exposed to both forms of assessment (formative and summative) so that teachers can use the outcomes to inform their planning for pupil progression. This is more difficult when only one form of assessment is used as the main means of ascertaining students' attainment, as pointed out in the last paragraph. In view of this, Wood-Groves and Hendrickson (2012) in their study on the role of assessment, draw on evidence from various articles and concluded that assessment should be based on multiple modes of student performance data. This is why summative assessments can be used (Waind et. al., 2012) in addition to other forms of assessment (questioning and feedback) to ascertain students' progress and attainment. The use of summative assessments as the main way of judging students' attainment at Key Stage 3 science has been challenged by DCSF (2009) who argues that the Assessing Pupil's Progress (APP) criteria can be used as an alternative means to summative assessment. For the APP criteria to be applicable meant that the final levels attained by the students in APP may not be reported, rather they will be assessed based on the criteria they have achieved. This may be useful to schools adopting the assessment without levels system of reporting pupils' progress promoted by the Government. I will discuss this further in chapter 4 when the use of levels in this study is compared to assessment without levels.

The APP criteria is a set of levelled success criteria based on the science framework in the National Curriculum in England (DCSF, 2009). Students are required to provide evidence for those success criteria based on the activities they are doing. Therefore, APP can be used by teachers to make periodic judgements on pupils' progress (DCSF, 2009; Slade, 2009), which can be done every half term in the school year (approximately 6-7 weeks). As a science teacher, I have used APP in my previous study (Magaji, 2012) in place of summative assessments with the view to adopting it in other topics in science. I found that the APP process of assessment is student-centred allowing all students equal opportunities of assessment compared to summative assessment. It also allows students to express what they know and can do based on the success criteria which allows them to provide evidence (Harlen, 2009) as well as measuring their progress and attainment alongside learning. In addition, my findings show that APP does not restrict students to answering questions as in summative assessment which may only judge what they know at a given point in time. The outcome from my previous work on APP has enabled me to conduct training sessions to support colleagues in implementing these assessments in their lessons. In addition, Stiggins (2002) argues that such assessments will reduce over dependency on summative assessments as a means to report students' progress in science.

Summative assessments at Key stage 3 plays a significant role in determining pupils' attainment and Parkinson (2004) noted that science departments depend on using published scheme tests provided in teachers' guide without considering the quality of the questions and how they cater for the different ability of students. He suggests that science departments should consider reviewing their methods of assessments and the types of tests they administer to pupils. In addition, Madaus and Kellaghan (1992) argue that these tests will have a negative effect on students' learning, especially for those who do not achieve their attainment, and it will reduce students' confidence and motivation to learn (Martin-Kniep, 2000). Alongside these arguments, summative assessment may also limit students' ability and scope for extending their learning as criticised by Scott and Morrison (2007), as well as preventing teachers from carrying out the right type of formative assessments. Additionally, Campbell, Abd-Hamid and Chapman (2010:16) note that:

> "*The long-term negative effects on curriculum, teaching, and learning of using measurement as the engine, or primary motivating power of the educational process, outweigh those positive benefits attributed to it*".

This becomes a problem when students' attainment are only judged by tests and examinations to account for what they have learnt (Hosp et. al., 2008), contrary to the use of formative assessment (for example, APP criteria without using the levels) in science as mentioned earlier. This is a view supported by Martin-Kniep (2000) who argues that assessing students formatively becomes difficult as their attainment is structured towards achieving the purpose of summative assessment. This makes it difficult for teachers to plan lessons using different combinations of AfL strategies to support students' learning as most schools may be results driven. Rather, teachers may be tempted to teach students to pass examinations ignoring the skills these students may acquire through well-structured formative assessment (questions and feedback).

This study seeks to encourage formative assessment in the science classroom by using different forms of assessments other than using tests (Hargreaves, 2005; Woods-Groves et. al., 2012). This kind of study where students have opportunities to contribute to the formative process through discussions and talking partners, as argued by Black, Harrison, Lee, Marshall, and Wiliam (2003), allows teachers to stand back from the activity and observe and reflect on what is happening. This type of assessment is done under conditions controlled by the students themselves as independent learners, in contrast to Scott and Morrison's (2007) criticism of summative assessment which does not allow students to assess each other. In addition Earl and Katz (2008) argue that this type of engagement where students lead their learning will improve their metacognition and allow them to use the feedback from such a process to adjust their learning and to make the required progress. Therefore, Earl et. al. (2008) make it clear that involving students in their own assessment will prevent them from attributing their failure to the teacher and subject content. Rather, students will be equipped with the skills to engage with their learning whilst understanding scientific concepts (Dhindsa, Khalid and Waldrip, 2007) and reshaping their thinking processes.

2.6 Assessment by teachers versus assessment by students

This section of the literature review highlights the involvement of students in their own assessments and seeks to find out how students' perception of assessment has been used in a way to further support them in understanding the criteria upon which they will be assessed. Research has shown that formative assessment supports learning among students and can enhance their attainment (Black et. al., 2006; Black et. al., 2010) when developed in the classroom (Black et. al., 1998). Therefore, there is need to consider students' views on how they think teachers have involved them in their own assessments in the classroom (Miller and Lavin, 2007). This makes the pupils' voice in assessment an important aspect in this study which will be reported later in chapter 5. This means that science teachers need to start thinking of ways to engage students by using different AfL strategies which may be led by the students. Dhindsa, Khalid and Waldrip (2007), in a study on students' perception of assessment in science lessons, make it clear that the students acknowledge that assessment takes place in their classroom. However, their results suggest that improvement is needed in the way students are assessed. Other research on students' perceptions of assessments includes the following; Cowie (2005) investigated children's beliefs about formative assessment processes and Black et. al. (2006), described the development of a questionnaire to measure children's attitudes in relation to formative assessment - all with a view to engaging students in their own assessments.

This study reiterates the view that students and teachers can be involved in assessment although Pratt (1994) argues that assessment of students has been left for teachers to do without involving students in the process, making this a weak aspect in teaching. Therefore, there is a need for teachers to consider strategies that may be used to involve students in their own assessment. In view of this, students have to be trained by teachers on how to assess their work, and this may include creating opportunities to engage them in classroom discourse (Kiemer et. al., 2014) such as questioning and giving peer feedback as used in this study. Hence, allowing students to lead their assessment will make this study an important contribution to knowledge. This may allow students to decide how to conduct their own assessment and evaluate their learning (Black et. al., 2010), for example, through engagement in the feedback processes (Black et. al., 2003; Juwah, Macfarlane-Dick, Matthew, Nicol, Ross and Smith, 2004) instead of teachers taking charge of it. This type of assessment by students is supported by Cowie et. al. (2011) who view this as a way to encourage independent learning. This view of independent learning is supported by a recent Ofsted (2013) report on maintaining curiosity- a survey into science education in England. In the survey, Ofsted (2013:1) reported that the "more pupils do science for themselves, the more they learn, the more interested they become, and the more likely they are to continue to study science in the future".

The above comments highlight the importance of involving students in their own assessment through questioning and feedback as used in this study. In alignment with this, Ofsted (2003) considered it as a means to foster thinking among students, enabling them to analyse issues pertinent to their learning and further extend their knowledge. This involves giving pupils responsibility for organising how they learn, and teachers have been encouraged to achieve this through using strategies such as students' presentations, modelling, displays, quizzes and the use of memory and recall techniques. These strategies have been adopted in this study and will be discussed later in the methodology section. This study focuses on the use of student-led questions and feedback to improve students' engagement and attainment in Key Stage 3 secondary science. Therefore, this type of study encourages students who, given the opportunity and support in lessons (Fautley and Savage, 2008), will be able to understand the assessment criteria to enhance their learning. However, this view is challenged by Dhindsa et. al. (2007) who pointed that teachers' lack of clarity on assessment criteria for students is a problem affecting their learning. Hence, making assessment criteria easily accessible by the students will arguably support them in their own assessment and learning.

The argument made above clearly justifies the need for involving students in their own assessment considering the benefits this will have on their learning and attainment in science. This is further supported by Wiliam (2011) who highlighted the fact that we must recognise the role of students in their own assessments in supporting each other in their learning despite lacking the training and experience of their teachers. In the same way, Earl and Katz (2008:91) make it clear that:

> *"Teachers must set tasks to encourage students to become their own instructors and evaluators, self-monitoring and self-regulating learners which may be based on some performance criterion to aid their autonomy".*

Although the comments on teachers allowing students to assess each other represent what teachers need to do daily in their classrooms to engage students in their own learning, the question is how often do teachers provide such assessment opportunities for students to lead their learning? This is an aspect of teaching and learning in science that this study seeks to address. That is why this study focuses on the use of student-led questions and feedback to improve students' engagement and attainment in Key Stage 3 secondary science by involving students in their own assessments and learning. Throughout this literature review and in other chapters in this thesis, I will highlight the importance of allowing students to lead their own assessment, which is the focus of this study. This makes the assessment process a learner-centred one so that pupils can make the necessary progress required.

2.7 Learner-centred science classrooms

This section of the literature review focuses on ways teachers can facilitate students' learning by creating the right environment where students are aware of their expectations and can lead their learning. Science teachers must know the scientific knowledge and skills to pass onto their students. This implies that the learning tasks must be designed to meet the needs of the students, as argued by Kasanda, Lubben, Gaoseb, Kandjeo-Marenga, Kapenda and Campbell (2005). This will encourage students to contribute to their own assessments which is considered to be a learner-centred approach to learning (McCombs et. al., 2007) supported by their teachers. In addition to this, McCombs et. al. (2007) make it clear that good subject knowledge is a key for science teachers to plan engaging and interesting lessons to support students' learning. Ofsted (2013) reported that based on an inspection of 180 schools in England, they found that strong leadership and skilled teachers will better support students' knowledge and understanding of science. This implies that science teachers require a good level of subject knowledge and skills to facilitate the learner-centred approach to learning which arguably will encourage students to set targets (Gray, 2009) and evaluate their own learning. In addition, teachers can support students leading their learning by creating the right environment where good questioning can be used to scaffold learning (Black et al., 1998; 2003) among students. This also involves giving quality feedback to students in order for them to make the required progress. This means teachers can use AfL strategies to engage students by personalizing their learning (McCombs et. al., 2007) to increase their interest and motivation which may enhance attainment. I will be discussing the importance of questioning and feedback below.

2.8 Research on questioning and feedback in learning.

Questioning and dialogue in classrooms enhances learning among teachers and their students (Black et. al., 2002; Black et. al., 2003) making it an important aspect of students' learning that must be well planned in science lessons. Hence, this could be in the form of group work, one to one discussions and whole class activity (Hodgen and Webb, 2008) so that everyone is involved in the learning process. Therefore, it can be argued that this process of questioning should be structured to include feedback from both teachers and students as Miller et. al. (2007) and Smith (2007) argue that the outcome from students' engagement in feedback to each other may be linked to improved attainment among the students. In agreement with this, Min and Carless (2013:287) pointed out that a framework for effective feedback should centre on what "cognitive attribute is fostered through the feedback; and how students relate to the teacher, their peers and the subject matter, and respond emotionally to feedback and assessment". This arguably will depend on how teachers create assessment opportunities to support pupils' learning and progress. Min and colleague noted here that feedback needs to focus students' attention on how to increase their capacity to self-regulate and how to use the feedback effectively. I will discuss reasons why students should be involved in giving feedback to their peers later in this chapter.

The kind of dialogue used in this study focuses on student-student interaction with the teacher intervening only when necessary. In addition, ARG (2002) argue that this type of interaction among students will help them to understand what they have learnt and what their next steps in learning will be. Therefore, it is important for science teachers to consider how they can help students to ask questions and give feedback to one another in lessons. However, too much emphasis has been placed on developing teachers' questioning skills (Wragg and Brown, 2001; Black et. al., 2003), a view supported by Clarke (2008) and TLRP (2010), who also considered teachers' questioning as important rather than considering how students' skills in questioning can be developed. That is why this type of study is important as it gives students opportunities to ask questions, talk, express themselves and demonstrate their scientific knowledge (Black et. al., 1998; Clarke, 2005) in order to enhance their learning. It will be worth mentioning that studies have been conducted to encourage talk in science lessons and have been found to be important in students' learning (Harlen, 2009; Hog, 2010; Wilson et. al., 2011) as it fosters engagement. In line with this, Waind et. al. (2012) suggested that students' talk in lessons can open up opportunities for students to evaluate their work which may involve the use of feedback to inform other formative assessments to improve teaching and learning.

Following on from the views above on giving feedback to students, Hodgen et. al. (2008) argue that oral feedback needs to be developed in the classroom especially in science lessons which is a focus in this study. Therefore, science teachers may require the right AfL strategies to engage students in oral feedback as this will help create dialogue in the lesson where teachers and students can air their views whilst reducing the risk of teachers doing the talking alone as argued by Alexander (2008). In view of this Alexander (2008) indicates that this type of dialogic teaching may lead to a sustained discourse in the classroom that may not be achieved in a science practical lesson. In addition, when good questions (high level ones) are asked they elicit good answers and feedback (Hodgen et. al., 2008) which can engage students in a deeper level of understanding of science concepts and improve their thought processes (Smart and Marshall, 2013). In the same way the feedback guides students to apply knowledge and skills to formulate hypotheses and it assists in their appraisal of the gap between current and desired performance (Min et. al., 2013). Hence the need to consider ways of developing strategies to support students in asking good questions, which I will discuss later in this chapter along with highlighting the relevance of students' questioning in the classroom. I will also reflect on strategies aimed at supporting assessment in Key Stage 3.

At Key Stage 3 science, schools have considered different strategies to support students to improve classroom discourse, for example Alexander (2008) argues that the National Literacy and Numeracy Strategies devised by the UK Government to encourage literacy and numeracy in lessons have not had a visible impact on talk in the classroom especially in the area of questioning and feedback. This view is also shared by Harris et al. (2012) who stated that further research is required on supporting students in developing questions, based on the outcome of their research which reported varying levels of progress made by students in developing own questions. Harris and colleague stated that teachers in their study invited students to think through their ideas and questions in some cases rather than giving them answers, as this has been found to bring about improvement in their attainment. This brings to the fore the earlier claim in the previous sections that the role of students in their own learning cannot be underestimated. I feel this may have implication for the way we, as teachers, plan for assessments that will involve students in contributing to the assessment process that may be student-led with a student-centred approach to learning. I have highlighted this in different sections in this thesis. This leads me to conclude that more work is required in this area to support students' learning. This will be discussed in detail in section 2.9 of this literature review.

Another important aspect in this study is thinking time among students, which may also be referred to as wait time for students to process their thoughts before responding to questions. In a bid to compare wait time when teachers ask questions and get feedback from students, Rowe (1974) reported an average of one second in a study in the USA to investigate classroom discourse whilst Ecclestone (2008) reported an average of four seconds. However, the problem of not giving enough time for students to think, as highlighted by Black et. al. (2003:32) is that the "answers given by students may not be as good as the questions they represent, and it will also reduce the number of students taking part in the feedback". Therefore, an average wait time for students to think and answer questions as suggested by Smith (2007) is between 3 to 10 seconds, and Ecclestone (2008) suggested 7 seconds, both different to the view of Clarke (2008) who did not give a time duration but argued that the use of talking partners in order to socialise students would help them engage with questions. In line with allowing wait time for students, Black et. al. (2010) suggested that when students listen to other students as they talk, allowing them some time to think, this may influence the type of feedback.

The view on socialising students to engage them in questioning and feedback as discussed in the last paragraph has been challenged by Alexander (2008) who argues that students' cognitive knowledge which can be developed through talk in lessons has been ignored by teachers who focus on the social aspect of talk. In addition, Alexander (2008) argues that if teachers do not engage students by referring to their answers to clarify any misconceptions and check their understanding, then the wait time issue becomes pointless and may not move students' learning forward. In line with this, Reinsvold and Kathryn (2012:748) make it clear that:

> *"Teachers have the power to provide questioning strategies that allow students to evaluate their understanding, to provide evidence for their claims and ideas, to apply what they know to a novel topic, and in general to reason at a higher level about what they know about science, but do they use it? How well does this power relate to classroom questions?"*

The above comment may be directed at teachers and supported by the views of TLRP (2005a) who encouraged teachers to use questions in the form of diagnostic assessment to check students' understanding of science ideas. These are in line with the purpose of this study but in this case students develop questions and lead the questioning and feedback while the teacher facilitates the process and gives support when necessary. This could be, for example, responding to unanswered questions. Therefore, as questioning is a focus in this study, it is important to highlight reasons for asking questions which Wragg and Brown (2001:11) classified as "cognitive, affective, social and procedural". Hence, this study focuses on the use of student-led questions and feedback to engage students in Key Stage 3 secondary science and improve their attainment. However, the challenge here would be how teachers can encourage students to ask questions in lessons, especially high level questions that may improve their thinking process. This will be explored in the next section on students' questioning which is a focus in this study.

2.9 Research on students' questioning in the classroom.

In the previous section I highlighted some reasons for asking students questions and also proposed that students could be supported by their teachers to learn how to develop their own questions in lessons, which has been identified as a challenge. This section explores the need for students to be engaged in developing their own questions in lessons and the learning outcome they will derive from this, for example, improved cognition. As science teachers, we strive to encourage students to ask questions in lessons but Wragg et. al. (2001) and Cowie (2005) argue that most students find it difficult to ask questions. This is a view supported by Mahmud (2015) who claimed that 97% of students fall into the category of having difficulty asking questions. To develop this argument further, a study conducted by Mahmud (2015) on the questioning power of undergraduate students reported that most students (80%) preferred to ask friends questions, rather than ask their teacher (20%). Some students ask questions to get attention whilst others may ask questions to get clarification on assignments they are given. In addition to this, Wragg et. al. (2001:10) make it clear that most questions students ask are “procedural and social rather than to do with thinking processes unless encouraged by the teacher to ask those questions”. This is a view challenged by Williams (2011) who argues that making students develop their own questions and answers may be a difficult task and requires teachers to support their students by giving them examples to follow.

From the comments in the last paragraph it is clear that students do not understand the relevance of asking questions in the classroom because they have the perception that questioning is the role of the teacher. This is a problem I have highlighted earlier, as too much emphasis has been placed on developing teachers’ questioning skills (TLRP, 2010; Smart et. al., 2013) without considering how students can be supported to improve in this area. In line with this view on students developing own questions, Harris et. al. (2012) pointed out that questioning is fundamental to science and that most students do not know how to ask and investigate their own questions because they are not taught. Therefore teachers need to create opportunities to involve students in classroom discourse in order to change the perspective of teachers leading the discourse (Kiemer, et. al., 2014). This is supported by Hodgen et. al. (2008) who pointed out that the best way to go about this is to train the students on how to develop questions. This view on supporting students to develop their own questions in lessons is also encouraged by Parkinson (2004), although he argues that it may require a lot of thinking and planning for teachers to involve students in questioning and answers in lessons, which may reflect on teachers’ levels of competence. This will be discussed later in this section. This means teachers are required to model some forms of questioning in the classroom so that students can engage with the process in order to empower them with the skills to lead their own assessment, for example through questioning and feedback which is the focus in this study.

In view of the above points on supporting students to be able to develop own questions in lessons, Hodgen et. al. (2008) in a study on questioning and dialogue to promote feedback, encouraged teachers to create opportunities where students are engaged in discussion with each other through questioning and feedback as earlier discussed in this chapter. In line with this, Harris et. al. (2012) identified two strategies teachers used for eliciting students' ideas and questions. The first strategy include asking questions and also encouraging students to ask questions in lesson as a means to check their procedural thinking and to help them in student-led investigations. Secondly, students are asked open ended questions which I have referred to as high order questions in this thesis, because these questions invite "wonderment thinking, hypothesizing and predicting, explaining and clarifying, and making sense of investigative experiences and results" (p778). In line with the benefits of asking high order questions, Smart et. al. (2013) pointed out that it will enable students to interact with their teachers and peers to respond to questions, which will, in turn, allow the teacher to scaffold the process and follow up students' responses with further questioning. Smart and colleague also noted that the high order questions will enable students to engage with science concepts at a deeper level, formulate hypotheses and use evidence to draw conclusions about phenomenon. In support of the benefits associated with questioning, Harris et. al. (2012) stated that when teachers help students to develop their ideas and questions, it will enhance students' attainment in their tests. This has been a proposal in this study.

I will reflect on the strategies, suggested by Harris et. al. (2012) in the last paragraph, for eliciting students' ideas and questions. In response to the first strategy I believe that both teachers and students can be involved in asking and developing questions in the classroom because of the benefits that it will have on students' engagement and attainment as highlighted earlier on. This has been a focus in this study. The second strategy stated that teachers asked open ended questions but the students were not involved in asking such questions to their peers. However, I know that teacher questioning is important in achieving effective classroom discourse (Smart et. al., 2013), which has been pointed out at different times in this thesis. The issue here is how can students' skills in asking high order questions be developed if they are not trained to ask and identify such high order or open questions that are required to improve their learning? This implies that assessment should not be left to teachers alone but students should be involved in the process. This calls for the use of strategies that will support student-led questioning by giving them question prompts from Bloom's taxonomy as stated in section 2.10 in this chapter. This will be discussed in detail later.

Following on from previous views by Harris et. al. (2012), that for teachers to support students in their own assessment in the area of developing own questions, it will depend on the level of competence and pedagogical content knowledge of the teacher. This in turn will enhance students' learning and progress in lessons. However, Harris and colleague also encouraged teachers to invite students to help each other think through their ideas and questions. As I have mentioned earlier when a focused assessment is used in the classroom, there could be other forms of assessments that may be used as support, such as peer assessment. This will encourage dialogue between teachers and students, promote student-student interaction (Black et. al., 2010; Dillon and Manning, 2010) and improve their learning, while Kiemer et. al. (2014) reported that such involvement of students in the classroom discourse would encourage students' autonomy, competence and social interactions that will strengthen their interest in science. In addition to this, when students are involved in questioning, it encourages them to find information and understand it which may assist in developing their cognitive abilities (TLRP, 2010; Finney, 2013) as well as enhance their engagement in science.

Drawing upon students' questioning in lessons, London G&T (2009) argues that this will enable students to identify good questions, a view supported by Fisher (2009) and Williams (2011) who argue that it is not about encouraging students to ask questions per se, but rather to ask good questions (high level questions). This is because the high level questions will engage students cognitively and encourage them to think and construct knowledge (Chin, 2006; Harris et. al., 2012), will help students to engage in deeper levels with science concepts and using evidence to draw conclusions about phenomenon (Smart et. al., 2012) in order to extend their learning. In addition to this, when students are allowed to develop their own questions, O'Dea (2010) argues that the process will encourage students to want to know about science, and learn about the inquiry Nature of Science rather than depend on teachers' questions (Anne and Richard, 2010). This may allow students to reach a point in their learning where they can probe each other's views as argued by Osborne and Dillon (2010) and become confident in challenging facts even if they are correct. In support of these claims on students' questioning, Windschitl (2003:114) makes it explicit that:

> *"for a science student, developing one's own question and the means to resolve the question suggests an inquiry experience that is different from the common*

tasks in science which consist of answering questions prescribed in the curriculum using methods also preordained in the curriculum or by the classroom teacher".

Therefore, one way to support students in developing their own questions and identifying the types of questions from low to high order ones may be through the use of Bloom's taxonomy question prompts (Bergman, 2009), which will be discussed in the next section of this chapter. One may question whether teachers remember to use Bloom's taxonomy to develop questions for their students in lessons let alone to support students in using Bloom's to develop questions.

2.10 Research on Bloom's taxonomy in learning

This section focuses on the importance of supporting students to ask high order questions using Bloom's taxonomy of learning. The order of cognitive development on Bloom's taxonomy is Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation (Kissock and Iyortsuun, 1982; Maynard, 2012) as shown in Figure 2.1, page 38 and appendix 1 showing question prompts under these categories. An example of question prompt from each category includes the following:

Knowledge question: What is a balanced diet?

Comprehension question: State in your own words

Application question: What factors would you change if......?

Analysis question: Can you state the difference between.......?

Synthesis question: What would happen if.......?

Evaluation question: Is there a better solution to.......?

The Knowledge and Comprehension questions are considered as involving low level thinking skills (DFES, 2004).

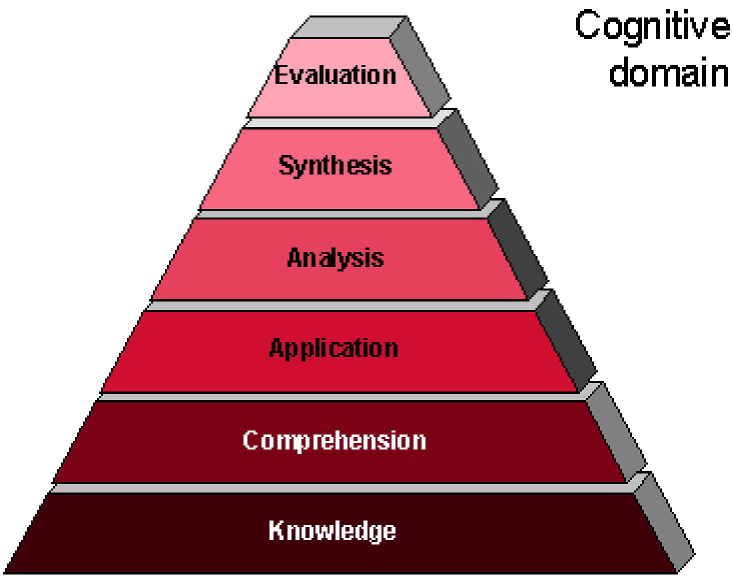

Figure 2.1: Bloom's taxonomy

Source: http://www.learningandteaching.info/learning/bloomtax.htm

I am aware of the revised Bloom's taxonomy as seen in figure 2.2, with the top category which involves creating new knowledge in the domain. I have decided to use the old version (figure 2.1) because it is commonly used and known (Atherton, 2013) and fulfils the purpose of this study.

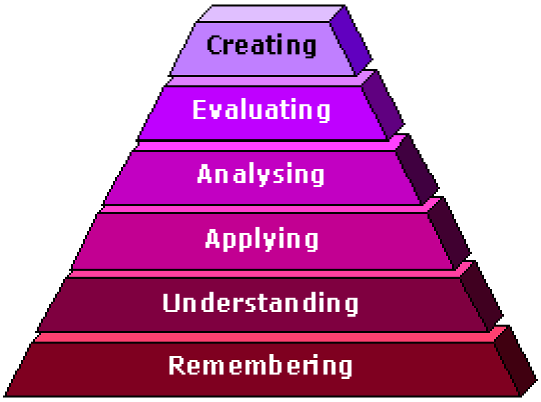

Figure 2.2: Revised version of Bloom's taxonomy

Source: http://www.learningandteaching.info/learning/bloomtax.htm

In comparison to Bloom's taxonomy, Socratic questions can also be used to develop students' cognition (Fisher, 2009). Socratic questions start from low level ones to open ended questions requiring some challenge. Therefore using Bloom's taxonomy and Socratic questioning may fulfil the same purpose in students' learning. However, Bloom's taxonomy has been considered right for this type of study as it gives samples of question prompts to train students and engage them in developing their own questions, whereas Socratic questions have no fixed set of questions (Fisher, 2009) which means they can take any form. Drawing on the low level questions mentioned earlier, which is used by teachers in the classroom and do not support students' critical thinking, an argument put forward is that when teachers ask such low level questions their students may ask similar questions, as teachers are required to model the type of learning they may require from their students. Therefore, teachers must support students to ask high level questions using Bloom's taxonomy question prompts (Zheng et. al., 2008; Bergman, 2009) to model questioning. This process, as argued by Dobson (2001), can improve students' thinking and enhance their cognitive development (Adey et. al., 2010) and support their questioning and feedback skills in AfL.

In the last paragraph I highlighted the importance of involving students in developing their own questions using Bloom's taxonomy question prompts. The argument here is that, involving Key Stage 3 science students (year 8) in using Bloom's taxonomy may seem to be a complex learning task for them at this stage of their cognitive development. This view is challenged by Adey et. al. (2010) who argue that it is right for teachers to initiate complex learning tasks for their students rather than waiting until their cognitive ability is fully developed for such activities. This implies we do not have to wait for such students to get to Key Stage 4 (year 10 and 11) before engaging them in using Bloom's taxonomy in their learning. In support of this argument, the DFES (2004) argues that when students are engaged in solving problems requiring high level questioning on Bloom's taxonomy such as Analysis, Synthesis and Evaluation, they will be able to attain level 5 and above (at Key Stage 3) and grade C and above (at GCSE, Key Stage 4) in England. As stated earlier in this chapter, good questioning will lead to better feedback among students and improve classroom interactions. Therefore, there is a need for teachers to involve students in giving feedback to each other in lessons, which I will be considering in the next section.

2.11 Research on students' feedback to peers

This part of the literature review explores the need for teachers to engage students in giving feedback to their peers. It also highlights the importance of using oral feedback as a preferred means of feedback compared to other forms. If teachers can encourage students to ask questions, for example to check their understanding as claimed by (Swaffield, 2008), I will contest that students are also capable of giving feedback in the same manner as the teacher (Juwah et. al., 2004; Swaffield, 2008) to improve their learning. However, this view of students giving feedback is challenged by Gielen, Tops, Dochy, Onghena and Smeets (2010) who argue that teachers provide students with feedback in most formative assessments because they are trained to do so, and that teachers' feedback is more effective than students' feedback. This view is challenged by Min (2008) who argues that students can also be trained in peer feedback so that it can be as effective as their teacher's. In contrast to Gielen's et. al. (2010) earlier preference of teacher's feedback to students, they also have some concern about their claim. This is because teachers have to give feedback to a lot of students in a lesson, and it may seem impossible for teachers to accomplish this, hence peer feedback would be considered important in this regard. Therefore, the challenge here is for science teachers to consider alternative means to plan activities where students will be engaged in giving feedback to each other which is a focus in this study.

Following on from the comments above about planning activities to engage students in feedback, the question to ask here would be which method of feedback will be considered most effective for learners. In response to this question, Wiliam (2011) pointed out that the timing of feedback depends on the kind of learning being undertaken, and immediate feedback appears to be most helpful where the task is well beyond the learner's capability. Whereas delayed feedback is appropriate for tasks that are well within the learner's capability. This implies that written feedback that may be used to help students in tasks that are above their capability may not help to move students' learning forward, as they have to wait until their books are marked by the teacher. Therefore, this study relies on the use of immediate oral feedback to students from both peers and teachers as a means to support students' understanding and knowledge development. This is due to the varied tasks they are engaged in, where some are above their ability. However, this view is not in line with the findings of Black et. al. (2003:43) who claimed that “comment only marking has more impact on students learning than other forms of feedback”. This view on written feedback is challenged by Alexander (2008) who argues that this has now become a concern in schools in Britain as the key means to show students’ progress rather than talk in lessons. Therefore Alexander (2008) encourages teachers to do less talking in lessons and engage students more in talk to promote their learning.

It may be important to highlight that schools adopt different methods of giving feedback to their students based on the schools’ policy. The school where this study took place uses comment and grade marking. In this situation, Black et al. (2003) may consider the aspect of grading students’ work as not being a productive means of formative feedback. This is because the grade does not tell the students the next step to improve their work. It is clear that comment only marking can support students’ learning but it is also important to state that some students may prefer oral feedback as a way to support their learning especially when the task is above their capability as stated earlier on. This applies to those students who may want to ask questions and get immediate feedback and ask other questions spontaneously. This means such students may be disadvantaged if they have to wait for comment feedback from the teacher in the next lesson as highlighted in the last paragraph. This situation of delayed feedback has been criticised by Hartley and Chesworth (2000) as not fulfilling the purpose of feedback, that is, to close the gap in students’ knowledge. Therefore, Gielen et. al. (2010) suggested that teachers should give regular feedback to students and involve students in giving feedback also, to make it more achievable. This view is supported by Cowie (2005), who in a study on student commentary on classroom assessment in science, makes it clear that students appreciate the teacher’s effort in involving them in their own assessments, and allowing them to ask questions and get feedback as well as giving them an opportunity to lead their assessment.

It is clear from the previous paragraphs that oral feedback forms need to be well developed in science lessons to cater for the needs of those students who may make progress in this way and fulfil their potential. In addition, Earl and Katz (2008) argue that engaging students in oral feedback is important, as this will enhance their metacognition and social construction (Adey et al., 2010). Whereas, Cowie (2005) argues that the feedback process that the students are engaged with, will help them to understand the Nature of Science. That is why this study focuses on the use of student-led questioning and feedback to improve students' engagement and attainment in Key Stage 3 secondary science. Therefore, it is important to state that students must also be supported to identify what good work looks like through the use of success criteria in lessons (Martin-Kniep, 2000; Juwah et. al., 2004) which can be a form of feedback to improve their learning.

2.12 Social pedagogy in the science classroom.

This section draws on different forms of discourse in the classroom and how they influenced this study. It argues that students can assume the role of the teacher in such discourse facilitated by the teacher. This study aims to encourage student-student interaction among Key Stage 3 secondary science students. Chin (2006), in a study on classroom interaction in science teachers' questioning and feedback to students' responses, makes it clear that teachers sometimes ask questions to find out what students know and also to correct any wrong answers. This process is referred to as Initiation, Response and Evaluation (IRE) by Cazden (2001). However, Chin (2006) argues that this IRE may limit the way students think and respond to questions and can affect the way they construct their knowledge. In addition, Van Dijk (2001) and Reinsvold et. al. (2012) argue that when teachers lead the IRE process, it may result in a social power relationship because they may dominate the discourse and assign roles to the students. This is an aspect challenged by Bourdieu who recognised that "cultural capital is a social relationship and that all students come with cultural capital through which certain students can exchange this cultural capital to improve their attainment" (Winkle-Wagner, 2010:8). Bourdieu further argues that this cultural capital (skills, abilities, norms) can be "cultivated" in a particular social setting (p8).

This study, therefore, resists the attitude of teachers' dominance by allowing students to control the learning process and talk in each other's zone of proximal development (Wells, 2012; Panofsky and Vadeboncoeur, 2012) where students will be confident in expressing their scientific knowledge. This means students will be engaged in asking questions and giving feedback to other students which does not limit the way they think but creates the opportunity for deeper learning in science, and an understanding of scientific concepts (Erdogan and Campbell, 2008; Adey et. al., 2010). This will enhance their learning and attainment in science. In view of this, Parkinson (2004) argues that activities designed to engage students must meet the requirements for their age group however, this is challenged by Adey et. al. (2010) who said that such activities should create opportunities for mental development of students. This view is further supported by Parkinson (2004:89) who makes it clear that "some students may have the ability to perform better than what is required of them for their age and stage of their mental development". This is in contrast to his earlier claim. This implies students must be engaged in challenging tasks such as questioning and feedback to enhance their learning.

Allowing students to lead their learning may favour a form of interactive and dialogic communication as suggested by Aguiar et. al. (2010). Hence, it is important to highlight forms of interactive discourse between teachers and students and state how this may be applicable to this study. Mortimer and Scott (2003) suggested three patterns of discourse, and a fourth pattern suggested by Lemke (1990). I have referred to these patterns as models for ease of understanding.

Model 1: I-R-E pattern in which the teacher initiates a question (I), the student responds (R) and the teacher makes an evaluation (E) in line with Cazden (2001).

Model 2: "This is the closed chain of interactions, I-R-P-R-P-R-E. The question is initiated by the teacher (I) and the student responds (R), followed by teacher prompts (P) to generate further responses. The sequence is finally closed with an evaluation (E) by the teacher".

Model 3: The open chain of interactions called I-R-P-R-P-R (Scott, Mortimer, and Aguiar, 2006) which has the same format as model 2 but does not involve an evaluation by the teacher.

Model 4: This is suggested by Lemke (1990) and called the question- and- answer pattern. This involves students initiating the questions and teachers responding to them.

The models that will be referred to are models 2 and 4 as this study's design has borrowed ideas from both of them. In this study, students' questions will be followed by students' answers, compared to Lemke's model 4 where students' questions are followed by the teacher's answers. In comparison with model 2 (I-R-P-R-P-R-E) where the teacher probes students to get further responses and make evaluations, this study allows students to do the probing and evaluation instead, to further enhance their learning. This implies that a new model of discourse will be developed in this study based on my methodology and highlighted in chapters 4 and 5. In addition to these perspectives, Sawyer (2006:2) makes it clear that:

> *"Students learn better when they express their developing knowledge either through conversation or by creating papers, reports or other artefacts and then are provided with opportunities to reflectively analyse their state of knowledge"*.

The view expressed by Sawyer (2006) about involving students in classroom discourse is in line with the purpose of this study as highlighted by models 2 and 4 above, which allow students to lead their learning and assessment. This also supports the claims made by Harris et. al. (2012) about creating opportunities to involve students in questioning and sharing their ideas, as this will help to engage pupils in their learning. I will be discussing those features that can be considered to constitute engagement of students in science lessons in the next section.

2.13 Research on students' engagement in Science

This section of the literature review explores strategies to engage science students in lessons and also defines features of engagement in lessons. This study focuses on the use of student-led questions and feedback to improve students' engagement and attainment in Key Stage 3 secondary science. This view of engagement as highlighted by Newton and Newton (2011) may have an impact on the way students are involved in activities in science lessons. Sampson and Blanchard (2012) posit that it will help to inform the nature of their scientific knowledge. However, Newton et. al. (2011) argue that the time students spend on such activities (for example, questioning and feedback) is a very important measure of their engagement. Therefore, when students are engaged in questioning and feedback in science lessons, these forms of engagement as argued by Cowie et. al. (2011) can improve their attainment. Hence, there is a need for further research into how to engage students in science lessons (Osborne, 2003; ASE, 2006; Reiss et. al., 2011). This includes ways to enhance the participation, engagement and achievement of students in science as challenged by Reiss et. al. (2011) who make this an issue of concern for science educators.

In alignment with students' engagement in science, Simon, Erduran and Osborne (2006) argue that students can also be engaged in a form of scientific argumentation, which may be dependent on teachers' pedagogical knowledge to support students in this type of assessment. Although scientific argumentation is not the focus of this study, it can be argued that some elements of scientific argumentation have been employed, for example teachers helping students to develop skills in supporting their scientific claims with evidence and in problem solving activities. Therefore, Cowie et. al., (2011:354) suggested three ways to increase students' engagement and participation in science which are also important in this study. These are "creating new ideas in assessment; allowing for students' funds of knowledge; and strategies for breaching the classroom walls". Students' funds of knowledge refers to the knowledge gained on their experiences outside school as pointed out by Olitsky (2007) and King and Glackin (2010), and this will enable students to contribute to their knowledge construction, which could also be a form of cultural capital that may enhance their learning and attainment as highlighted earlier by Bourdieu in chapter 2 of this thesis (2.1 theoretical framework).

Allowing students to contribute to their knowledge, arguably, will help teachers and students to identify any difficulties in students' learning (Hosp et. al., 2008) and also help students in self and peer assessments which contribute to their own learning and problem solving in science. In addition, teachers must also create opportunities for students to interact and use different research materials (Aguiar et. al., 2010; Cowie et. al., 2011) to support their learning in science. These materials may include text books, internet, worksheets and homework resources. All these materials will be used in this study to engage students in the problem solving tasks and to encourage the feedback process in AfL. In view of this, science teachers are encouraged to seek other assessment strategies in science to engage their students rather than depending on the science practical work alone (Magaji, 2008; Wilson et. al., 2011), which this study opposes. In support of this, the ASE (2006) argues that science teachers have the wrong notion that practical in science lessons will engage students, however most students have become bored in science lessons because of too much practical work. This view again is contrary to that of OFSTED (2013) who argue that teachers must engage students more in science practical in secondary schools to sustain their interest in the subject. However, in agreement with the view by OFSTED, Newton et. al. (2011) assert that engaging students in science practical alone may have accounted for this being the preferred means of students' assessments by teachers. However, in another context, Turner et. al. (2010) argue that some students consider science to be a difficult subject which is why they are not interested in the subject.

The discussion in the last paragraph suggests students are willing to be engaged in science learning but they may require other strategies to sustain their interest thus opening up other forms of engagement in science learning. Therefore, science teachers have the task of developing the right assessment strategies in their lessons to support students' learning. This may open up more opportunities for science lessons to be taught in classrooms in the school apart from the science laboratory (Williams, 2011). This requires flexibility in planning science lessons and adaptation to a non-science classroom. At this point it is important to ask at which Key Stage is it appropriate for teachers to engage secondary science students in various assessment strategies. This is a question I consider to be important in this study. Although I reported earlier in this literature review that this type of study can also be carried out in primary school (Key Stage 2), my focus is secondary school students. Simon et. al. (2010) in a study reported the views of various authors with regard to engagement of pupils in science. The outcome shows that pupils can be engaged in various assessment strategies between the ages of 10 and 14 year old. The finding suggests that earlier engagement of pupils in science will help their interest in the STEM-related careers, particularly girls.

The finding above as to which stage to engage secondary school students in various assessment strategies shows Key Stage 3 (ages 12-13 that is, year 7 and 8, in England) satisfies this purpose. Therefore, this study involved choosing year 8 students (13 years old) in Key Stage 3, at the second year of their secondary education, in order to sustain the interests which they may have developed in science in year 7 (Abrahams, 2009). In support of this, Adey et. al., (2010:100) make it clear that evidence from their work on using Cognitive Acceleration through Science Education materials showed “an increase in cognitive development of students in years 7 and 8, and higher grades in their GCSEs were attained for those in year 8”. The materials used to engage students in their study involved problem solving activities. This implies that when the right assessment activity is designed for pupils, it can have a positive impact on their engagement and attainment in science. This study supports this notion and encourages teachers to create opportunities for more student-led activities to give them ownership of their learning, whilst being facilitated by the teacher. I have found myself in a position where I thought something more needed to be done to support students’ assessment at Key Stage 3. This would involve not relying on assessments prescribed in the schemes of work. This has been the impetus behind this study as mentioned in chapter one. Therefore, it is necessary for teachers to consider ways to engage students in their learning in order to support their progress. The big question here is how can we measure students’ engagement in science lessons?

At this stage it is pertinent to consider factors that may constitute engagement in science. Darby (2005) in a study involving 11 and 12 year old students in an Australian middle school considered the type of instructions given to students and relationships developed in the classroom as key to their engagement in science. This is contrary to the views of Fielding-Wells and Makar (2008) who put it that time on task, attentiveness, and students willing to learn and involve in assessments is important in their engagement. However, Olitsky (2007) argues that students’ interests in their learning in a supportive environment where they are emotionally comfortable, in addition to their prior knowledge constitutes engagement. Put differently, McCombs et. al. (2007) argue that a change in students’ attitude, commitments and behaviour constitutes engagement. This is different from Black’s et. al. (2010) views of active learning which involves students listening and contributing to discourse in science lessons. Given these views by different authors on how to measure engagement in lessons, it is clear that teachers must provide a conducive environment to encourage students’ interest in their learning, and create assessment opportunities to engage students in classroom discourse. This will help them to discuss issues in science and improve their understanding of the Nature of Science, which I will be exploring in the section below.

2.14 Nature of Science in the science Curriculum

This section explains how an understanding of the Nature of Science (NoS) can support students to learn about processes in science and link this to science in real life situations. Teachers are required to develop lessons around science topics in order to support students' learning and assessment. In addition to this, Williams (2011) suggested that activities leading to problem solving can be created around such topics in lessons to aid students' learning, a view supported by Hogg (2010) that it will enhance students' critical thinking and engagement in science. Similarly, Hohenstein et. al. (2010) and Cowie et. al. (2011) pointed out that this will allow the students to apply what they know from previous experiences, and contribute to the current knowledge generation. This may be linked to the aspect of students' funds of knowledge, that is, knowledge gained from experience outside the classroom, which was highlighted earlier as constituting engagement in science. In line with this Toplis and Cleaves (2009) and Windale (2010) posit that this form of engagement is an important step towards making students understand science, as this will enable them to apply science in their everyday life experiences which will reflect How Science Works (Grime, 2012; Millar, 2012).

The concept of How Science Works (HSW) is very important as it also help students with the process of scientific investigations (TES, 2013). This includes planning an investigation; obtaining data; presenting evidence and analysis; and evaluating. It support students in their communication skills. Golabek and Amrane-Cooper (2013) make it clear that HSW is a concern in teaching science because teachers sometimes do not plan for this in their lessons, therefore failing to engage students in a way that will increase their interest in science subjects. Hence, Parkinson (2004) and Golabek et. al. (2013) encourage teachers to understand the Nature of Science in order to apply the concepts of HSW in lessons. In line with this view, Millar (2010) and Osborne et. al. (2010) argue that students must also be taught how to understand the Nature of Science as this will enhance their learning and improve attainment. Therefore, Golabek et. al (2013:30) make it clear that the Nature of Science is the “sociology and philosophy of science which can help the development of knowledge in science”. The Nature of Science that may apply to this type of study as put forward by Golabek et. al (2013) are scientific investigations, scientific thinking and social and cultural influences on science. The implication here is that for teaching and learning to be effective both teachers and students must be involved in developing their understanding of the Nature of Science (TLRP, 2005b). In addition, Williams (2010) suggests that science teachers must engage students with activities that will enable them to think and understand processes which they can apply to solve problems rather than teaching facts as is sometimes the case.

In the paragraphs above, I have highlighted the importance of the NoS in students' learning and also the need for students to be supported in understanding the NoS, as it will bring about improvement in how they relate to scientific processes, in addition to applying HSW. It is clear that the authors mentioned have considered the role of students in their own learning and assessment, a view I have shared at different points in this thesis, and which has been the focus of this study. Therefore, this study encourages science teachers to seek alternative means to engage students as over dependence on practical work by teachers as noted earlier can result in students only being taught facts. Having said this, I am also aware from my experience that students have different learning needs and their responses to teaching and learning strategies may vary. This may be due to some barriers that militate against their learning, which I will be discussing in the next section.

2.15 Barriers to learning

This section explores some of the barriers that may prevent students from fulfilling their potential as learners and partakers in their own assessments. All students are required to make progress in every lesson and teachers are required to facilitate this learning process. However, some factors among students may inhibit their learning. McCombs et. al. (2007:46) grouped these factors as “cognitive and metacognitive; motivational and affective; developmental and social, and individual differences”. These groupings have been challenged by McCrory (2008) who argues that it may be difficult to separate cognition and affect. With reference to science, Millar (2012:22) noted that “learning science poses both cognitive and affective challenges for the learner”. This means the process of knowledge creation by the students may be influenced partly by their feelings (Smith, 2007) and also partly by the kind of activities that they are engaged with in the classroom. Both factors may pose as barriers to their learning. In contrast Hosp et. al. (2008) postulate that the subject content and resources available to students, as well as their setting in class rooms and social backgrounds may hinder their learning. However, with reference to the views on subject content, Simon and Osborne (2010) argue that gender preference is most important. This reiterates the idea of boys preferring activities involving science practical work, more than girls. This brings to light gender differences in engaging students in science, an issue highlighted by Ofsted (2013) who argue that too few girls study Physics after the age of 16.

In line with the barriers mentioned above, Ofsted (2002) blamed lack of curriculum continuity from Key Stage 2 to 3 as a hindrance to students learning. Therefore, this must be considered by Key Stage 3 teachers in order to support students during their transition from Key Stage 2 to Key Stage 3. I know that from my discussion with the member of staff responsible for assessment in the school where this study took place, there has been some consultations with the feeder primary schools (schools where students are recruited from, to join the secondary school), to share assessment criteria across Key stages 2 and 3, to better support pupils’ progression. I will discuss more on this issue in chapter 4 when talking about the national curriculum reform on assessment without levels. Still on barriers to learning, the view of Simon et. al. (2010) is that when teachers have good subject knowledge, most of the barriers to learning can be overcome by students. In a different context, Fairbrother (1993) argues that assessing scientific skills can be a problem for teachers. This is an important aspect in this study. Therefore, strategies must be devised to monitor students’ progress and attainment formatively. However, using ideas from Cohen, Manion and Morrison (2007) a scoring system on a Likert scale with success criteria can be adopted in such a situation as this study presents.

2.16 Conclusion

In order to improve students' engagement and attainment in Key Stage 3 science, the literature suggests five themes of which Assessment for Learning is a key: engaging students in developing their own questions; supporting students in giving feedback to each other; encouraging independent learning and giving students autonomy of their learning in the Initiation, Response and Evaluation model of interaction; helping students to understand the Nature of Science and How Science Works; and addressing barriers to students' learning. These factors are considered significant for example, Nicol (2007) argues that engaging students in questioning and feedback will empower students to take ownership of their learning, with a view to improving their engagement and attainment. However, in the case of students developing their own questions and giving feedback to each other, the literature shows that too much emphasis has been placed on teachers' questioning (Wragg et. al., 2001; Clarke, 2008; TLRP, 2010). This will hinder teachers from putting strategies in place to support students in science. This is because Gielen et. al. (2010) consider teachers to be trained professionals in questioning and giving feedback to students. Therefore, Bergman (2009) encourages teachers to give students some question prompts to support them in developing their own questions.

It is important to state here that giving students question prompts will help them to develop questions but it does not assist them in understanding the quality and hierarchy of questions developed. That is why engaging students in using Bloom's taxonomy to develop questions (Zheng et. al., 2008) as utilised in this study will help to develop students' questioning and thinking skills (Adey et. al., 2010) required to bring about an improvement in their engagement and attainment. This is because the quality of the questions students ask can influence the kind of feedback they will receive as good questions (high level ones) will elicit good feedback (Earl et. al., 2008; Hayes et. al., 2008; Hodgen et. al., 2008). Despite the importance of focused assessment on students' learning (for example questions and feedback), evidence from literature has shown that students are more engaged in Drama, Physical Education, English and Art lessons (Darlington, 2012; Turner et. al., 2010), with regard to asking questions and giving feedback compared to science lessons. Therefore, there is a need for more research into how to improve students' engagement and attainment in science lessons (ASE, 2006;

Reiss et. al., 2011). This may involve creating the right environment where students are engaged in using research materials, text books, work sheets and other sources of information (Cowie et. al., 2011) to develop their questioning and feedback skills.

The type of learning activity described above will improve students' understanding of the Nature of Science and apply the concepts of How Science Works in their explanation of scientific phenomenon (Golabek et. al., 2013). This kind of learning will exemplify a constructivist learning environment which has been found to be lacking in many science classrooms (Blumenfeld et. al., 2006; Savasci et. al., 2012) because students just memorize facts and procedures, and are not engaged in deeper learning through questions and feedback, which enables them to take ownership of their own learning. In addition some factors that constitute barriers to students' learning have been identified (McCombs et. al., 2007; Hosp et. al., 2008) and this will hinder students' engagement and attainment. However, when science teachers use the right AfL strategies such as questions and feedback as used in this study, students can overcome these barriers to their learning.

CHAPTER 3
METHODOLOGY

3.0 Introduction

There are several parts to this chapter. First, I will outline the research paradigm adopted in this study and give an overview of my research design. I will state the main research question and subsidiary questions. This will be followed by the theoretical perspective which informs the design of this research. Next, I will discuss the techniques of enquiry used in this research which constitutes a mixed method approach and would justify the study as an action research and state my position as a researcher. Finally I will summarise the ethical considerations and approval in this study and conclusion.

3.1 Research Paradigm

This study focuses on the use of student-led questions and feedback to improve students' engagement and attainment in Key Stage 3 secondary science. The research paradigm adopted in this study is a constructivist paradigm which involves students creating their own knowledge which form an interpretation of their own world (Parkinson, 2004; Adey et. al., 2010). This paradigm fits into the model of Assessment for Learning in the classroom (Clarke, 2005) which is a focus in this study. The students involved in this study were engaged in making sense of their own learning by contributing their views on the topic Food and Glorious Food in the science syllabus (Key Stage 3 National Curriculum, England, 2013) which was used as a problem solving activity. Being a scientist conducting a science based research like this, adopting a positivist paradigm which involves collecting and analysing quantitative data would have been the norm (Cohen et. al., 2007). However, the focus of this study lends itself to a qualitative approach with constructivist paradigm different from the positivist paradigm as mentioned.

3.1.1 The main research question

This is a mixed methods study framed within a Constructivist paradigm approach to research in order to examine this main research question:

- How can both student-led questions and feedback be used to enhance students' engagement and attainment in a Learner-centred Key Stage 3 science classroom?

This research question has been identified in the literature review as a concern in teaching and learning in schools in Britain (Alexander, 2008) that requires further study, especially in the area of students developing their own questions and giving feedback to their peers, a view which the ASE (2006) and Reiss et. al. (2011) also indicate has become a concern for schools and science educators in engagement of students in science.

3.1.2 Subsidiary research questions

This study focuses on using student-led questions and feedback to improve students' engagement and attainment in Key Stage 3 secondary science, which OFSTED (2013) consider will be a way of enhancing students' achievement in science. The subsidiary research questions are also areas of concerns identified in the literature review which has been informed by the main research question. Thus, the subsidiary questions are:

- How can student-student interaction in questioning and feedback be used to improve students' engagement in science lessons?
- What is the nature of teachers' perceptions in the use of questioning and feedback in engaging students in science lessons?

3.2 Theoretical perspectives

This study is influenced by my ontological perspective of how teaching in the science classroom may be portrayed in a way to engage students in leading their own learning and assessment as active learners. Therefore this study was based on an "inductive approach" to research as plans were made to collect data and answer the research questions to see the patterns that emerged (Gray, 2009:14). I am also aware that a "deductive approach would have involved testing a hypothesis which may be confirmed, modified, or refuted" (Gray, 2009:14) and does not apply to this study. My constructivist approach to learning has influenced the method of data collection (tables 3.1 and 3.2, pages 56 and 69-70 respectively) which involved lesson observation of students solving problems (appendix 6) leading to questions and feedback led by the students. As a follow up to the lesson observation, I interviewed the teachers involved to seek their perceptions of how the questions and feedback has engaged the students. In addition, questionnaires were also used to find out how the questions and feedback has improved the students' engagement supported by the field notes collected. End of unit science test results pre and post data collection were compared to ascertain the value added score to find out how the questions and feedback has improved the attainment of the students involved. The methods of data collection and analysis are discussed in detail in this chapter.

3.3 Overview of research design

The research design has been carefully considered in two different phases as put forward by Cohen et. al. (2007:78) who make it clear that the researcher must consider the "divergent and convergent phases of research planning". The divergent phase enabled me to consider different methods (for example observation) and methodology (action research) available to deal with my research questions while the convergent phase enabled me to sort out these options and decide which combinations best address the research questions. An overview of the research design showing the relationships between the different variables considered is shown in table 3.1 below.

Table 3.1: The relationships between ontology, epistemology and theoretical perspectives, and how they influenced my methodology and research methods

Ontology and Epistemology	Theoretical perspectives	Methodology	Methods
Epistemology in this study is Constructivism	• Interpretivism/ Constructivism (Charmaz, 2006) -symbolic interaction	Action research Empowerment research	• Questionnaires • Interviews • Observations - audio recording - field notes - Likert scale for scoring students' presentations • End of unit science test results, value added calculated

3.4 Description of the sample

This study was conducted using two groups of classes in the science department identified by the school as part of the raising students' achievement in science. The students were chosen because the school wanted them to improve on their attainment with some forms of interventions.

The number of students involved in the study was 52, with mixed ability and gender, in Key Stage 3, year 8 (ages 13 years old), in a secondary Academy. Data collected on the 52 students was based on lesson observation of questions and feedback led by the students after problem solving tasks. Two teachers were involved in the lesson observation, and interviewed afterwards. A total of twelve teachers completed a questionnaire. In addition analysis of the data on observation was limited to the 52 students involved making it easier to use all the data for analysis (Newby, 2010) rather than comparing with a control group of similar students. In keeping up with this study being an action research study, McNiff and Whitehead's (2002) advice is to keep the research small and focused to understand the issue more.

To justify the samples used in this study, I make reference to a study conducted by Chin (2006) on classroom interaction in science- teacher questioning and feedback to students' responses, which also involved only two teachers whose students were engaged in a discourse. In a different study to investigate the affective value of practical work in secondary school science, Abrahams (2009) limited his interviews to only the teachers whose lessons were observed, as this allows the "researcher to focus on the observation of actual practices conducted in the context of the observations" (p2340). This justifies the involvement of two teachers in my study as reliable data can be generated with such a limited sample. Thus, the samples used in this study were deemed right for analysis to provide reliable and valid results for the research questions.

3.5 Data collection methods and analysis

This study is predominantly a qualitative study, however, some of the data collected were analysed both qualitatively and quantitatively making this a mixed method study (Creswell and Plano Clark, 2007). The questionnaire questions were developed "concurrently" in both quantitative and qualitative methods (Gray, 2009:209) as discussed under the questionnaire section in this chapter (page 61). In addition to observation being the main data collection method adopted, Scott, et. al. (2007) and Newby (2010) stated that such observation will allow the collection of quantitative and qualitative data. The methods of data collection and analysis (table 3.2, pages 69-70) and why they are used, will be discussed in this section. This includes observation, questionnaire, interviews, and end of unit science tests. Collecting different data allowed me to conduct triangulation of my data, to verify its validity and reliability**.**

3.5.1 Observation

This study focuses on the use of student-led questions and feedback to improve students' engagement and attainment in Key Stage 3 secondary science lessons. Observation method formed the basis of this study and was used to collect data for the main research question (3.1.1) and my first subsidiary question (3.1.2). The observation took place in the classroom in term 5 of the academic year (April-May, 2013). The school where the study took place has six half terms in each academic year lasting 6-7weeks. A unit or two in the syllabus comprising different topics is taught in each term. At the start of the year, teachers are assigned units in the National Curriculum to teach on a rota basis. The unit used in this study was the Food and Glorious Food topic which is required to be taught in year 8 in the National Curriculum subjects (Chapman et. al., 2001; Gannon, 2003). I chose four different topics under the unit for the problem solving activities (appendix 6) that will interest students and engage them in some forms of discourse. However, I am aware that all students cannot reach the standards of performance required of them at the same time (Martin-Kniep, 2000).

Two teachers were involved in observing 52 students, that is, 26 students from each teacher's class. The students were divided into 6 groups and each consisting of 4 students. The students were allowed to choose members of their groups based on those they think they would work better with and or receive the necessary support. The groups were assigned four different problems to solve and the criteria to be met for each standards (appendix 6). This meant that out of the 6 groups, two groups were assigned similar problems to solve. Assigning the same problem to that group of boys and girls meant I could compare performances of certain groups of interest. The teachers assigned the problems based on the students' abilities from each group, that is, the tasks were differentiated. The students read the tasks in their groups to allow ease of understanding. The students researched the assigned problem solving tasks in their groups over two lesson periods in a week for three weeks. A lesson in the school where this study took place lasts 55 minutes. The students gathered information from their exercise books, text books, previous homework tasks, resources provided by the teacher, and internet resources as suggested by Cowie et. al. (2011) as this will foster active engagement and commitment of the students in understanding the problems.

I am aware of the data to be recorded during the lesson observation (Gray, 2009) and this included audio-recording of verbal interactions between students (questions and feedback) during presentations of their findings from the problem solving tasks. This was also done over two lesson periods in a week for three weeks. The students developed their own questions using Bloom's taxonomy question prompts (Bergman, 2009) provided by the teacher (appendix 1) and also gave feedback to other students. The teacher facilitated the process and encouraged students to ask high order questions on Bloom's taxonomy as this will enhance their attainment (DFES, 2004; Zheng et. al., 2008) based on the feedback they were engaged in. In addition to the questions and feedback, the teachers involved scored students' presentations based on some success criteria on a scale of 1-5 (appendix 13) with idea from OSLA (2012) model of inquiry to keep them engaged in the tasks. This idea of using success criteria to score students is encouraged by Martin-Kniep (2000) who argues that the success criteria will enable the students to know what good work looks like and support them in producing high quality work as mentioned in my literature review. Therefore, using a Likert scale to score students' presentations enabled me to collect quantitative data (Cohen et. al., 2007) while observing the students during the questions and feedback. This type of observation is said to be a "systematic observation" (Scott et. al., 2007:241) because it allowed both qualitative and quantitative data to be collected (Newby, 2010) based on the observation.

The teacher as an observer in this study is "inactive and known" (Newby, 2010:367) by the students. This allowed the students to talk in each other zones of proximal development thereby eliminating any form of teacher's dominance as seen in model 1 of discourse that is, Initiation, Response and Evaluation (page 43). However, students were allowed to challenge other students' views and if any wrong answers could not be corrected by the students, then the teacher could give an alternative answer and feedback (Reinsvold et. al., 2012). In addition during the lesson observation field notes were recorded on those attitudes that constituted engagement in learning during the problem solving activities. The field note was used as an additional means of data collection. Based on the focus of this study, audio-recording of students' interaction was considered most appropriate rather than using a field note as all comments made by the students were recorded (Gray, 2009), an action which may not be achievable using a field note. As observation formed the main data collection method, I recorded some "context data" (appendix 14) as advised by Newby (2010:369) to describe factors in the environment that may lead to barriers to learning, which were not mentioned in the literature review page 49). Newby makes it clear that these context data may not necessarily be required to answer the research questions.

At this stage I am aware that observation as a method of data collection has its own weaknesses. Scott et al. (2007) and Newby (2010) noted that observation as a research method may encounter different forms of bias, for example the researcher may be interested in those observed features that confirm their research questions, and sometimes their judgement of an issue may not be right. This bias was avoided because I was not involved in observing the students. In addition the teachers carried out the lesson observation voluntarily (see appendices 4 and 5 for teacher's consent letter and participant information sheet respectively). Another issue raised by Gray (2009) and Newby (2010) is that of ethical concerns in observing children in the classroom. To deal with this, I ensured that parents and students completed consent letters (appendix 4).

3.5.2 Data analysis for observation

The data collected on audio-recording of students' interaction (questions and feedback) was transcribed and content analysis used to identify patterns and categories within the text (Cohen et. al., 2007; Gray, 2009), based on words that conveyed similar meanings to the words used by the students in the transcripts. Due to the large data obtained from the questions and feedback, NVIVO 10 (Penna, 2013, QSR, 2012) was used as a suitable tool to further analyse the categories that emerged from the content analysis, which are referred to as nodes in NVIVO. For ease of coding with NVIVO 10, I used a parent node as guided by Penna (2013), and grouped other sub nodes or children nodes under the parent nodes, for example, a parent node used in this study was nutrition, and other sub nodes such as nutrients, diets and dieting, were placed under it. Several nodes were generated from this study, however, only those that are linked to engagement of students; student-student feedback; and teachers' feedback were used in the discussion in chapter 4 to present my findings. NVIVO 10 made it easier to analyse the nodes generated as it automatically counted the frequencies of their occurrence rather than doing this manually which would be time consuming.

I used code numbers from 1-6 to rate questions developed by students based on Bloom's taxonomy rating scale (Zheng et. al., 2008). This enabled me to identify the types of questions generated by the students ranging from low to high order ones. The total number of questions developed and percentages were calculated and presented on a table, and used in a pie chart and bar graph to show the trends in the types of questions developed by the students. In subsidiary research question 1 (3.1.2), the audio-recorded interactions of students was used to compare the quality of questions and feedback generated by the students. This included how the students were able to apply scientific keywords in their explanations, and identifying any misconceptions associated with it. Scores obtained from students' presentations based on the success criteria were analysed to calculate average scores for all five criteria used to judge students' engagement. It was also used to calculate the average scores on students' questions and feedback (appendix 11). Some of the responses analysed from the interview transcripts (appendix 8) was also used to answer subsidiary research question 1.

3.5.3 Questionnaire

The questionnaire questions were considered “concurrently” through both quantitative and qualitative methods (Gray, 2009:209) to enable me to understand how questioning and feedback can be used to support Key Stage 3 science students' engagement and attainment. However, Gray (2009:209) also advises that a questionnaire can be designed in a mixed method “sequentially” with the questions analysed quantitative then qualitative; and qualitative then quantitative. The questionnaire (appendix 2) has been informed in the following ways: by the pilot study carried out within the preliminary investigation (3.9 pilot study) involving other colleagues in improving the questionnaire; from questions drawn in the literature review, for example how long does a teacher wait for a student's response after asking a question? (Smith, 2007; Ecclestone, 2008). Developing questions with different sources of information as used here ensured the validity of the outcome (Arksey and Knight, 1999). The questionnaire was designed to answer my main research and subsidiary questions (3.1.1 and 3.1.2 respectively). The type of questionnaire used in this study is a semi-structured one (Cohen et. al., 2007) which considered both open and closed questions. In the course of developing my questionnaire (appendix 2), I kept the words simple and short to allow ease of understanding by the participants (deVaus, 1996, 2002; Newby, 2010) and also avoided complex and leading questions as suggested by deVaus (2002) which may make the questionnaire difficult to answer.

As discussed above regarding the questionnaire, it is important to state that all the respondents were science teachers. The wording of the questions were directed towards their practices as professionals in the classroom as well as using questions guided by the literature review. This included finding out what sort of questions students ask during lessons (Wragg et el., 2001); how effective is questioning and feedback in supporting students' learning in lessons (Black et. al., 2003; Hodgen et. al., 2008). I started the questionnaire with simple closed questions (questions 1-16, appendix 2) and then moved onto open ended questions (questions 17-21, appendix 2) as suggested by Cohen et. al.

(2007). Following this pattern also ensured that the closed questions helped to support some information and theories in my literature (Creswell, 2012). In one closed question (question 2, appendix 2), I was interested in finding out teachers' views on whether they think involving students in questions and feedback can improve their engagement and attainment, a view supported in my literature review chapter. In addition the open ended questions allowed the teachers to answer the questions in their own words to give a truer indication of their perception of how student-led questions and feedback can be used to improve students' engagement in science (Cohen et. al., 2007; Newby, 2010; Creswell, 2012), and to cover areas not addressed by the closed questions.

The reasons for using a questionnaire rather than an interview in this situation is that questionnaires are "easy to use and can generate lots of data" (Newby, 2010: 333), and it is less time consuming compared to interviews. In addition teachers are always very busy and difficult to track down for interviews. I am aware that in using questionnaires there are some problems that may hinder the collection of accurate data, and Newby (2010:314) encourage new researchers like me to avoid "bias questions where respondents may find it difficult to respond to certain questions requiring them to agree or disagree". I was careful in avoiding such pitfalls in questions 11 and 12 in the questionnaire (appendix 2) which would have been difficult for the respondents to answer. That was why I used a Likert scale (Cohen et. al., 2007) to avoid bias and ensure ease of response. I used 5 scale points on the Likert scale as guided by Newby (2010:319) who consider "5 and 7 scale positions as the tried and tested numbers commonly used in research as it gives options to respondents". A total of twelve questionnaires were completed by the teachers without my presence in order to ensure anonymity (Cohen et. al., 2007) and eliminate any bias in their responses, which may have occurred if I was present.

3.5.4 Data analysis for questionnaire

In answering subsidiary research question 2 (3.1.2), a total of twelve science teachers completed some questionnaires in order to seek their perceptions on the use of questions and feedback in engaging students in science lessons. Their responses to the questionnaires were analysed manually due to the small sample (Cohen et. al., 2007) and also to allow me to familiarise myself with the data rather than using computer software

(Gray, 2009). However, if the sample was larger I could have analysed the data using SPSS (Pallant, 2009). The outcome from the questionnaire analysis was used to answer the main and subsidiary research questions. The questionnaire comprised closed and open-ended questions with 21 questions in all. The questionnaires were analysed in two parts, part 1 was the analyses of questionnaires completed by ten teachers; and part 2 the analyses of the questionnaires completed by two teachers. This is because the two teachers had previously completed a similar questionnaire and had to complete it again after the lesson observation in which they were involved. This enabled them to include their experiences of what they observed among the students in the lessons (Chin, 2006). Questions 1 to 16 are closed questions and analysed manually by assigning code numbers to the variables considered. In the case of gender, male was assigned 1 and female 2 (appendix 12). This made the data easier to interpret (Cohen et. al., 2007). Questions 17 to 21 are open questions and were coded to identify common themes in the text using content analysis (Gray, 2009). The two questionnaires completed by the two teachers were also subjected to similar analyses and their responses compared to the outcome from the ten teachers.

3.5.5 Interviews

This study focuses on the use of student-led questions and feedback to improve students' engagement and attainment in Key Stage 3 secondary science lessons. Interviews were used to answer the main and subsidiary research questions (3.1.1 and 3.1.2). The interview was audio-recorded rather than writing down the interviewees' responses. This enabled me to capture all the comments made by the interviewees and the tone of their voices (Cohen et, al., 2007). Ethical consideration was adhered to before the interview, such as the confirmation of the confidentiality of responses (see appendices 4 and 5 for consent letter and participant's information sheet respectively). The interview questions (appendix 8) was partly informed by the outcome from the questionnaire analysis while other questions were based on the lesson observations carried out on students (Chin, 2006). One question asked the interviewees to state the attributes of engagement based on the lesson observation. Questions were also drawn from my literature review on Assessment for Learning. One of the questions asked how the teachers would develop their students' questioning skills and get them more engaged in lessons (ASE, 2006; Reiss et. al., 2011).

Conducting the interview schedules with questions drawn from various sources as stated above ensured the validity and reliability of the data obtained as argued by Arksey et. al. (1999). The type of interview used in this study is a standardised one (Cohen et al., 2007; Scott et. al., 2007). This is because the questions were determined in advance and the interviewees were asked the same questions in the same order (appendix 8). However, during the interview, I included some elements of probing in response to the interviewees' comments such as "Do you think this is what we can practise with the students and get them used to it?" This encouraged the interviewees to express themselves further and confirmed previous comments made rather than withholding information required by me. This probing is a feature of a semi-structured interview and not considered in a standardised interview. Therefore, it would not be misleading for me to adopt the term for the interview conducted as a standardised semi-structured one. The strength of using a standardised interview was that it enabled me to compare the responses of the interviewees and allowed ease of data analysis (Cohen et al., 2007).

I used interviews because this method allowed the teachers to express their views on students' engagement in science using questions and feedback (Cohen et. al., 2007; Gray, 2009) as an Assessment for learning strategy. Interviews also enabled me to ask extensive questions and get more responses from certain issues that may not be covered in the questionnaire. In one of the questions I requested the teachers to express their views on what constitutes engagement in learning from the lesson observation of students they carried out (appendix 8). In addition Morgan (1988 cited in Cohen et. al., 2007) argues that more data will be collected from interviews than using focus groups with the same number of people as in interviews. Therefore, I make a case here that considering the limited number of people interviewed in this study, more data was generated to answer the research questions. However, Gray (2009) and Creswell (2012) made it clear that a problem may arise when interviewees withhold some important information required for the data, and the interview may be limited to particular individuals which may also affect the responses obtained. I am also aware that interviews can be time consuming especially where it involves teachers who are very busy and sometimes difficult to track down. The alternative, to save time, would be to use a focus group instead of interviewing (Gray, 2009). Unfortunately, the problem with focus groups is that one participant's view may be influenced by the others and sometimes all participants may not have an equal opportunity to contribute to the discourse (Newby, 2010; Creswell, 2012). In addition, the interviewer may not be able to recognise the voices of the interviewees making it difficult to compare their views.

3.5.6 Data analysis for interview

I interviewed two teachers whose classes were used for the lesson observation in order to allow them to focus their views on students' engagement in science based on what they observed in the classroom (Chin, 2006). Content analysis was used to identify the themes from the interview transcript (Cohen et. al., 2007; Gray, 2009). I read the transcripts from the interview several times to become familiar with the content as advised by Sapsford and Jupp (2006) and Cohen et. al. (2007), in order to enable ease of analysis and also identify some codes in the data. I placed the data on a word document and assigned a number to each line of words. I went through the data, line by line and wrote a "descriptive code by the side of each piece of datum" (Cohen et. al., 2007:480) to show the meaning of the words used by the teachers, and how the words show engagement of students in science lesson. However, as a check, I reflected on some pre-codes that constituted engagement of students in science lessons based on my literature review, for example, questioning and feedback as stated in page 44. This reflection is important as Sapsford et. al., (2006:171) noted that such pre-codes should be "aligned with the research context". This meant that I was able to compare the codes developed from my data showing students' engagement (table 4.1, page 79) and that of existing literature, which further enhanced categorization of my data.

The codes generated were independent of my own views on students' engagement in science lessons as well as that of the literature review used in this study. The codes were based on the exact meaning and similar meaning of the words used by the teachers in the interview, which allowed the codes to show the true meaning of the words used (Sapsford et. al., 2006). However, the problem of using one method of coding, that is, using the exact meaning of words as argued by Cohen et. al. (2007) is that it will lead to a high number of data loss. This is because it may be difficult to code the exact meaning of every word and the message it conveys. After coding my data, I identified patterns and themes that were closely related and categorized them based on words with close meanings as Cohen et. al., (2007) argue that words and single codes on their own do not hold importance in coding data. In some situations I asked the teachers to clarify the meaning of the words used during the interview as this supported the validity of the data collected. In one instance, I asked the teachers to clarify comments made on students taking ownership of their learning and independent learning (appendix 8). The codes developed were further subjected to scrutiny by the teachers involved to improve the reliability and validity of the data obtained. I counted the frequencies of codes developed in each category (Creswell, 2012; Denzin and Lincoln, 2013) and presented on table 4.1, page 79. This allowed me to show the trend among the factors that constituted engagement in science at Key Stage 3.

3.5.7 End of unit science test

The end of unit science test was based on the topic Food and Glorious Food as used in the questions and feedback sessions. At the end of each teaching unit of a science topic lasting 6-7 weeks, students are tested using a standardised end of unit science test to ascertain their attainment measured in levels at Key Stage 3 in England. The science test used in this study was conducted in term 5 as the study took place in term 5 of the academic year between April-May, 2013. Therefore, end of unit science test results of individual students after the study (end of term 5) were compared to their previous attainment in term 4 (achieved before the study) to see if any value was added (appendix 10). Students' levels were based on the National Curriculum levels for Key Stage 3. These levels of attainments are further divided into sub-levels, for example, level 4, can have a sub-levels of 4a, 4b and 4c. A student on level 4a is considered to have made more progress than 4b, and 4c respectively. A student on level 4b has also made more progress than a student on level 4c. The value added scores in this study was calculated by comparing the differences between students' levels attained in terms 4 and 5 where, for example, in the results table in appendix 10, student 1 scored level 5c in term 4 and level 6b in term 5. This meant that the student made one level of progress and a sub-level added, moving from 5c through to 5b, 5a, 6c and 6b.

The students' scores in appendix 10 are referred to in my discussion chapter. This was used to check if the intervention (questions and feedback) in this study has improved students' attainment (Scott et. al., 2007). However, Cohen et. al. (2007) and Creswell (2012) argue that performances of the main group in a study like this can be compared to a control group in order to determine any progress made. This is supported by Torgerson (2003) and Newby (2010) who make it clear that the statistical implication in such a situation will be based on calculating the effect size, which compares the performance of students in the experimental and control groups. This is because effect size will show the "extent to which the intervention has had an impact on the performance of students and not on the significance of the difference" (Newby, 2010:577) in contrast to using the value added scores. After calculating the effect sizes, Torgerson (2003:82) suggested that all the data should be "pooled in a meta-analysis which means that the effect sizes from each trial is weighted by the trial's size" and this is done using a software program.

Reflecting on the effect size, I would argue here that this study is designed to ascertain an individual student's progress through formative assessments compared to other students involved in the study, as well as reporting collective progress made by all the students. In view of this I converted students' scores from the end of unit science test results into levels of attainment (appendix 10) which is normally used to determine the students' attainment at Key Stage 3, rather than using raw scores from the science test which may be required for calculating the effect size. This implies that meta-analysis is not suitable in this study, and also comparing the scores of the students involved in the intervention with other groups may deviate from the focus. In addition this study is an action research one with interventions on some focused students, therefore using a control group will raise some ethical issues in the area of giving all students equal opportunity to learning. I used results from the students' end of unit science tests to back up the outcome from the formative assessments (Waind et. al., 2012), as the use of tests to ascertain students' final attainment has been challenged by DCSF (2009) on the basis that it does not give a true indication of students' ability in Key Stage 3 assessment.

In line with the argument put forward by DCSF (2009) in favour of formative assessment, I am aware that at the time of this study, there has been a proposal by the Government to remove levels of attainment when schools are reporting pupils' progress. This meant that reports would be done formatively highlighting what pupils have achieved and what they need to do to improve. This idea supports the purpose of this study where formative assessment is key to reporting outcome from students' assessment while the end of unit test with levels was used as a backup. I will discuss more on the use of levels and any shortcomings associated with them in chapter 4 when analysing data from students' end of unit tests.

Table 3.2: Methods of data collection and analysis

Research Question	Sample numbers	Methods of data collection	Method of data analysis
RQ1: How can both student-led questions and feedback be used to enhance students' engagement and attainment in a Learner-centred Key Stage 3 science classroom?	Main research group First group: number of students 26, year 8 class (ages 13) Second group: Number of students 26, year 8 class (ages 13) 12 teachers completed questionnaires 2 teachers interviewed	Audio recording of students' questions and feedback by the two teachers involved in data collection End of unit Science tests results Questionnaires Interviews Field notes	Content analysis Audio recording transcribed and uploaded onto NVIVO 10 to identify themes Questions developed were categorized using Bloom's taxonomy Total for each question was presented on a table and bar graph, and percentages calculated for use on a Pie chart. Examples of teacher's feedback, and comments from interviews Comparison of results from end of unit Science tests pre and post data collection for value added. Questionnaire and Interview analyses

Subsidiary Question 1: How can student-student interaction in questioning and feedback be used to improve students' engagement in science lessons?	Same number of students as in main research question 12 teachers completed questionnaires 2 teachers interviewed	Audio recording same as above. Scoring students' presentations using a scale of 1-5 Field notes Questionnaires Interviews	Compared quality of questions and feedback from students and checked scientific terms used and misconceptions. Categorized questions created using Bloom's taxonomy. All criteria scored for individual students during presentations were analysed to calculate average scores and percentages. Questionnaire and Interview analyses
Subsidiary Question 2: What is the nature of teachers' perceptions in the use of questioning and feedback in engaging students in science lessons?	12 science teachers. 2 teachers interviewed	Questionnaires Interview	Content analysis of interview Questionnaires analysed to inform interview questions. Questionnaires given to two teachers again after data collection.

3.6 Triangulation

I used different methods of data collection (table 3.2, pages 69-70) and each research question has been addressed by more than one method of data collection which ensured the reliability and validity of the outcome (Schostak and Schostak, 2008; Newby, 2010). This fulfils a mixed method research approach and allowed me to study the research questions in detail (Scott et. al., 2007; Gray, 2009).

3.7 Research methodology

In the following section I will outline the research methodology used in this study, such as action research including its strengths and weaknesses.

3.7.1 Action research - strengths and weaknesses.

This study focuses on the use of student-led questions and feedback to improve students' engagement and attainment in Key Stage 3 secondary science. The study was designed to take place in a school in response to an urgent problem in science teaching and learning in that school, and to improve engagement and attainment of some Key Stage 3 students (year 8), aged 13 years old. The problem was tagged by the science department as raising students' achievement in science since the groups of students involved had been identified by the school as needing interventions in order to support their learning. Cohen et. al (2007) and Scott et. al. (2007) argue that finding a solution to such a problem fulfils the criteria of an action research as well as involving other teachers in the lesson observation carried out. Finding solutions to improve students' engagement and attainment in science enabled me to consider various assessment strategies and decide on those (questions and feedback) that will support my students (Newton et. al., 2011) and empower them to take ownership of their learning as independent learners (Nicol, 2007; Creswell, 2012). This can bring about transformation in the way they respond to assessment in Key Stage 3.

The effect of the intervention on students from action research was monitored through their engagement in the problem solving activities involving questions and feedback, and outcome from the end of unit science test scores based on value added by individual students. In addition the teachers involved also used the AfL strategies gained as a platform to improve their professional development and share good practices across the science department. The idea of involving other colleagues in the study other than myself (Gray, 2009), made it more productive as we can collectively evaluate the outcome from the strategies used and make any improvements. This view is supported by Cohen et. al. (2007) who argue that action research can create dialogue and discourse between participants and may improve their scientific knowledge.

Action research has been identified as having some weaknesses (Scott et. al., 2007:6). The first is that "action research is specific as it concerns itself in changing the activities of one type or a few practitioners, in one setting or one set of circumstances" as seen in this study. However, it is argued that the outcome from this type of research may be applicable to another school with a similar situation being investigated (Abrahams, 2009). This view is considered by Lincoln and Guba (2000) to be on the basis of best fit for purpose because of its generalisation. The second weakness put forward by Scott et. al. (2007:6) is that action research may encourage some forms of ethical issues with regard to involving colleagues. This is because they may "forget their role in relation to the use of data collected in the processes". I will discuss this further when addressing issues of researcher positionality later in this section. However, I make an argument that involving other colleagues did not raise ethical issues as guidelines on conducting research was adhered to (BERA, 2011) and ethical approval was granted by the University of Greenwich Ethics Committee to carry out this study (appendix 15). Third, the issue of power and authority have been raised as concerns with action research by Cohen et. al. (2007) and Scott et. al. (2007). I had no problem in the aspect of power and authority as the focus of the study was aimed at improving students' engagement and attainment in science, with the students leading their learning facilitated by the teacher. This is because Bourdieu argues that students have a form of cultural capital that they may contribute in the classroom (Winkle-Wagner, 2010) to improve their learning and attainment.

Given the issues discussed above, there is a need for me to pay attention to issues of researcher positionality and bias that may be encountered in this type of study, which I have reflected in this chapter and may require further clarifications for the reader. As an action researcher, my ontological and epistemological position is one that enabled me to create opportunities for my students to express their views as earlier mentioned in chapter 2 of this thesis. In view of this I reiterate that this study is an action research with a constructivist approach to learning where all students are given equal opportunity to express their views and make contributions to their learning and attainment. McNiff (2013) stated that the way we think about ourselves could influence how we see other people and how we position ourselves in the research. My position in this research may be considered to be that of an insider researcher (working in the organization but not involved in the data collection) as earlier pointed in my methodology, which may support my view of creating opportunity for the students involved to generate their own knowledge under the guidance of the teachers involved. This implies that the students and teachers involved in the study are considered equally important. An example of this can be seen in the lesson observation and collection of data (chapter 3) which was carried out by the teachers involved without my presence. In the same way, I consulted the teachers to have their views during data analysis in order to clarify some of the terms used during the interviews so as to have a true interpretation of comments made. I also involved colleagues during the pilot study to share their views and make suggestions for improvement as stated in my methodology.

In addition to the above points, my position as an insider researcher would eliminate certain forms of bias that may be encountered in data collection as pointed to in my methodology chapter. For example, collecting data to answer certain questions of interest to me (Newby, 2010), and ignoring others, and having a familiarity with the students I was working with, may affect the quality of the data. This is important as McNiff (2013:39) advises that the key issue in this type of study is the "researcher positionality and how the researcher sees other people in the research as subjects, participants or colleagues, and the kind of relationships that exists between them". I believe that my position in this research does not influence any form of data collection and control over the participants but helped to foster good relationships with the teachers, who may be considered as custodians of knowledge, facilitating the learning experience of the students involved. With this in mind, I reflect below on my data collection methods and how this was influenced by my position.

In chapter 3 I highlighted all the weaknesses involved in the methods of data collection adopted in this study to create awareness of potential bias and how I would overcome them. I think my position as a researcher requires me to state this in order not to make a conclusive claim about the outcome from this study, which I have mentioned before. Therefore, I have tried to remove any personal emotions attached to this study that may be a potential bias and have kept my expectations open to the outcomes from the data analysis. An example of this can be seen in chapter 4 where evidence from this study supports the view that students are capable of developing mostly low level questions on Bloom's taxonomy. However, with training and support from the teachers involved, they were able to improve in generating some high level questions which I did not expect as most studies concentrate on developing teachers' questioning skills, and ignoring the students' skills in this area as mentioned in my literature review. I am aware that this type of study requires fulfilment of ethical conditions, and the tendency of abuse of position of power as advised by McNiff (2013), which was also shared by Cohen et. al. (2007) as earlier mentioned. In view of this, I have taken all measures to satisfy all ethical conditions with approval by University of Greenwich ethics committee as mentioned in chapter 3 (3.8 and 3.8.1).

3.8 Ethical considerations

This kind of study, which involves observing children, may lead to ethical issues (observation method page 57) requiring consent from the people involved with the care of such children. This includes parents/carers, head teacher, the students themselves and other teachers. I have identified this concern and consent letters and participants' information sheets (appendices 4 and 5 respectively) were given to all participants, and I also adhered to guidelines by BERA (2011) in terms of honesty, transparency and students' anonymity with regards to using data collected. This also applied to teachers involved in the study.

3.8.1 Ethical approval

Prior to commencing this study, all ethical issues have been considered as stated in 3.8, and an application was made to the University of Greenwich ethics committee for consideration. Ethical approval was granted for the study (appendix 15) which indicated that I have carefully considered all necessary guidelines for a successful ethical research thesis as guided by BERA (2011).

3.9 Pilot study

I discussed my intentions with colleagues about the pilot study and that their input would be appreciated. The pilot study created opportunity for other science teachers (in the same school) to contribute their expertise in suggesting improvements to certain aspects of the study. One example of this related to the structuring of the questionnaire and success criteria used during students' presentations and questions and feedback. The focus of the study was based on the idea of students leading their own learning facilitated by their teachers. Colleagues welcomed this as a good idea and they made the following comments:

Teacher 1: "it will be interesting to see how my class can be responsible for their own learning and also to have a feel of the type of questions they will ask- as they have never bothered to ask questions in my lessons".

Teacher 2: "*this will be a good idea to support the students in developing their own question as the study involves using Bloom's taxonomy which I do not remember using myself, at least this will now get me in the habit of using Bloom's in my lesson"*.

Teacher 3: "*this means less planning for me as this project may extend for more than 4 weeks of lesson time when it is well planned"*.

Teacher 4: "*this will give me free space to watch the students learning themselves"*.

In addition, colleagues all agreed that this type of study which allows students to give feedback to other students is worthwhile in the science classroom.

The comments above indicate that colleagues are willing to be involved in the study as it will help in Assessment for Learning and support teaching and learning in the science department. With regard to the questionnaire developed (appendix 2) and given to teachers, they were instructed to make changes to the questions as they felt necessary, to give more clarity or that may need amendment. Only one change in the questionnaire layout was suggested such as including a text box in front of the questions for respondents to tick an option and which I duly amended (appendix 2). Newby (2010) suggested using two or three people to pilot the questionnaire. In addition suggestions were made on the success criteria used to score students during presentation of their findings, to include a wider range of scores from 1-5 based on their engagement in the tasks. This was also amended (appendix 13). I had initially designed the success criteria to be in the range of a 1-3 grading system. No change was made to the interview questions. The idea of involving colleagues in the research process has been highlighted by Cohen et. al. (2007) and Scott et. al. (2007) as fulfilling an action research criteria. Therefore, the pilot study has helped to redefine my research questions and methods of data collection based on my theoretical perspectives linked to a constructivist approach to learning.

3.10 Conclusion

This study focuses on the use of student-led questions and feedback to improve students' engagement and attainment in Key Stage 3 secondary science. In this chapter, I have been able to show that this study was informed by the pilot study conducted in the preliminary stages of this research. I have been able to justify how my theoretical perspectives influenced the methodology and choices of research methods to address my research questions based on a mixed method approach to research. I have been able to present several cases where the approach adopted in data collection to answer my research questions were deemed better than other methods, for example 3.5.3 in the case of using a questionnaire rather than a focus group.

CHAPTER 4

DATA ANALYSIS AND DISCUSSION

4.0 Introduction

This study focuses on the use of student-led questions and feedback to improve students' engagement and attainment in Key Stage 3 secondary science. A total of 52 students were involved in this study with a response rate of 100%. Twelve questionnaires were completed by teachers, and 2 teachers were involved in the lesson observation and interviewed afterwards. Data was also analysed from the end of unit science tests and field notes. The findings are presented in this chapter, and the research questions answered based on the methods of data analysis as described in table 3.2 pages 69-70. For each research question I presented my results and discussion. Similar patterns evolving across the research questions were identified and cross referenced, relating the outcomes to literature on Assessment for Learning. Finally, I made a summary of key findings in relation to each research question and wrote a short discussion to bring these together.

The main research question was:

- How can both student-led questions and feedback be used to enhance students' engagement and attainment in a Learner-centred Key Stage 3 science classroom?

This main research question was answered drawing on data from lesson observations, based on the audio recording of students' questions and feedback. This also included outcomes from the use of Blooms' taxonomy to develop questions by the students; interviews; end of unit science test results pre and post data collection; questionnaires; field notes; and examples of teacher's feedback to students. The findings from the subsidiary research questions also supported the outcome from the main research question.

The subsidiary research question one was:

- How can student-student interaction in questioning and feedback be used to improve students' engagement in science lessons?

This subsidiary research question was answered based on audio recording of students' questions and feedback. The quality of questions and feedback from students was compared and checked for any scientific terms used and misconceptions. Scores from students' presentations were analysed and used to judge their overall engagement in the problem solving tasks. Data was also drawn from the questionnaires, interviews and field notes to answer this question.

The subsidiary research question two was:

- What is the nature of teachers' perceptions in the use of questioning and feedback in engaging students' in science lessons?

This subsidiary research question was answered based on the outcome from questionnaires and interview analyses.

The main research question: How can both student-led questions and feedback be used to enhance students' engagement and attainment in a Learner-centred Key Stage 3 science classroom?

Questioning and feedback are used as Assessment for Learning strategies, and form a very important aspect of this study. They can influence students' progress (Waind et. al., 2012) and attainment. This claim is supported by the analyses of teachers' responses to the question in the questionnaire which asks whether questioning and feedback improve students' engagement and attainment in lessons (appendix 2). All 12 teachers were in support of the proposition that questioning and feedback improves students' engagement and attainment in science lessons (appendix 12, questionnaire analyses). The question here is, how can teachers use these questions and feedback effectively to improve students' engagement and attainment? As teachers, we ask questions which students answer and this is followed in some cases by giving feedback to the students. This form of interaction in the classroom is called the Initiation, Response and Evaluation model (Cazden, 2001) and referred to as model 1 in my literature review (page 43). This type of interaction has been argued by Chin (2006), to limit the way students think and respond to questions and can affect the way they construct their knowledge. This view by Chin (2006) is supported by the outcome from analysis of questionnaires in this study. One of the questions asked in the questionnaire was "should students be given the opportunity to develop their own questions in lesson?" All 10 teachers sampled, and the 2 teachers involved in lesson observation of students (a total of twelve teachers) agreed that students should be given an opportunity to develop their own questions in lessons (appendix 12 questionnaire analyses). In addition to this, all the teachers also agreed that students must regularly be encouraged to express their own unique thoughts and beliefs in lessons. What this means is that when students are allowed to lead the learning by developing questions and answers, and giving feedback to other students, it will enable students to be fully engaged with the discourse. This was confirmed by the outcome from the interview analyses, with questions and feedback (frequency of 53), considered to be the best form of engaging students (table 4.1).

Key areas/codes	Frequency
Enjoyment	2
Clarity	5
Engagement/attentiveness and more focused	22
Thinking skills/cognitive development	10
Metacognition	5
Knowledge creation/prior knowledge	3
Challenging others views/stimulation/probing	4
Sharing ideas with others/distributed learning/teamwork/socialisation	7
Questioning and feedback	53
Independent learning/ownership/taking charge/leadership/student led	5
Attainment	2
Good behaviour	2
Problem solving/finding solutions	2
Motivation	8
Interests/readiness	3
Willingness	4
Time spent on tasks	4
Planning resources	3
Practice	2
Repetition/repeat activity	3
Active listening	2
Facilitating learning	4
High expectations about what to do/good quality work	2
Assessing/monitoring learning	4
Building confidence	2
Involvement/participation	11

Table 4.1: Summary of interview analyses with frequencies

This view of using questions and feedback to engage students is supported by the comments made by one of the interviewees who stated that:

> *"I think it's more pupil led letting the learning take the direction the students want it to go rather than me giving them the questions I want them to answer, and choosing the journey I want them to take. Their leading of it makes them take ownership of the learning and I think it is something that should be considered in normal lessons based on this project"* (Teacher interviewee 1).

This type of students' engagement shows that model 1 which is the Initiation, Response and Evaluation (IRE) process of discourse can be led by the students just like their teacher. The comments made by the teacher interviewee show that the students were more engaged in the discourse than when it was directed by the teacher, and contrary to the views of Cazden (2001), who noted the IRE model 1 to be a teacher-led activity. This is because Van Dijk (2001) and Reinsvold et. al. (2012) argue that when teachers dominate the discourse, it can lead to social power relationships, as teachers will assign roles to the students and control the discourse. Thus undermining the views of Bourdieu who considered all students to possess some forms of "cultural capital" such as knowledge, that they may contribute in the classroom to improve their attainment (Winkle-Wagner, 2010:8). Hence this study is designed to allow the students to talk in each other zones of proximal development (Adey et. al., 2010; Wells, 2012), where they can be confident in sharing their ideas, and developing knowledge themselves, a view further confirmed by all the teachers who completed the questionnaires (see appendix 12). In addition to allowing students to lead the discourse, questioning and feedback was rated as the best form of engaging students (with a frequency of 53) as mentioned earlier, and engagement/attentiveness with a frequency of 22 was rated as the second (table 4.1, page 79). These findings will be discussed in detail in my subsidiary research question two, later in this chapter.

The outcome from this study shows that the barrier to discourse involving the IRE model 1, which is normally led by teachers can be overcome by students taking ownership of their learning. The encouraging aspect of this study is that the teachers involved are facilitators of learning, a view considered by the interviewees as a factor that may constitute students' engagement (with a frequency of 4, based on the interview analyses) in table 4.1, page 79. However, in the transcript obtained from the students' questioning and feedback, there were scenarios where the teacher made contributions to the students' learning through answering questions and giving feedback when it was necessary to do so, but they did not dominate the discourse. An example of such interaction arose when a student asked a question about diabetes, and the responses from other students did not quite answer the question. The discourse which ensued is highlighted below:

Student 1 question: What would happen if you don't *have your five a day?*

Student 2: *You wouldn't get enough nutrients and vitamins and so, you would have an unhealthy diet*

Student 3: You see the way you said type 2 diabetes, what is that?

Student 4: Oh it's like when you don't have enough sugar in your body

Student 3: *Oh yes what are the other types?* (Same student trying to find out more information by probing the response).

Student 5: *Type 1 is the other one- yes, yes (at this point, 3 students from the same group answering the question).* The students have not given the right answer to this question.

Student 6 question: Can you defend your position about what you said on type 2 diabetes, you said that it does not involve sugar but if you are obese you are fat and it must come from sugar.

Student 7 response (James): *Yes, there are different types, type 1 would be where you have high sugar and your blood just got too much sugar and you can have heart strokes a lot*

Student 8: Yes, but if you are obese

The teacher tried to stop the group and said they had not actually learnt this topic. Student 8 stepped in again, to answer the same question on diabetes.

Student 8 feedback (Jack): I don't know the difference but when you have type 1 diabetes you have to have injections every day to help your glucose level, type 2 is not as serious and you can have tablets to help you.

Teacher now steps in at this stage and made this comment about diabetes:

Teacher: Type 1 diabetes, if you are born as a child and you don't produce this chemical called insulin which is a hormone and what it does is, it tells your body that you are carrying too much sugar in your blood and you need to store it or use it up. So, type 1 diabetes is called juvenile diabetes- because children have it. They will be given injections of insulin throughout the day and that would affect their blood glucose levels.

Type 2, because of your diet you develop resistance to insulin and so, your insulin doesn't work anymore. You need to control this by having a healthy diet.

It is important to state here that the teacher acknowledged that the students had not learnt anything about diabetes. However, the students had been able to demonstrate some knowledge and understanding of the issues around diabetes from previous experiences and thereby contributed towards the knowledge creation (Cowie et. al., 2011). This was due to their engagement in questions and feedback which evolved from the problem solving activities (Williams, 2011) in appendix 6, that they were engaged in through using research materials, text books and other resources. The student (Jack) who stepped in to answer the question at one point, agreed with the response from the previous student (James), who said "*Yes, there are different types of diabetes, type 1 would be where you have high sugar and your blood just got too much sugar and you can have heart strokes a lot*". However, Jack felt that more information was required to answer the question on the types of diabetes, based on James' response. Hence Jack gave feedback by developing the response from James, about type 1 diabetes, which was similar to the teacher's feedback, a view which Min (2008) argues that when we train students in this way they can give feedback which is as effective as their teachers. However, it is worth noting that the teacher's feedback was more detailed here. This meant that Jack was able to compare his feedback to the teacher's feedback and develop his own skills in giving feedback, which also applied to the other students.

The sequence of interaction described above clearly demonstrated model 2 closed chain of discourse (page 43), although in this case the whole process was led by the students which involved student initiation of questions (SI), student response (SR), student probing (SP), and student evaluation (SE). This model of discourse forms part of the new model presented in this thesis (page 102). In addition teachers must also consider giving students thinking time to respond to questions (Smith, 2007; Ecclestone, 2008) and provide encouragement rather than assuming that a topic has not been learnt and students may not therefore, be able to answer the questions as seen in this case. In addition the feedback from Jack has enabled the students to develop their own knowledge (Buhagiar, 2007; Cowie et. al., 2011), a view supported by responses from the interviewees who stated that:

> *"When students are regularly allowed to develop their own questions and give feedback to each other in lessons, this will improve their engagement and develop their thinking skills in science"* (Teacher interviewees 1 and 2).

The students were engaged in giving feedback to other students in this study in addition to the feedback given by the teacher whenever the need arose. This shows that feedback may be useful in clarifying any misconceptions that may pose as barriers to students' learning, a view which is supported by Harlem et. al. (2012) and Waind et. al., (2012), who indicate that this kind of interaction will enable teachers to assess students' learning and improve dialogue between students and their teachers (Nicol, 2007). This will also improve students' engagement (Hog, 2010; Wilson et. al., 2011) as well as their attainment.

The use of questions and feedback to engage students and improve their attainment was also supported by the views of the two interviewees (appendix 8) who made the following comments:

> *"Especially looking at this activity they were constantly having to be aware and thinking. It was not like they could switch off for a while. They were not being disruptive, they were all working, but in a normal lesson most of them would be totally disengaged, but in this project it was different because they were processing information constantly because they knew they would be asked questions and may be required to answer them. This made them to be on task completely and with full attention"* (Teacher interviewee 1)

> *"When I do questions and answers in my class, I don't do hands up policy, I ask those students that don't put their hands up in order to get them involved in the lesson, so that they know they have to work a bit harder. I think that is why the idea in this study will support the students to get involved"* (Teacher interviewee 2)

The idea of teachers being facilitators of learning in this study therefore, created opportunities for the students to be more engaged in asking questions and providing feedback to each other as seen in the audio transcript in appendix 7. This may have accounted for the high number of questions generated by the students using Bloom's taxonomy question prompts as seen in table 4.2 below.

Bloom’s taxonomy	Bloom’s taxonomy rating	Number of questions developed by students	Percentage of questions developed (%)
Knowledge	1	51	32
Comprehension	2	51	32
Application	3	23	14
Analysis	4	8	5
Synthesis	5	11	7
Evaluation	6	17	10
Total		161	100

Table 4.2: Breakdown of questions developed by the students using Bloom’s taxonomy

From table 4.2, Knowledge and Comprehension questions are low level questions and Application, Analysis, Synthesis, and Evaluation questions are considered high level questions (DFES, 2004). The data in table 4.2 has also been presented on a bar graph shown in figure 4.1 (page 86), and on a pie chart in figure 4.2 (page 87), to describe the trend in the results. In table 4.2 the total number of Knowledge questions developed by the students was 51 (32%); Comprehension questions 51 (32%); Application 23 (14%); Analysis 8 (5%); Synthesis 11 (7%); and Evaluation 17 (10%). The data in table 4.2 and figures 4.1 and 4.2 shows that more questions were developed based on the Knowledge and Comprehension questions, which accounts for 64% of the total questions developed by the students. These Knowledge and Comprehension questions constitute the low level questions as stated earlier. The high level questions, which are Application, Analysis, Synthesis, and Evaluation questions, accounted for 36% of the total questions developed by the students (table 4.2, page 84 and figure 4.2, page 87). When the low level and high level questions developed by the students (64% and 36% respectively) are compared, it shows a 28% difference in favour of the low level questions. This result obtained is consistent with the views of Wragg et. al. (2001), who stated that most questions asked by students are procedural and social rather than to do with the thinking process, and that students find it difficult to ask questions unless encouraged by their teachers to do so

(Williams, 2011). These procedural and social questions fall under the low level questions on Bloom's taxonomy. This view is also supported by the outcome from the question on the questionnaire, which requests teachers to state *what sort of questions pupils ask during lessons?* Six out of the ten teachers said closed questions (appendix 12 questionnaire analyses), which may also form part of the low level questions on Bloom's taxonomy. The comments made about students asking closed questions in lesson were confirmed by the two teachers during the interviews, based on their experience in the lesson observation (Chin, 2006) and from responses to the questionnaires. The comments made by the interviewees include the following:

> *"I would say generally they ask quite close questions like what is this and so on, just wanting to know facts. Sometimes I get a good question that opens up a discussion but it's rare and generally they are low order questions"* (Teacher interviewee 1).
>
> *"Some closed questions and some open questions. Those that asked open questions know why they asked such because they are thinking about the topic and just need some clarification"* (Teacher interviewee 2).

The comments made by the teacher interviewees show that most of the questions the students asked were closed ones (low level questions), although the interviewees stated that, rarely, the students asked open questions. Reflecting on the responses from the questionnaire analyses, one of the teachers considered students' questions as insightful, another said students ask clarification questions (also confirmed by teacher interviewee 2 earlier), which are considered as part of the low level questions. These closed or low level questions do not challenge students and support their learning (Zheng et. al., 2008), rather they are mainly factual recall of processes. However, the results obtained are encouraging at this stage of the study considering the nature of interventions set for the students involved. This shows that there is scope for the development of this type of activity over a period of time to enable students to become accustomed to developing good questions (high level ones), and be able to give quality feedback to other students in order to improve their engagement and attainment. This view of students practising questions and feedback over time (with a frequency of 2, table 4.1, page 79) was identified as one of the factors that may constitute students' engagement in science. This is based on the outcome of the interview analyses used to answer the subsidiary research question 2, which will be discussed in detail later in this chapter.

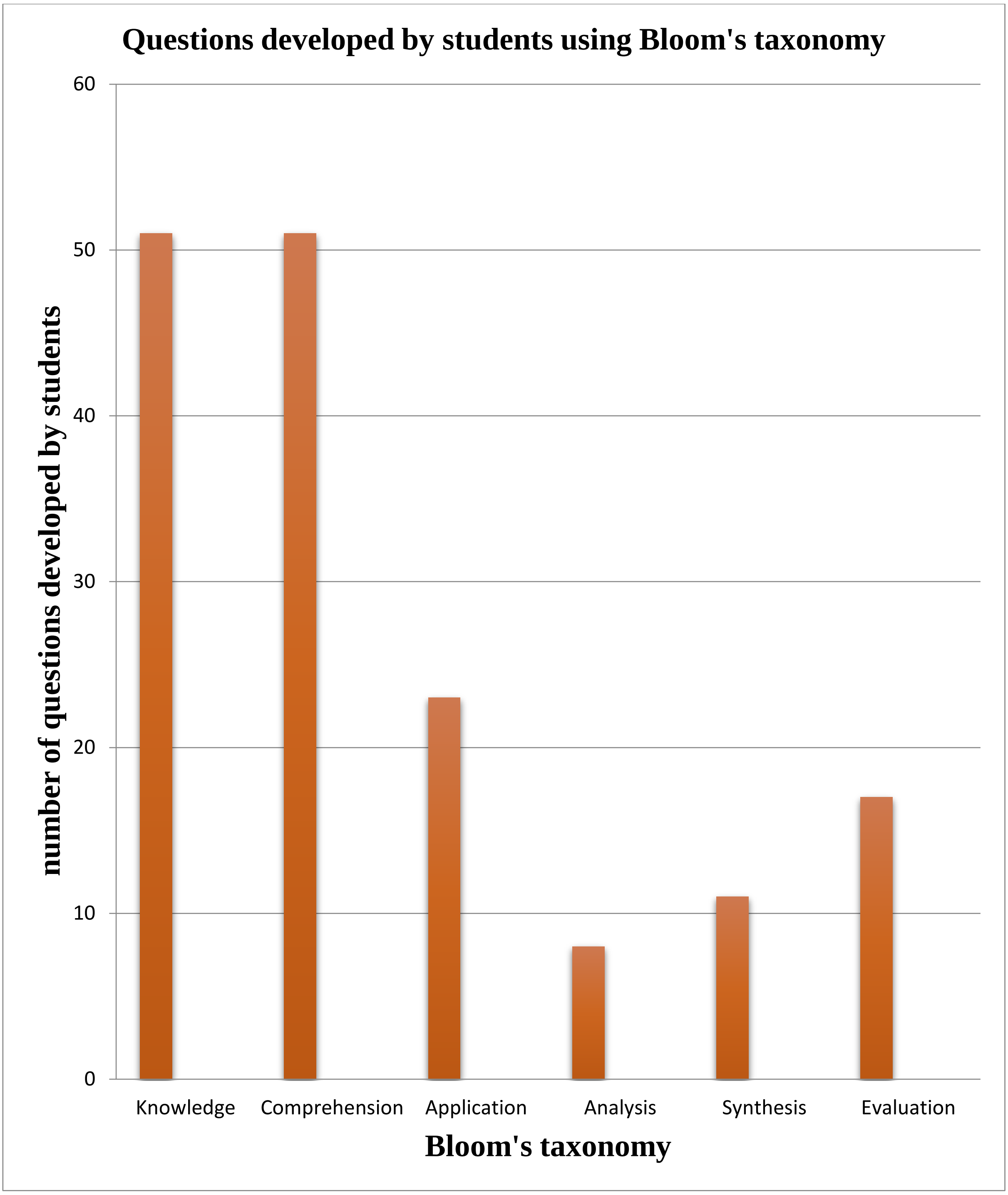

Figure 4.1: Bar graph of the questions developed by the students using Bloom's taxonomy.

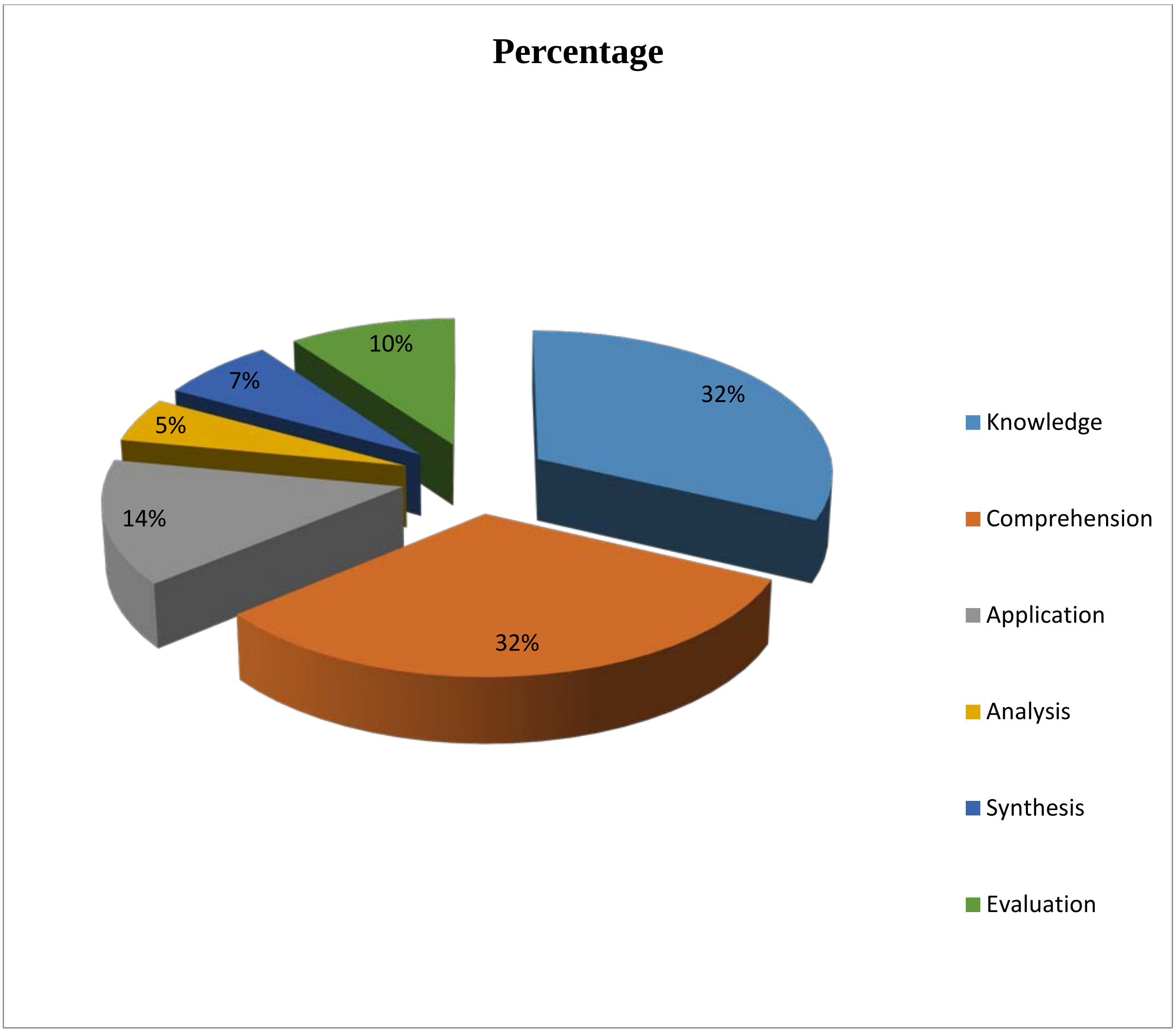

Figure 4.2: Pie Chart showing the percentages of questions developed by the students using Bloom's taxonomy.

The idea of students sometimes asking open questions was confirmed by two respondents to the questionnaire (appendix 12), who stated that students "ask application questions and questions related to solving problems" respectively. This meant that there are opportunities to develop students' questioning skills to enable them to ask high level questions in lessons. Williams (2011) however, noted that teachers must encourage students to develop such high level questions by giving them examples to follow. In addition this finding shows that science teachers need to work on strategies to improve students' engagement by allowing students to develop their own questions in lessons, rather than depending on the science practical work as the main form of students' engagement (Magaji, 2008; Darlington, 2012). This is due to the fact that the type of questions the students develop will also influence the kind of feedback they will get from other students. Good questions (high level ones) will result in quality feedback among the students (Hodgen et. al., 2008), and also improve their engagement and attainment. This is because such high level questions which may also be considered open questions require students to think and build on their ideas (Smart et. al., 2012) rather than recalling facts, a view supported by the interviewees with comments below:

> *"Questioning them through the process whether its Key Stage 3, 4 or 5, helps them think things through instead of just remembering things, they are thinking of how to get the answers themselves. This questioning improves students' engagement and attainment in lessons"* (Teacher interviewee 1)
>
> *"Yes, definitely teachers can use questioning and feedback to engage students in Key Stage 3 science and help to improve their attainment'. It is about modelling the questions to the students to guide them here, for example, high order questions"* (Teacher interviewee 1).
>
> *"I think in science their exam questions can be quite close, because there are no right or wrong answers, no interpretations. But the way students get there, we need to open up their minds because in the wider world, science can be an open subject and there is so much out there that they need to find out, and we need to help them find the knowledge they may need for those questions they may get in their exams in a way that keeps their mind open. So that they are not just thinking only about finding out facts but need to keep their mind open. For example with my sixth form students, I tell them don't just remember the facts but remember the process that helps you get there. This will help you outside as well"* (Teacher interviewee 1).
>
> *"I quite like question and answers but you also get out of it students' questioning as well which broadens the topic. Yes students should be given opportunities in lessons to ask their own questions. As each group presented their work, this further enhanced the progress of other students to be more involved especially those not serious initially and lots of them realised they could get more out of the activities"*. (Teacher interviewee 2).
>
> *"I think it's a good idea-students developing their own questions and giving feedback like we have done in this project, as it makes the students think deeper about the subject they are actually learning. If they can come up with questions and may be a possible answer themselves, this makes a difference to their learning"* (Teacher interviewee 2)

In support of the comments made by the interviewees above, Windschitl (2003) and O'Dea (2010) noted that when science students are allowed to develop their own questions and resolve them it helps their inquiry skills in the Nature of Science and improves their experience. This differs from when they are responding to questions from curriculum tests and teachers' questions. It can therefore be argued that evidence from analyses of the questionnaires (appendix 12), shows that all 10 teachers plus the 2 teachers who completed the questionnaires strongly agreed that questioning and feedback improves students' engagement and attainment in science lessons. This view is further supported by the interviewees who said that they

> *"Strongly agree that if students are regularly allowed to develop their own questions and give feedback to each other in lessons, this will improve their engagement and develop their thinking skills"* (Teacher interviewees 1 and 2)

Reflecting on the questions developed by the students as shown on the bar graph (figure 4.1, page 86), the low level questions developed (Knowledge and Comprehension questions) are the highest, with an expectation that the number of questions developed by the students would decrease as it approaches the high level ones on Bloom's taxonomy (Wragg et. al., 2001). This finding is in line with my experience of supporting students in developing questions. However, this decreasing trend was not sustained as the bar graph, figure 4.1 page 86 shows that Synthesis and Evaluation questions rose up (11 and 17 respectively) when compared to the Analysis question (8) which is the baseline point for the high level questions. This rise in the high level questions mimicked a "U" curve. This shows a recovery in the type of questions developed by the students, who at this point realised that if they can develop high level questions, this can support their learning and attainment. Comments made by one of the interviewees supports this outcome:

> *"I think it's something that will be beneficial in the long run and is something you have to practice with them over time and embed in the lesson. I think some of them wanted to answer the high order questions more often, whilst some still struggled with the low order thinking questions. But with more practice they will get used to it and it will help them learn as well"* (Teacher interviewee 1).

The comments made by the interviewee above shows that the teacher must make the students realise the fact that they have to get used to developing the high level questions. This is because the high level questions have been found to improve students' learning (Hodgen et. al., 2008), and the feedback from such high level questions can enable the students to evaluate their own learning (Waind et. al., 2012), a feature which has been considered in this study. That is why this study will contribute to the body of knowledge by supporting students to develop their own questioning skills.

Until now, too much emphasis has been placed on developing teachers' questioning skills (Black et. al., 2003; Clarke, 2008; TLRP, 2010), and not considering how students can also be supported in this way, which can bring about an improvement in their engagement and attainment. In addition the comments from the interviewee showed that the students are willing to be engaged in developing the high level questions and give feedback because they are aware of its impact on their engagement and attainment. This can be shown by the rise in the high level questions developed as earlier mentioned. I can argue here that the rise in the high level questions developed challenged the earlier claim by Wragg (2001) who considered students to be good only at developing low level questions, a view supported by the outcomes from the questionnaire and interview analyses. Therefore, this finding shows that teachers must support students in developing their own questions (Williams, 2011) and also train them to give feedback to other students (Min, 2008) that will be as effective as the teacher's feedback. This is because evidence from this study has shown that engagement of students in questions and feedback linked to the new model of discourse presented in this thesis (page 102), which is student-led can improve their attainment. This is supported by the analysis of the end of unit science test results which shows that 48 out of the 52 students (that is 92% of the students) achieved their required target set by the school with improved attainment based on the value added scores (appendix 10). This result is quite encouraging and shows that the intervention used in this study (questions and feedback) had an impact on students' attainment. Details on students' attainment with regard to the end of unit science test results will be discussed later in this chapter.

Results from both interview analyses (table 4.1, page 79) and questionnaire analyses (appendix 12) show that the use of open ended questions can enhance students' learning, a view supported by TLRP (2010) and Finney (2013), who indicated that this will encourage students to find information and understand it, and also enable them to develop their cognitive abilities. These open ended questions are similar to the high level questions on Bloom's taxonomy. However, it is important to identify which of these high level questions can support students' learning better. In the course of grouping the questions developed by the students into the different categories on Bloom's taxonomy, I discovered that it may be difficult to differentiate certain groups of questions, especially the high level ones. These are some of the high level questions developed by the students:

Application question: *What would happen if I wasn't able to digest food?*
Synthesis question*: What would happen if the woman ate more calories than the man?*
Both questions started with "what would happen if", appearing to be similar. However, the application question requires the students to use their knowledge to answer the question in a way they are familiar with and apply it to a new situation. The synthesis question is considered higher than the application question because the student will be required to answer the question by creating something new. This may include proposing an alternative response to the question. Therefore, it would not be misleading to conclude that when science teachers have a good understanding of Bloom's taxonomy question prompts, they can effectively support students' learning by engaging them in using Bloom's taxonomy to develop their own questions (Zheng et. al., 2008; Bergman, 2009) as well as modelling questioning to students. This includes encouraging the students to identify those high level questions that will enhance their learning and attainment. However, evidence from the questionnaire analyses reveals that 7 out of 10 teachers, and 1 out of the 2 teachers sampled, agreed that they do not use Bloom's taxonomy to develop questions in their lessons (appendix 12). Despite this, all the teachers admitted to planning for questions in advance before the lesson, as well as making up questions in lessons when the need arises. Further to this I asked the teachers to state if their students ask relevant questions in lessons. 4 out of the 10 teachers said "yes", 5 teachers stated "sometimes", and 1 teacher said "no". Out of the other 2 teachers sampled, 1 said "yes" and the other answered "sometimes". This outcome shows that students sometimes ask relevant questions in lessons but may not be consistent and in some cases they do not ask questions at all, a view supported by Cowie (2005) who notes that most students find it difficult to ask questions.

Based on the outcome from the questionnaire analyses, I make a case here that, if teachers find it difficult to use Bloom's taxonomy to develop questions before and during lessons, or do not remember to use Bloom's taxonomy, which was the case for the teachers sampled, it means that we cannot support the students in developing their own questioning skills. Therefore, the quality of the feedback process as a result of poor questioning skills will also be affected. The reason is that good questions lead to quality feedback (Hodgen et. al., 2008) that will engage students and improve their attainment. Hence this study reveal areas to be considered in order to engage students and improve their attainment. This includes the use of Bloom's taxonomy as a guide to developing questions before the lesson (for teachers), and during the lesson (teachers and students). This is because using Bloom's taxonomy will help students' cognitive development (Kissock et. al., 1982; Adey et. al., 2010; Atherton, 2013) as the question prompts are categorised into six levels of cognitive domain starting with the Knowledge and Comprehension questions considered as low level thinking skills (DFES 2004) and moving onto the high level questions (appendix 1, and figure 2.1 page 38). In addition Black et. al. (2010) argue that when students ask questions and other students listen to them, whilst talking and giving feedback, this allows them time to make their contributions which may in turn influence the quality of feedback, a focus in this study. This will bring about improved engagement and attainment among the students. A view supported by one of the interviewees based on the factors that may constitute engagement of students, as thus:

> *"The students were actively listening and watching, and asking and answering questions"* (Teacher interviewee 1).

At this point, I can claim from my results that this study has supported the students in developing their questioning skills (figure 4.1, page 86) and giving feedback to other students as stated earlier in this chapter. Therefore, it would not be misleading to state that this improvement in the students' engagement led directly to an improvement in their attainment in the end of unit science tests (Cowie et. al., 2011; Waind et. al., 2012) which I will discuss later in this section. Hence, it is important to highlight the test results obtained by comparing students' results pre and post-data collection for any value added, which was the means used to ascertain if the interventions (questions and feedback) contributed to their attainment (Scott et. al., 2007) as highlighted in my methodology page 66. An analyses of the science test results from the 52 students sampled (appendix 10), shows 48 students (92%) made the required progress with improved attainment in their levels in the science tests, and were on target based on the levels set by the school which they were required to attain in term 5, when this study took place. The attainment levels of the students were quite broad with some students achieving more than others, when the difference between their previous attainment (in term 4) and current attainment (in term 5 after data collection) is considered. The students' attainment was measured by value added scores which varies from 1 to 7 (appendix 10). Looking at the analysis of results in appendix 10, the value added score for student 10 is 1 sub-level (which can be considered as the lowest value added in this study) and student 35 had a value added score of 7 (approximately 2 levels of progress), which can be considered as the highest value added in this study. Comparing the difference in the value added scores of these students (students 10 and 35) does not mean that the student with the most valued added score (student 35) made the most progress. This is because some of the students who made 1 or 2 sub-levels of progress may have been higher achievers who needed to be supported to get to the next level of attainment (ARG, 2002) through developing high level questions which complements quality feedback, leading to an improved attainment. A further example to support this claim on the progress made by the high achieving students (appendix 10) shows that student 29 moved up 2 sub-levels from 6b to 7c; and student 37 moved up 1 sub-level from 6a to 7c. This can be compared to students with 6 or 7 value added scores (approximately 2 levels of progress) who were initially classified as low achievers, for example, student 35 had a value added score of 7 that is approximately 2 levels of progress from 4c to 6b; and student 46 with a value added score of 6 from 3a to 5a, moving up by 2 levels of progress. Therefore evidence from this study shows that engaging students in questions and feedback has led to an improvement in their attainment (Cowie et. al., 2011), a view supported by Reinsvold et. al. (2012:748) who stated that:

> *"Teachers have the power to provide questioning strategies that allow students to evaluate their understanding, to provide evidence for their claims and ideas, to apply what they know to a novel topic, and in general, to reason at a higher level about what they know about science"*.

I set out to report on individual and collective attainment of the students involved rather than comparing with a control group as suggested by Cohen et. al. (2007) as it will deviate from my focus, and such an approach may also raise ethical issues about not giving all science students in year 8, an equal opportunity of taking part in this intervention as highlighted in my methodology. Following on from the end of unit science tests, out of the 4 students not on target, that is students 2, 3, 5 and 49 (appendix 10), one of the students (student 2) dropped by a sub-level (that is, from 5b to 5c), while the other three students remained on the same levels attained in term 4 until term 5 after the intervention. Student 3 had level 6c in term 4 and remained on level 6c in term 5. However, when you compare the science target level of term 5 for student 3 (level 5a, appendix 10) with the same students' current level (level 6c, term 5), then student 3 will be considered to have made 1 sub-level of progress and to be on target, well above the science target level for end of year 8 and target level for term 5 respectively. This same situation also applies to student 5 who made 2 sub-levels of progress above the target level for term 5 (appendix 10). These results for students 3 and 5 provokes a question. Although my analyses show that no value was added for both students, I would have expected the school's analysis of results to show that both students are on target which did not occur in this situation. This may be due to the fact that the school sometimes over predict students' attainment based on the levels they feel students should be working at during each term in the school year as shown on appendix 10.

The attainment of students in the science test was due to their engagement in questions and feedback which helped them cognitively and encouraged them to think and construct knowledge (Chin, 2006). This is a view supported by Zheng et. al (2008) and Bergman (2009), who comment that teachers can model questioning in lessons, encouraging the high order questions on Bloom's taxonomy. In the same way, Harris et. al. (2012) reported from their study that teachers who supported students in developing their ideas and questions in lesson, enhanced their attainment in test. These comments therefore support the notion of using different forms of assessments to measure pupils' progress. However, the use of levels and sub-levels to measure pupils' attainment, which was currency during the time of this study is what I would like to dwell upon at this stage.
I have reflected below on the advantages and shortcomings associated with the use of levels in assessments and also assessment without levels. In terms of using levels in my analysis, I argue that this study is predominantly based on the use of formative assessment (questions and feedback). This gives students opportunities to express their views towards contributing to their own knowledge, which is supported by my theoretical perspective of a constructivist approach to learning, earlier mentioned in chapter two. Levels from end of unit test was used to report on pupils' attainment because the school where the study took place uses levels. The test was used to back up the outcome from the formative assessment. This can be considered as a good practice because Wood-Groves et. al. (2012) concluded from their study that assessment should be based on multiple modes of student performance data (formative and summative) as shown in

appendix 10 (end of unit test results) and appendix 11 (scores from students' presentations and questions and feedback).

I reiterate that during the time of this study, the main means of reporting students' progress in the school where this study took place was the use of levels from end of unit test. Only reporting what students are able to do and achieve, as shown in appendix 11, concurs with DFES (2014) views on assessment without levels. In the context of this study this would raise some questions among colleagues in the science department and the leadership team in the school. This is because they would have expected to see students' attainment through levels achieved from the study. This highlights the problem of schools which are over reliant on levels to judge attainment of students at the expense of formative assessment, which would have been the key towards determining the progress made by pupils. I will discuss more on the shortcomings of using levels later in this section. The school where this study took place is still using levels to report pupils' attainment at Key stage 3 and would be changing to using assessment without levels in the academic year September 2015/16. The member of staff responsible for assessments in the school confirmed that their greatest concern at the moment is trying to work out assessment criteria that would be used formatively at Key stage 3 to assess pupils and also how to communicate this to parents and carers (Earle and Davies, 2014), who are already used to levels as means to ascertain their children's attainment. She also mentioned that this would involve contacting feeder primary schools (schools they recruit students from, into year 7), in order to share the assessment criteria with them and also get an idea of what assessment criteria are used for pupils in year 6 so that this could be considered when developing whole school assessment criteria. These views are shared by DFE (2014) as part of the national curriculum reforms which require schools to build a robust assessment framework into their curriculum to check what pupils have learned and track their progress.

I thought the idea of assessment without levels would enable us (secondary school) to know what the pupils are able to do and achieve in science so that we could be able to support a differentiated learning experiences for all students in Key stage 3. Being a science teacher who has used levels over the years to report on students' attainment, I believe that there are benefits and shortcomings in its use. Firstly, this study aims to give pupils autonomy and independence over their learning (see definition of terms in page xii) and allow them to make contributions towards developing their own knowledge as a form of cultural capital which they bring into the classroom. This opportunity to express their views may be lacking when their overall performance is based on an end of unit test. This brings to light the possibilities for schools to create assessment criteria that may be used to judge students' attainment formatively through the use of assessment without levels encouraged by the Government (DFE, 2014) rather than using the end of unit tests, based on levels. It is useful to know that some schools have adopted the use of APP criteria to assess students formatively on what they can do and achieve at different stages without using the levels associated with the criteria. This is a view shared by Earle et. al. (2014) who said that the APP grid can be used to track pupils' scientific skills, which I have also pointed in chapter two of this thesis. The benefit of using this criteria is that students can track their progress and are also involved in their own assessments by setting targets and reviewing their progress. This gives all students equal opportunity to be assessed based on the differentiated tasks as opposed to using levels, which may sometimes discourage students if they did not achieve their desired levels.

Still on the issue of levels, I pointed out in my analysis earlier in this chapter that levels cannot be used conclusively to ascertain the true performance of a student. For example, with reference to attainments for students 3 and 5 (appendix 10), they were considered by the school to have not made any levels of progress based on the target levels set by the school. I reiterate that this raised a question about the credibility of using levels to judge attainment of students. This is because both students 3 and 5 who achieved level 6c were shown by my analysis to have exceeded their science target levels for both end of year 8 and term 5, however, did not add value to their results when terms 4 and 5 were compared but these students made progress in the formative assessments (appendix 11). Therefore, the use of assessments without levels meant that the progress made by such students can be reported to judge accurately what they can do and achieve and also identify areas that may require improvement rather than end of unit tests with levels of attainment that may not identify what they need to do to improve.

Reporting on the science test used as means to verify students' attainment in this type of study may not be the only issue to contend with for example, this study also shows that clarity in terms of the instructions given to students before and during questioning and feedback as an intervention is key to helping students' engagement, which may improve their attainment. Evidence of this evolved from the responses by the interviewees as stated below:

> *"I think they quite enjoyed it but at first they were unsure of what they were meant to be doing. That was my fault for not explaining it clearly enough, but once they went through it again, they seemed to get used to it and engaged very well"* (Teacher interviewee 1)
>
> *"Some were very engaged, some were not and others not sure of what they were supposed to be doing. Once they were told again what they were supposed to be doing they were okay"* (Teacher interviewee 2).

This clarity must also be seen in the type of questions asked (both teachers and students). In the transcripts from students' questioning and feedback (appendix 7), the following discourse ensued between the students highlighting the issue of clarity in questioning:

Student 1 question: What will happen if you mixed enzymes to dissolved meat but don't have meat in your body?

Student 2: What? (This student exclaimed, showing the question was not understood)

Student 1 reframed the question: What will happen if you mixed like, enzymes and dissolved meat with another type of food group?

Students: What? Can you repeat the question again? (Chorus by 3 students who requested the question to be reframed again because they do not yet understand it)

*Student 1: There are different enzymes to dissolve different things, what would happen if you mix two of them that don't work together (*Boy finally repeats the question twice).

At this stage, student 2 was no longer interested in answering the question because he did not understand it. Here is the response to student's 1 question by the other students.

Student 3: An enzyme cuts up anything or any food molecule, basically, the enzyme travel and want to make the food go through the intestine.

Student 4: Basically, it's not just one enzyme, there are different types of enzymes, the one that wants to dissolve this one goes into this one, and the other one goes into that other one.

At this point there was a background noise from another student saying "*That is what I said, that is what I said"*.

Teacher: Be careful using the word dissolve to describe enzyme action, you should use the term breakdown.

Student: Student now corrects herself and said break down.

The trend in the discourse above has shown that careful thought must be given when developing questions that will be easily accessible by students. In the case here, student 1 had to repeat his question twice before other students were able to give answers and feedback. In this situation, the response from student 4 can be considered a more scientific approach to answering the question as the student was trying to describe the function of enzymes as being specific in their actions. Student 3 gave a general view of the function of an enzyme which may not be scientific enough to address this question. However, there was good use of a key word (food molecule). The response from student 4 can therefore, be considered as a form of feedback to the answer given by student 3. This interaction reflects the new model of discourse presented in this thesis (page 102). However, the teacher was able to identify an area of weakness in the feedback from student 4 by saying the student should not use the word "dissolved" when describing the function of an enzyme, rather use the term "break down". This shows that when students use the right scientific key words in describing scientific phenomena it can have a positive effect on the quality of feedback they can give, and also it will enhance their understanding of the Nature of Science (Windale, 2010; Golabek et. al., 2013) and improve their attainment.

The evidence to further support students' attainment in the science test was based on the outcome from the interview analyses (table 4.1, page 79), and engagement of students in the questions and feedback (appendix 7) using NVIVO 10 to identify the themes that emerged. Of all the themes identified in both the interview, and students' questions and feedback (appendix 7), the following aspects will be considered. Students' funds of knowledge as suggested by King et. al. (2010) and Cowie et. al. (2011), which is also referred to as students' prior knowledge; questions and feedback (Miller et. al., 2007; Reinsvold et. al., 2012), which is the focus of this study; engagement in learning (Newton et. al., 2011; Sampson et. al., 2012) which is another focus of this study; and how the students have applied their knowledge to solve the questions asked. These factors led to improvement in students' engagement and attainment. Questions and feedback was rated higher with a frequency of 53 followed by Engagement/attentiveness with a frequency of 22, and Prior knowledge with a frequency of 3 (table 4.1, page 79). I will highlight examples of how these factors constituted engagement of students under the following paragraphs.

In the aspect of applying prior knowledge, examples of situations where students ask questions and other students responded and gave feedback based on their prior knowledge are considered here:

Student 1 question: How do the fats actually become fat in someone's body?

Student 2: First of all you are skinny and eat a lot and a lot, it takes time for all the fat to build up in the body and you become fat.

Student 3: For example if I am an energetic person and my body is used to being active and later I become lazy and I still eat like I do, the fat will start building up in my body because fat is energy. If I don't use the energy it will run out and the fat remains on me.

Student 4 question: If we don't eat any fats what will happen to us?

Student 5: You will get fat because you are eating only one type of food, do you watch super skinny versus super fat on TV, the people who are skinny eat the same type of food all the time like chocolate, you can still eat a fat diet and be skinny. This could be bad for you. Too much of everything is bad. You see if you are really skinny people don't think you will get heart attack.

The responses of the students to both questions (by students 1 and 4) demonstrated their abilities to engage with the questions based on their prior knowledge, guided by the findings in the problem solving activities they were engaged in (Williams, 2011). Students 2 and 3 stated that fat can build up in our body due to poor dieting. However, student 3 noted that a change in our lifestyles can also encourage the fat to build up. Student 5 made reference to the TV programme titled "super fat versus super skinny" to answer the question, which other students found very useful at this stage to help them visualize the problem at hand. This enabled the students to relate the problem to a real life situation which supports How Science Works experiences of the students, and an understanding of the Nature of Science which they can apply to other situations (Grime, 2012; Miller, 2012). This also enabled the students to apply what they know from previous experiences and contribute to knowledge generation, (Hohenstein et. al., 2010; Cowie et. al., 2011) as a form of cultural capital that they bring into the classroom discourse, which Bourdieu argues will improve their attainment (Winkle-Wagner, 2010). The sequence of interaction among the students forms part of the new model of discourse presented in this thesis (page 102) as it involved students' initiation of questions (SI), student response (SR), student probing (SP) and student evaluation (SE).

In the aspect of engagement through questions and feedback, an example of a scenario where students asked questions and gave feedback to each other was considered.

Student 1 question: Let's say I want to slim down, what would you recommend me to do?

Student 2 response: You have to diet, exercising.

Student 3 feedback: Can I comment on that? If he stops eating it's going to have a bad effect on him because he is used to eating. For example when you are smoking, you cannot just stop immediately and this is the same thing as when you are dieting. The person is really fat and cannot move but it has to be gradual. They can also do liposuction.

The responses from students 2 and 3 referred to dieting as a way to answer the question posed by student 1. The statement made by student 3, who asked "can I comment on that" suggests he wanted to give some feedback to the response from student 2 and also to add some vital information. This situation where the students are engaged in questioning and feedback creates an opportunity for deeper learning in science and an understanding of scientific concepts (Erdogan et. al., 2008; Adey et. al., 2010), which has been achieved through the new model of discourse presented in this thesis (page 102). The students would not have made substantial progress in their learning if they were engaged in any of the four models of discourse (page 43) because these models are teacher-led and limit students' contribution to the classroom discourse. Additionally, student 3 referred to fat treatment by Liposuction, which is a way of removing fat from the body through surgery as described by The Harley Medical Group (2014).

The contribution from student 3 above shows the application of prior knowledge to solve problems which I have discussed earlier. This can also be considered as an element of deeper learning in science as this student is able to link what he knows about Liposuction with reference to the question raised by another student. This demonstrated an aspect of How Science Works, which is an important area in science teaching and learning (TES, 2013) that links real life situations to the concept being explored. The feedback from student 3 also created awareness of a new concept about the issue being discussed as well as knowledge development for other students, who did not know what Liposuction meant, before their involvement in the questions and feedback activities. This view is supported by one of the interviewees who stated that:

> “*This is an environment where students are presenting and asking questions, even engaging with new material as well. They are looking at something they have never seen before. They are practising asking questions and looking at new materials and new knowledge”* (Teacher interviewee 1).

This comment made by the interviewee based on engaging students in developing their own knowledge using new material is also supported by the views of Sawyer (2006:2) who noted that:

> *“Students learn better when they express their developing knowledge either through conversation or by creating papers, reports or other artefacts and then are provided with opportunities to reflectively analyse their state of knowledge”.*

At this point I will consider how questions and feedback contributed to students’ engagement in their learning. Although other factors that constitute engagement in learning are addressed in detail in the subsidiary research question 2 based on the interview analyses. The questions and feedback stated below are examples of interactions between the students (appendix 7).

Student 1: State in your own words what obesity means?

Student 2: *Obesity means someone bigger and slightly overweight*

Student 3: What do you think might happen to someone obese?

Student 4: *If you carry on eating and are obese, you could have a heart attack, diabetes and may die.*

Student 5: You can also have high blood pressure.

Student 6: What changes do you recommend for an obese person?

Student 7: Do more exercise, diet or eat a balanced diet.

Student 8: Eat a little bit of everything, vegetables and so on.

Student 9: Can you explain what must have happened before getting obese?

Student 10: Lack of exercise, eating too much.

Student 11: Explain why obesity happens?

Student 12: Lack of exercise, eating wrong foods.

Student 13: Is there any solution you could give to people to help them.

Student 14: *Eat sensibly.*

Student 15: What will happen if you get too obese?

Student 16: *You will get heart attack, diabetes, and stroke.*

Student 17: What are the difference between obesity and anorexic?

Student 18: Obesity is when you are too fat and anorexic too skinny.

Student 19: *Obesity is when you are overweight.*

In this discourse, the students were partly engaged in model 4 Question-and-Answer pattern of interaction (Lemke, 1990) which was led by them and not the teacher. They were asking questions and giving answers, monitoring their work, as well as choosing other students to answer the questions, a view supported by one of the interviewees who said "*if students can come up with questions and may be a possible answer themselves, this makes a difference to their learning"*. The role of the teacher in this discourse is passive as a facilitator of the learning process. This is contrary to the model 1 type of discourse that is, Initiation, Response and Evaluation (IRE) pattern of interactions which is consistent with the normal classroom discourse led by the teacher (Mortimer et. al., 2003) as stated in my literature review page 43. In the Question and Answer model of interactions (Lemke, 1990) students' questions are answered by the teacher, therefore the example stated in this section is not in line with this model because it is a student-led question and answer sequence.

The model of interaction highlighted in the discourse (between students 1 to 19) above is in line with model 2 closed chain of interactions (page 43) which is normally teacher-led. That is Initiation, Response, Prompts, Response, Prompts, Response and Evaluation (I-R-P-R-P-R-E) by Scott et. al. (2006). However, in this study the model is student-led and not teacher led. Therefore, the new model of discourse presented in this thesis is SI-SR-SP-SR-SP-SR-SP-SP-SP-SR-SP-SR-SP-SR-SE, where SI represents Student Initiation, SR is Student Response, SP is Student Probing, and SE is Student Evaluation. This new model shows that the questions are initiated by the students as well as the responses, probing and evaluation. Probing with a frequency of 4 (table 4.1, page 79) has been identified as a factor that enhanced students' engagement in this study. The evaluation was done by student 19 who referred to obesity as being "overweight", a better answer when compared to the response by student 18 who referred to obesity as being "too fat". This sort of student-led interaction fosters engagement of students as stated in the comments made by one of the interviewee's:

> *"I think it is more pupil led, letting the learning take the direction the students want it to go rather than me giving them the questions I want them to answer and me choosing the journey I want them to take. Their leading of it makes them take ownership of the learning and I think it is something that should be considered in normal lessons based on this project"* (Teacher interviewee 1).

This interviewee's view was also supported by a comment from the field notes obtained which states that *"I identified three students whom in normal lessons will not take part in activities, but were engaged with the tasks, and asking questions.* (Teacher's field notes). The comment from the field note in support of students' engagement was supported by one of the interviewees' who stated that:

> *"As each group presented their work, this further enhanced the interest of other students to become more involved especially those not serious initially and lots of them realised they could get more learning out of the activities"* (Teacher interviewee 2).

Reflecting on the sequence of interactions highlighted in this section (between the 19 students, pages 101-102), it is obvious that the students were fully in charge of their learning. This engaged them more in the discourse when compared to a normal classroom discourse led by the teacher (common to the four models of discourse, page 43), where a teacher asks questions and the students respond, followed by the teacher's feedback. In this scenario it has been found that in most cases, the students do not ask questions (Wragg, 2001; Cowie, 2005). This is a view supported by Williams (2011), who argues that teachers must encourage students to ask questions in lessons by giving them examples to follow. In addition to supporting the views of the interviewees and the outcome from engaging students in the formative assessment, Blumenfeld et. al. (2006) and Kafai (2006) stated that in a classroom where these forms of Constructivism are operating (as seen in the new model of discourse presented in this thesis), students ask questions and give feedback. This enables them to be more engaged cognitively than in a typical science lesson where students may be involved in practical work but not actively engaged in learning (Abrahams, 2009). Whilst, Savasci et. al. (2012) reported that science teachers embraced constructivism, their study on lesson observations did not confirm implementation of it in most cases. That is why this study is important in building students' skills in questioning with the view that it will enhance their feedback, engagement and attainment.

Following on from the sequence of questions and answers/feedback highlighted in this section (pages 101-102) taken from appendix 7, this took the students some time to complete. However, this study did not measure the actual time spent on the activities. Notwithstanding, duration of time spent on task was considered one of the factors that constitutes engagement in students' learning with a frequency of 4 (table 4.1, page 79), which is in line with the views of Newton et. al. (2011) and Aguiar et. al. (2010) who pointed out that engagement of students can be measured by the time they spend on activities. This view of time spent on task as a form of engagement was also supported by the responses of the interviewees who stated that:

> *"Yes my year 8 students were very engaged and I was surprised how well they performed. Especially with the presentations which were two lessons in a row. I thought they would get a bit tired towards the end but they were very engaged for up to 5 presentations"* (Teacher interviewee 1).

> *"They enjoyed it and wanted to do well in it. They would like to do things like this again. As I said before, I thought they would not be engaged and may lose interest but I was wrong as they were all engaged. Normally if we do some tasks in a lesson for an extended period of time they become bored and lose interest but it's been different with this project. I was surprised they were engaged for a long time in the lesson"* (Teacher interviewee 1).

I have discussed the impact of the intervention used in this study (questions and feedback) on pupils' learning. It is necessary to highlight other teaching and learning strategies that the students would have experienced and how this intervention can be compared to them. I reiterate that questioning and feedback is the focus of this study and this may bring about improvement in students' attainment (Waind et. al, 2012). Teachers are encouraged to support students in developing their ideas in order to further support their attainment in tests as put forward by Harris et. al. (2012). These claims can be justified from the findings from this study which show that all teachers agreed that questioning and feedback can improve students' engagement and attainment and that students must be given opportunities in lessons to develop their own unique thoughts and beliefs (appendix 12). This outcome is also supported by comments from the teachers' interview (appendix 8). Despite the benefits of students' involvement in questioning and feedback, there are other teaching and learning strategies that the students have experienced with their teachers and it is necessary to mention them. Before presenting these strategies, I will refer to my experience of being a science teacher and strategies that I have used to support teaching and learning in science. These included questioning and feedback, practical work and scientific inquiry (Dolan and Grady, 2010; Dkeidek et. al., 2011), whole class and group discussions (Dkeidek et. al., 2011), field work based on topics on Ecology, finding out information through the use of text books and ICT (Cowie et. al., 2011), and problem solving.

I believe that the teachers involved in this study have used the strategies highlighted above to engage their students. For example, the interviewees (appendix 8) agreed that they engage their students in questioning and feedback in lessons but feel that this needs to be done regularly with the students to give them more opportunity for independent learning and to practice asking high order questions that may improve their learning, rather than being teacher-led. This is in alignment with the views of Dkeidek et. al. (2011) who stated that the question asking ability of students is an integral part of meaningful learning and scientific inquiry. Dkeidek and colleague went further to state the outcome of their study by comparing two groups of students from different cultures based on their question asking ability and its influence on their learning. They found out that

> "*the group of students who worked independently with little guidance from their teachers and who decided on the research questions to develop, performed better than those students who depended on their teachers all the time whilst they formulated the inquiry questions, with their teachers scaffolding them and helping them in formulating the research question"* (p1325).

The outcome from the group of students that performed better supports the views of the interviewees in this study who stated that when students are allowed to find out information for themselves, working in groups and being involved in classroom discussion, and presenting their findings as experienced in this study, it will enhance their thinking skills and enable them to learn more about science.

The interviewees referred to above also agreed that the students involved were fully engaged in the activity and were processing information as they knew that they could be called upon to answer questions at any time, as opposed to when they are answering teacher's questions, carrying out practical work or working from the textbooks, which is common practice in the science classroom. The engagement of students in the tasks also helped to improve their behaviour and listening skills, which the interviewees said is uncommon in a normal science lesson where practical work is taking place. It may also be interesting to point out that the interviewees stated that they were surprised to see their students engaged for several lessons, despite the extended period of involvement in this intervention (questions and feedback). The interviewees had not experienced this with their students before as they were inclined to lose focus and interest in tasks that had gone on for as long as this one (appendix 8). Therefore, they recommended that this type of activity should be practiced with students throughout their secondary education and incorporated into the science schemes of work to improve teaching and learning.

In my own view, I think the progress made by the students could have been due to the structure of the intervention (questions and feedback) which is more student-led with student centred assessments allowing them to take ownership of their own assessments, assigning roles to each other and making contributions, which improved their confidence in challenging each other's views - whether right or wrong. This sustained their interest in the activities, a view supported by the interviewees, and Dolan et. al. (2010) who suggested similar engagement of students in an inquiry lesson. In addition to this, interviewee 1 noted that the structure of this intervention is such that it allows the teacher to explore how much the students are learning and also affords them the opportunity to correct misconceptions among students, an example of which I have highlighted earlier in this chapter. However, the concerns raised by the teachers interviewed (appendix 8) are that students find it difficult to reason and express their own ideas, and the questionnaire analysis (appendix 12) shows that teachers should be encouraged to create opportunities in lessons where students can express their own unique thoughts and beliefs to support pupils' learning and attainment. That is why this type of study is relevant in the science classroom to support students in developing their own questions and giving feedback to peers.

With regards to giving feedback to students, I have earlier pointed out in chapter 2 that students and teachers alike have considered giving feedback to be the main responsibility of the teacher and that students cannot give feedback. However, it was argued that when students are trained, they can give feedback as effectively as their teachers. The argument put forward here, and supported by the findings from this study, shows that students can give feedback when they are trained to do so and the most effective form is through oral feedback as opposed to written feedback (appendix 8), as this type of feedback will cater for the needs of pupils, especially when the task is beyond their capability (Wiliam, 2011). This means feedback must be timely and not delayed as this can have an adverse effect on correcting pupils' misconceptions. For example, interviewee 1 noted that 5% of her students may consider reading written feedback but are interested in the grades alone. This suggests that 95% of her students would prefer oral feedback to improve their learning. This brings to the fore the importance of formative assessments in judging pupils' attainment rather than using levels from end of unit tests, which I have discussed earlier. Therefore, this study aims to report pupils progress based on what they are able to do and achieve, which may contribute to their engagement and attainment in science. This study ensures that all students involved know that their views are considered important by their teachers and other students. I will now discuss practical work and its contribution to learning and engagement.

I have earlier mentioned in this thesis that practical work can be used to engage students and improve their attainment when it is structured to enable students to talk about what they are doing in groups, asking questions and presenting their findings. However, from my experience students' learning could be compromised when practical work is used by teachers to develop students' scientific knowledge rather than scientific ideas which would allow them to express their own views and improve their thinking skills as presented by the new model of discourse in this thesis, and supported by the comments from the interviewees (appendix 8). This same concern is shared by Abrahams et. al. (2011:40) who stated that "practical work is found to be more effective in getting students to learn what the teacher intended about observables and phenomena than getting them to learn about scientific ideas", a feature that is currently less common in the teaching of science (Osborne, 2011). The implication of getting students to learn what the teacher intended about observables is that students are not able to use the right scientific terminology, thinking and talking about objects (Abrahams et. al., 2011) to improve their learning. In view of this, Osborne (2011) encouraged the teaching of science through different strategies rather than concentrating on scientific inquiry as the main means, a view I share, and which has formed the basis of this study. Therefore Abrahams et. al.

(2011) encouraged teachers to consider planning how they wanted students to learn about ideas in their lessons, and this will be guided by the type of assessment used.

For assessment to be effective, it is necessary to know what is being assessed. An example of such assessment focus may be practical skills as pointed by Abrahams, Reiss and Sharpe (2013). Practical work is used by science teachers (including myself) to support pupils' learning and in most cases, it could be incorrectly used due to the way pupils are being assessed. This makes it difficult for pupils to achieve the intended learning outcome. The norm is that teachers get pupils to carry out practical work, collect data and report their findings, without assessing whether students actually know what they are doing. The work of Abrahams et al. (2013) has brought clarity and guidance on how students can be supported in practical skills, and I believe it is relevant to highlight this in this study as it will help science teachers to improve their practices in this area. With reference to assessment of practical work, Abrahams et. al. (2013:214) made a distinction between two forms of assessments that is, "Direct Assessment of Practical Skills (DAPS) and the Indirect Assessment of Practical Skills (IAPS)". They referred to DAPS as any form of assessment that requires students to demonstrate their practical skills through the manipulation of tangible objects that can be used to show their level of competence. While IAPS refers to a form of assessment in which students' level of competence is inferred from the data generated and or reports of the practical work that they undertook (p214). In their study, Abrahams and colleagues reported that current assessment of GCSE practical work in England shows that it is indirect with emphasis on assessing students' understanding of practical work rather than their competency in undertaking it. Also, students are required to provide evidence for this through their writing, which the authors believed may sometimes not be a true indication of students' competence. However, they reported that DAPS is present in some of the assessment criteria.

Furthermore, in regard to assessment of practical work in England, Abrahams et. al. (2013) reported their findings by comparing assessment of practical work from various countries, especially those that are rated higher than England in assessment of practical skills. They argued that a substantial proportion of DAPS is used to assess students in those countries compared to the use of IAPS in England. This revelation will open up opportunities to restructure how we assess students in practical work (Key Stage 3 inclusive). Abrahams and colleagues stated that in China, students are able to gain credit for their skills in practical work as a separate mark that indicates their competence rather than from examinations (p236). I believe that this type of assessment will enable students to discuss and share scientific ideas, which will improve their learning and progress. This is where an understanding of the Nature of Science becomes very useful (Golabek et. al., 2013) as earlier mentioned in chapter 2 and may help students in applying the concepts of How Science Works. Therefore, from the views posed by Abrahams et. al. (2013) it is clear that assessment of practical skills for students should combine both DAPS and IAPS, with some preference given to DAPS form of assessment for better learning outcomes for pupils.

I can recall stating in this study that teachers have been over reliant on practical work as a means to support pupils' learning and progress. I also reiterate that practical work can improve engagement and attainment of pupils. In support of this, the work of Dolan et. al (2010) on teaching by inquiry using practical lessons stated that it can enhance students' development of reasoning skills. However, this may also be linked to teachers' confidence in their subject knowledge and pedagogy, which enables them to design activities to support pupils' learning. In view of this, I contend that the activity must be structured to keep students engaged and interested in the task and they must be willing to learn (ref. table 4.1, page 79). In line with this, Dolan et. al (2010:37) encouraged teachers in an inquiry lesson to:

> "*allow students to talk about the purpose of their experiments, identify their variables, discuss what decisions they had made during the inquiry and their rationale for these choices, describe what they learned from conducting the experiments, and share how their ideas about science had changed*"

The views shared by Dolan and colleague are similar to that of Dkeidek et. al. (2011) who encouraged teachers in a scientific inquiry lesson to allow students to work in groups where they are asking relevant questions, planning an investigation, hypothesizing, observing and recording phenomena. Following on from the comments by Dolan et. al. (2010) about inquiry lessons, Dolan and colleague stated that the students are also encouraged to generate questions during their investigations. However, the students did not appear to pursue these questions further. Could this have been due to lack of guidance in developing relevant questions that may encourage deeper levels of thinking or could it have been attributed to a lack of clarity in questioning as both have been pointed out in this study. Again, this revelation makes this study very important as it will help address these shortcomings in teaching and learning.

The shortcomings highlighted above will encourage teachers to support students in identifying the types of questions to ask and also to model questioning using Bloom's taxonomy. For example, Osborne (2011:102) noted that the "practice of asking questions is not unique to science but the practice of asking scientific questions is, and students need to know what it is that differentiates a scientific question from a non-scientific question". Questioning and feedback has been identified as the best method of engaging students, leading to an improvement in their attainment as presented in this study. Therefore, in comparing the intervention used in this study (question and feedback) to other strategies used by the teachers involved, it can be argued that more work needs to be done in order to support various forms of assessment in science learning. This arguably will depend on the teacher's subject knowledge and pedagogy, which I have highlighted earlier. In this study students were involved in developing questions using Bloom's taxonomy, presenting their findings, engaging in whole class and group discussion leading to arguments and debates, with students expressing their own ideas, which have all contributed to their engagement and attainment as presented in this thesis. I will now consider my subsidiary research question one.

Subsidiary research question 1: How can student-student interaction in questioning and feedback be used to improve students' engagement in science lessons?

This subsidiary research question relied on the outcome from students' questions and feedback to provide evidence for their engagement in the discourse (Engle and Conant, 2002). This is in line with the views of Hodgen et. al. (2008) and Aguiar et. al. (2010) that the quality of questions students ask can enhance their learning as well as the quality of feedback to other students. This subsidiary research question was also answered drawing evidence from the questionnaire and interview outcomes; field notes; and scores from students' presentations. These multiple forms of data collection to solve the research question helped in triangulation to address the research problem in detail (Gray, 2009), whilst verifying the validity and reliability of my findings (Newby, 2010). I reflected on the outcome of the scores on students' presentations (appendix 11) based on some success criteria used (appendix 13). I also compared the types of questions and feedback by the students. This is because research has shown that when students are engaged in talking and sharing ideas about issues in science (for example the topic used in this study, Food and Glorious Food), it can improve their engagement (Nicol, 2007; Wilson et. al., 2011; Waind et. al., 2012) and attainment, as well as develop their skills in the use of scientific keywords (Skamp, 2007, cited in Anne et. al., 2010; OFSTED, 2013) as evidenced in the main research question. On this basis, the quality of questions and feedback from the students were explored (Aguiar et. al., 2010), and checked for any scientific terms and misconceptions used. This is because the ability for students to engage with other students' answers and challenge the answers, whether right or wrong can move their learning forward (Alexander, 2008) and improve their engagement in science. I chose some examples of questions developed by the students (appendix 7) based on using Bloom's taxonomy question prompts categorized into the following question stems: Knowledge; Comprehension; Application; Analysis; Synthesis and Evaluation (appendix 1), which are discussed here in different paragraphs.

The knowledge questions highlighted here are used to bring my argument to the fore.

Student question 1: How many ways can you stop obesity?

Student 2 response: Exercise, less fatty foods, eating a good portion of every food- virtually everything.
Student question 3: What happens if you exercise too much?

Student response 4: You will get tired, become anorexic, you can't say after PE in school that is the only exercise you have to do, you can run.

The questions asked by the students are classified as low level questions requiring factual recall (DFES, 2004), which have been found to be a common practice in science learning among science teachers (Blumenfeld et. al., 2006) and may need some modification in order to engage students more and support their learning. These types of factual recall questions do not require students to think before responding, and may have accounted for the large number of questions developed under the Knowledge questions as presented in table 4.2 (page 84) and figure 4.1 (page 86). Student 2, responded to the question raised by student 1, without having to think about the answer and made contributions outside what they had learnt in the classroom. However, in the response, student 2 said "*eat a good portion of every food, virtually everything*". This was a good answer to the question, although at this stage, I would have expected student 2 to have used the scientific key word associated with the topic, "balanced diet". In addition, the response from student 2, prompted student 3 to ask another question which reflected the answer given by student 2. The teacher was not involved in this interaction, which I regard as initiation of a question by a student (SI), response by a student (SR), probing by another student (SP), and student response (SR) which is represented as (SI-SR-SP-SR). It can be argued that this model falls into the new model of discourse presented in this thesis (page 102). However, the questions asked by the students did not involve any form of evaluation. This model of discourse highlighted here is contrary to models 1 and 4 (page 43) because it is student-led. In model 4 question-and-answer by Lemke (1990), the students ask questions and the teacher responds to them while model 1 that is, Initiation, Response and Evaluation (IRE) (Mortimer et. al., 2003) is led by the teacher. The IRE model of interaction led by the teacher is considered to limit the way students think and respond to questions, and can affect the way they construct their knowledge (Chin, 2006). In the same way, model 4 of discourse suggested by Lemke may help to develop the students' questioning skills but may not develop their ability to respond to questions and give feedback because the feedback is given by the teacher. That is why the new model of discourse presented in this thesis contributes to the body of knowledge as evidence from this study shows that it developed feedback skills among the students, which enhanced their engagement and attainment.

The Comprehension questions are also classified as low level questions requiring factual recall (DFES, 2004), and do not involve extended forms of thinking. These examples were chosen from the questions asked by the students (appendix 7). The names used are pseudonyms.

Student question (Jill): Can you clarify what differences that fruits and vegetables do to our body. Are they like different?

Student response (Gemma): In vegetables they contain different vitamins and nutrients like fruits also

Student question (Jill reframed question) No, I meant like what affect do they have? What do vitamins do in the body?

Student question (reframed again by Gemma) Oh, so you mean like what do different vitamins do?

Student question (Jill reframed question again) No I meant what does each one do in the body?

Student question (Tom) what she meant was can you differentiate their functions?

Student response (Gemma) Fruits would give like vitamins B or C which can help the bones get stronger whereas vegetables can contain different vitamins like A or D.

In the main research question based on the findings from the interview, I pointed out that clarity in the way teachers give instructions as well as clarity in questioning can enhance students' engagement. This clarity also applies to student questioning. The interaction between the students in this case shows an example of how clarity is very important. Jill asked a question concerning the function of fruits and vegetables in our body which can also be classified as a factual recall question, and received a response from Gemma. The response from Gemma only highlighted the types of nutrients contained in vegetables without stating the functions of vegetables and fruits in our bodies, which Jill was asking. Jill had to reframe the question so that Gemma would be able to state the functions in a second attempt at answering the question. Gemma at this point, tried to reframe the question herself in order to understand it and give the right answer but she deviated from the initial question asked by Jill. Jill repeated the question again. Another student, Tom, reframed the question which became clearer to Gemma. At this point, Gemma answered the question. Gemma appeared not to have understood the question.

Looking at the question by Jill and repeated by Tom above, I felt the question required a form of recall answer that does not involve extended thinking, which makes it a low level one (DFES, 2004). This type of question was responsible for the large number of questions developed by the students in the Comprehension questions presented in table 4.2 (page 84) and figure 4.1 (page 86), accounting for 32% of the questions developed (figure 4.2, page 87). However, the response from Gemma shows that she was not completely sure of what the question required, and this was reflected in her answer to the question. The right response would have been, fruits contain vitamins C and they help maintain our health by keeping our immune system healthy. Gemma was not sure of this answer as she said fruits contain vitamins B or C, and she also said fruits help the bones get stronger, which is not true. Vitamins D is responsible for strong bones and teeth. The teacher in this study could have picked another student to respond to the question and give feedback, however she knew they would come back to this subject again during the course of the presentations. The type of interaction among the students is in line with model 4 of discourse (question and answer model) by Lemke (1990), page 43. Although in this case, student questions were answered by students rather than the teacher as seen in model 4. Therefore the sequence of interaction demonstrated by the students (student initiation and student response) form part of the new model of discourse presented in this thesis (page 102). This type of interaction gives opportunity to the students to express their ideas whether right or wrong. One of the comments from the field notes obtained from the teachers who carried out the lesson observations confirmed this aspect of students supporting each other and it states *"some students helped others to reframe their questions if they felt it was not well presented"*. In this situation, the students were fully in charge of the discourse as supported by the views of the interviewees stated here:

> *"I think it's more pupil led, letting the learning take the direction the students want it to go rather than me giving them the questions I want them to answer and me choosing the journey I want them to take. Their leading it makes them take ownership of the learning and I think it is something that should be considered in normal lessons based on this project"* (Teacher interviewee 1).
>
> *"I think this sort of work will actually make them realise that presentations and giving good answers is all part of growing up and learning"* (Teacher interviewee 2).

The Application question is considered as one of the high level questions in Bloom's taxonomy with a rating of 3, table 4.2 (page 84). The question highlighted here was raised by a student as a follow up from a previous discourse on the effect of the intake of too many calories and its effect on our metabolism (appendix 7). This led to some answers and feedback from other students.

Student question (Jane): You said that carbohydrates are really good for your body but like what will happen if that is the only food I ate?

Student response (Jim): You will get fatter because the carbohydrate contains high calorie as well. For example most people dieting, take low carb diets because carbohydrates have more calories in them.

Student response (Ellie): And you said they were healthy?

Student response (Jim): Yes they are all healthy as long as you use the energy of the carbohydrate. If you do not use them, the energy will be stored as fat which is bad for you.

The question raised by Jane required a form of application and use of prior knowledge to answer the question (Cowie et. al., 2011), a view supported by one of the interviewees who said that "*some students had prior knowledge and were able to apply it to problem solving*". This view is also supported by comments made from the field notes of one of the teachers, who said that *"some students were using the knowledge gained from other areas of their lives to answer questions"*. Jim's response to the question showed that he was aware that too much carbohydrate would result in more body weight due to its high energy calories, and that is why he stated that when people are dieting they are advised to eat less carbohydrate. However, Ellie seem not to agree with the answer given by Jim because she thought that if one is advised to eat only a small amount of carbohydrates, it will not be good for them. In response to this, Jim gave feedback which showed his understanding of the scientific concepts involved in healthy eating and dieting. Jim responded by acknowledging that carbohydrates are healthy foods and can be eaten in any quantity as long as we use the energy in the food, but if the energy is not used, it will be stored in the body as fat. This response from Jim shows that the activity had enabled him to apply aspects of science to everyday life experiences which Grime (2012) and Millar (2012) argue will reflect How Science Works, a concept promoted by the National Curriculum to improve students' engagement and interest in science subjects. This allows the students to link their learning in science to real life situations (TES, 2013).

Sampson et al. al. (2012) noted that this form of engagement in questions and feedback will help to inform the Nature of Scientific knowledge of the students, and enhance their critical thinking skills (Hogg, 2010). This view is supported by Newton et. al. (2011) that it may also have an impact on how students are involved in activities in science lessons. Jim's feedback is consistent with the type of response the teacher would give when posed with such a question. However, the concept of a balanced diet would have been introduced by the teacher when responding to this type of question as discussed earlier in answer to a question in this chapter. Another feedback that Jim could have given to Ellie was to state that the way we can use up the energy from the carbohydrate is by exercising. This would have been good feedback to give if Jim is unsure whether Ellie knows how the calories from the carbohydrate foods can be used up by the body. This supports the argument by Min (2008) that students' feedback can be as effective as the teachers when students are trained to give feedback which is a focus in this study. The students involved in the discourse were engaged in the initiation of questions, response, probing, feedback and evaluation in line with the new model of discourse presented in this thesis (page 102). This is a good way of engaging students in science learning that has improved their attainment when compared to the other models (models 1 to 4, page 43) that are teacher-led and do not encourage students' autonomy of their own learning.

An Analysis question is considered as one of the high level questions in Bloom's taxonomy. The question highlighted here was chosen from the transcripts of students' questions and feedback session (appendix 7).

Student question (Chris): Can you state the relationship between the large and small intestines?

Student response (Jack): One is bigger and one is smaller.

Student response (John): They both like have hair in them it's not like the hair on our skin but they have smaller hair.

Student feedback (James): it is called villi.

Student response (John): Yes and that makes the food go through.

Jack's response to the question posed by Chris referred to the small and large intestines by saying that "one is bigger and one is smaller". This response is not scientific and did not give the main difference between the small and large intestines that is expected from such a question. This is not encouraging. John's response shows his understanding of both the small and large intestines but it could be misleading as the large intestine does not have the hair-like structure he mentioned, which can only be found in the small intestines. The feedback from James is perfect at this stage because he has engaged with the scientific key word called "villi", the name of the hair-like structure described by John. This feedback from James can be seen as a form of support which aided John to conclude the discourse by saying the villi helps the food to go through. This shows that the students controlled the discourse and talked in each other's zone of proximal development (Wells, 2012; Panofsky and Vadeboncoeur, 2012). This is another good form of interaction among the students, which led to an improvement in their engagement in the task, a view supported by the outcome from the interview analyses with Sharing ideas/Distributed learning having a frequency of 7 (table 4.1 page 79). This interaction shows that the students were involved in initiating questions, response and feedback, and evaluation as a reflection of the new model of discourse presented in this thesis (page 102).

In reaction to John's final comment which says the villi helps the food go through, he could have stated that the villi in the small intestine helps to absorb the food into our blood stream. However, I noted that no further comment was made about the structure of the large intestine and its function in digestion. It could have been that the students did not know the function of the large intestine or they may have forgotten to comment on this. The teacher involved in the study could have raised this concern with the students and demanded a response to it but the teacher may have been acting on the instructions given to her at the start of the project, which stipulated that all activities must be student-led. No response was given to the question raised by Chris which requires the students to state the differences in the structures of the small and large intestines and their functions. In this case, clarity of the question as identified earlier was not an issue but students' understanding of the question and what the question is trying to convey is the problem. This implies that for students to answer such a question they have to analyse the question and break it into parts in order to give the answers required. Looking at table 4.2 (page 84) and figures 4.1 and 4.2 on pages 86 and 87 respectively, it can be seen that the analysis questions developed by the students (8 questions), represented 5% of the total questions developed which is considered low. This is because such questions may require a high level of thinking to frame them, and responding to such questions will also require the students to think deeply. However, this may not be the reason why the analysis questions were few in number in this study. Other reasons may be suggested as we progress through the other high level questions remaining (Synthesis and Evaluation).

The Synthesis questions are part of the high level questions, with a rating of 5 (table 4.2, page 84). An example of this question developed by the students and feedback given is shown here:

Student question (Diana): if a person is allergic to carbohydrates, what will they be given to keep on having the same lifestyle?

Student response (Jake): you can also eat protein to get some energy. Protein actually contain some energy and it depends on how much you eat.

This response from Jake follows on from a contribution by another student that carbohydrate foods are the only source of energy for humans. During the course of the presentations, and questions and feedback, some of the students were aware that fatty foods can also provide us with energy. However, the feedback from Jake is an important contribution to the students' learning by stating that proteins can also provide us with some energy, a view supported by Bell, Berrington, Cowie, Daniels, Mitchell and Smiles (2011:16), "that protein is used to supply energy only in an emergency such as starvation, when fats and carbohydrates are not available". Prior to this interaction none of the students knew that protein could also give us energy. From my experience of teaching science, this aspect of scientific information may be shared with the students when they get to Key Stage 4. This is because at Key Stage 3, the students are taught that protein helps us grow and repair damaged tissues in our bodies. The response from Jake can be considered as a high level response which served as feedback to other students and created new knowledge for the others who at this stage did not know this fact. Creating such new knowledge has been considered in this study as one of the ways to improve students' engagement with a frequency of 3 (table 4.1, page 79). This is what this study is all about and such new knowledge may be associated with Synthesis questions.

The student-student interaction highlighted above also falls in line with the new model of discourse presented in this thesis (page 102) that encourages students' ownership of their learning. Jake was able to give this feedback due to his engagement in the tasks, through researching and using new materials to solve problems (Cowie et. al., 2011), a view supported by one of the interviewees, who stated that:

> *"This is an environment where students are presenting and asking questions, even engaging with new material as well. They are looking at something they have never seen before. They are practicing asking questions and looking at new materials and new knowledge"* (Teacher interviewee 1).

When the feedback was given by Jake to the other students, I could hear some background noise from the audio recording as the students were shouting and challenging the response from Jake, that protein is not a source of energy. Therefore, this kind of study where students are engaged in questions and feedback, places them in a position to challenge other's views whether right or wrong (Osborne et. al., 2010), a notion also shared by the interviewees that it will improve students' engagement in their learning, with the comments below:

> "*Yes I do consider this scenario where children are challenging themselves on right and wrong answers as engagement. I think that stimulation is actually finding out whether they are right or wrong*" (Teacher interviewee 1).
>
> *"In this activity the students were positively challenging what they were talking about and at the same time they were thinking is that right or wrong. It kind of removes any form of personalisation"* (Teacher interviewee 2).

An Evaluation question is one of the high level questions on Bloom's taxonomy. An example of a question in this category and the accompanying feedback is highlighted here.

Student question (Andy): What changes would you recommend to eating fat foods?

Student response (Mary): Eat small portion of fats with salads and drink plenty of water instead of soft drinks, because they are not very healthy for you.

Student response (Phil): If you go to the shops buy those things so that when you fry your chips, it sucks out the oil so you get less fat in your body.

In the course of the questions and feedback, the students have discussed the types of foods that contain fats and that energy can be derived from such foods. They have identified that too much fatty food can make people develop fat in their body and this can block the arteries and lead to heart disease. This kind of discourse helped to build the students' knowledge and consolidate their learning, helping them to apply what they have learnt to a new situation. The question raised by Andy enabled Mary and Phil to link the knowledge they have developed from this study and their prior knowledge (Cowie et. al., 2011) to solve the question, a view considered to enhance students' engagement, with Prior knowledge having a frequency of 3 (table 4.1, page 79). Applying prior knowledge has been confirmed in response to the main research question as one of the ways to improve students' engagement and attainment in their learning. This is because it enabled them to construct knowledge (King et. al., 2010) and contribute to the classroom discourse. In addition the use of prior knowledge in students' learning has been supported by the views of one of the interviewees, who stated that:

> *"Some had prior knowledge, others were quite happy to sit and read and find information out and tell others what pieces of information to add to their posters. Some children had that, I am taking charge attitude of leadership. These attitudes kept them on track"* (Teacher interviewee 2).

Mary's response seems to address the question raised by Andy by suggesting people should eat small portions of fatty foods with salads, and drink plenty of water instead of drinks (juices and fizzy drinks) because they are unhealthy for them. Her response is similar to what a teacher would offer for such a question. Mary's response can also be referred to as advising people to eat a balanced diet, which would have been good feedback if she had used the key word. Phil's feedback complemented the answer given by Mary. Phil's contribution, probably, was based on his prior knowledge or from the problem solving tasks, as such a response may not have been covered in the schemes of work for the topic used in this study. In addition the response from Phil can be linked to a healthy lifestyle factor based on the choices we make in our feeding habits. This interaction among the students also falls into the new model of discourse presented in this thesis (page 102) involving questions and feedback. Having discussed examples of questions developed by the students and feedback, I will now consider outcomes from students' presentations.

Analyses of students' presentations

As stated in my methodology, the students involved carried out research to solve some problems and each group presented their outcome to the rest of the students, leading to questions and feedback. The students were scored based on some success criteria with ratings of 1 to 5 (appendix 13), adapted from OSLA (2012) model of inquiry and research. The success criteria was used to score students in order to monitor their engagement in the tasks and also to keep them focused. In addition the success criteria helped to assess scientific skills of the students formatively, which Fairbrother (1993) argues can be a problem for science teachers. In line with this, Trauth-Nare et. al. (2011) argue that formative assessment should be an ongoing activity in the classroom, which can be in the form of questions and feedback, and the outcome from such activity can be used with summative assessment to report students' progress and attainment in science. Therefore, the outcome from using a success criteria in this study, if successful, will be employed in other science subjects to assess students. The scores obtained by each student during the questions and feedback sessions were presented in appendix 11. The average score for all five criteria used to judge students' engagement (appendix 11) was calculated and the following observation was made from the table of result: 6 students

(11%) achieved an average score of 1 considered to be outstanding; 25 students (48%) achieved an average score of 2 considered to be good; 20 students (39%) achieved an average score of 3 which is satisfactory; and 1 student (2%) achieved an average score of 4 considered as needing improvement. Based on these figures, a total of 59% of the students achieved outstanding or good in their presentations, and 39% were satisfactory.

The result above is impressive because of the high percentage of students engaged in the tasks, a view supported by the interviewees that:

> *"The students who were more engaged in the activity are the ones that actually did the better presentations. It is not about them sitting down and writing in their books and listening to me talk but they are actually doing the work and engaging themselves"* (Teacher interviewee 2).
>
> *"As each group presented their work, this further enhanced the progress of other students to be more involved especially those not serious initially and lots of them realised they could get more out of the activities"* (Teacher interviewee 2)

These comments from the interviewees may play a significant role in the way the students were engaged in the activities and how they influenced other students to be involved as well. This may have been responsible for 59% of the students who achieved good or outstanding results in their presentations. Reflecting on the combined scores of the students for outstanding (11%), good (48%) and satisfactory (39%), a total of 98% of the students were engaged in the activity, a view also supported by findings from the interview analyses with engagement of students having a frequency of 22 (table 4.1, page 79). This result on students' engagement may also have been responsible for the sudden improvement in the high level questions developed by the students (figure 4.1, page 86), with a "U" curve as stated earlier. Although the 2% of the students classified as needing improvement were engaged in the activities but not to their full potential. These were the students considered by one of the interviewees as "*those not serious initially but realised they could get more out of the activities*". This outcome does not mean a failure for the 2% of the students, however they need to be supported in this kind of activity to achieve their full potential which may be in the area of developing good questions (high level questions) and giving quality feedback to other students. An example of this situation is highlighted in the Comprehension question (page 112), where Jill asked a low level question and the response from Gemma did not meet the requirements for the question.

From the same results in appendix 11, the average scores achieved by the students based on the questions developed, and answering questions/feedback was also calculated. The outcome is presented as thus: 4 students (8%) achieved an average score of 1 considered to be outstanding; 14 students (27%) achieved an average score of 2 deemed to be good; 29 (56%) were judged satisfactory; and 5 students (9%) classified as needing improvement. From this analysis, a total of 35% of the students were considered to be good or outstanding in developing questions and giving feedback to other students; 56% of the students remained satisfactory and 9% needed improvement. Most of the students fall into the category of being satisfactory, which may have resulted in more questions developed under the Knowledge and Comprehension categories on Bloom's taxonomy, table 4.2 (page 84). This finding shows that more effort is required by teachers to support students' engagement in science (ASE, 2006; Reiss et. al., 2011). This can be in the form of student-student interactions in lessons through questions and feedback (Alexander, 2008; Swaffield, 2008) in order to improve their attainment. However, with 35% of the students having good or outstanding skills in developing questions and giving feedback, this shows a positive result for this study. This percentage of students may have been responsible for the increase in the number of high level questions developed using Bloom's taxonomy (table 4.2 and figure 4.1, pages 84 and 86 respectively), rising between the Synthesis and Evaluation questions, which I would have expected to be lower. This is an important contribution to knowledge. It is also important to state that some students may have been good in developing high level questions and not good at giving feedback to other students. Therefore, considering students' scores separately on questions developed and feedback given may be worthwhile to prove this point.

In the aspect of students developing their own questions (appendix 11), 8 students (15%) were judged as outstanding; 20 students (39%) considered as good; 20 students (39%) were considered as satisfactory; and 4 students (7%) needed improvement. This data shows that a combined total of 54% of the students were judged as developing good or outstanding questions. This may have contributed to a rise in the number of high level questions (Application, Analysis, Synthesis, and Evaluation questions), which came to 36% of the total questions developed by the students using Bloom's taxonomy (table 4.2, page 84) and figure 4.2 (page 87). This may also be responsible for the engagement of students in this activity. With regard to giving feedback to other students (appendix 11), the following data was analysed as follow: 7 students (13%) were judged as outstanding; 16 students (31%) were judged as good; 25 students (48%) were considered as satisfactory; and 4 students (8%) needed improvement. Therefore, a combined total of 44% of the students were good or outstanding in giving feedback to other students, while 48% remained satisfactory. If we combine the figures for satisfactory and those needing improvement, a total of 56% of the students, therefore, needed to be supported in order to become good at giving feedback just like their teacher. This view is supported by Gielen et. al. (2010) who noted that teachers should involve students in the process of giving feedback to each other in order to make it effective, and that teachers should also give regular feedback to students, so that the students can learn from their teachers. This view is also in line with that of Min (2008) who stated that if students are trained to give feedback, their feedback can be as effective as their teachers. These comments were further supported by one of the interviewees, who stated that:

> *"I think it's something that will be beneficial in the long run and is something you have to practice with them over time and embed in the lesson. I think some of them wanted to answer the high order questions more often, and some still struggled with the low order thinking questions. But with more practice they will get used to it and it will help them learn as well"* (Teacher interviewee 1).

At this point, it may be important to compare the data obtained on students developing own questions with the data on giving feedback (appendix 11) to see which area showed better performance by the students (questioning or giving feedback). It can be recalled that 54% of the students were judged as good or outstanding in developing questions, and 44% considered as good or outstanding in giving feedback to other students. This result shows that the students were better at asking questions than giving feedback, which can be an area for development in order to enhance students' engagement and attainment. The improvement in their questioning ability was due to their engagement in developing questions using Bloom's taxonomy question prompts which they practiced over the course of this study. Practice with a frequency of 2 (table 4.1, page 79) was identified as one of the factors that constitute students' engagement. Therefore this study shows that more effort is required by teachers to train students in giving feedback to other students as suggested by Min (2008), which also includes supporting students to develop high level questions. Given the positive outcome from this result with improved questioning skills among the students, this does not allow for complacency as more effort is also required to support the students to become better in developing questions using Bloom's taxonomy. This revelation has highlighted an area for professional development support for teachers, which will take into account their experience in supporting students to give feedback to other students. Therefore, oral feedback forms need to be well developed in lessons to cater for the needs of those students who may achieve by this means and fulfil their potential. This is because delayed feedback to students, which can be in the form of book marking has been criticised by Hartley and Chesworth (2000), in that it may not serve the purpose of feedback which is intended to close the gap in students' knowledge. This view of using oral feedback to support students' learning is strongly supported by the interviewees in this study with the following comments:

> *"I would say oral feedback is most effective in supporting my students' learning. I am not sure how much emphasis the students put on written feedback. Even if you mark their books some of them will look at it and come to me and ask questions about it because they prefer to have their conversation with me rather than just me making comments in their books"* (Teacher interviewee 1).

> *"Both I think, oral feedback I think on the spot in the classroom, while written feedback when you are marking their books"* (Teacher interviewee 2).

The use of oral feedback in supporting and engaging students in their learning was also confirmed by the outcome from the questionnaire analyses (appendix 12). The result shows 9 out of the 10 teachers sampled, considered oral feedback as more effective in supporting students' learning when compared to written feedback, a view also supported by the 2 teachers who completed the questionnaires after the lesson observations they were involved in. This is because such engagement of students in verbal interaction can help students to develop their understanding and knowledge. However, one of the teachers sampled considered written feedback as the most effective, in line with the views of Black et. al. (2003) who stated that comment only marking will bring about greater impact in students' learning than other forms of feedback. A further analysis of question eleven on the questionnaire (appendix 2), which seeks to find out the views of teachers on the effectiveness of oral feedback in lessons, shows that five teachers scored oral feedback as 5 (most effective); three teachers scored oral feedback as 4 (very effective); and two teachers scored oral feedback as 3 (effective). In addition to these results, the other two teachers sampled, scored oral feedback as 4 (very effective) and 5 (most effective). Therefore, the findings from this study based on the questionnaire analyses (appendix 12) and interview (appendix 8) show that oral feedback is considered more effective than written feedback in engaging students and supporting them in their learning. In support of these findings, Earl and Katz (2008) and Adey et al. (2010) noted that engaging students in oral feedback will enhance their metacognition and social construction, and also help them to understand the Nature of Science (Cowie, 2005). Having answered the main research question and subsidiary research question one, I will now consider subsidiary research question two.

Subsidiary research question 2: What is the nature of teachers' perception in the use of questioning and feedback in engaging students in science lessons?

This question was answered based on the outcome from the questionnaire and interview analyses. The outcome from the questionnaire analyses (appendix 12) shows that all 12 teachers agreed that questioning and feedback can have a positive impact on students' engagement and attainment, and also encourage students to express their own unique thoughts and beliefs. This view is supported by Miller et. al. (2007) and Smith (2007) who noted that questioning in lessons should be structured to include feedback as it can bring about improved attainment of students. All the 12 teachers sampled confirmed that they plan for questions in advance before their lessons as well as making up some questions during the lesson whenever the need arises (appendix 12). In addition to the fact that good questions can elicit better responses and feedback (Hodgen et. al., 2008), the questionnaire analyses shows that 3 teachers agreed that they plan for likely feedback from students' response to questions; 5 teachers do not plan for feedback from students; and 2 teachers say they fall into both categories. Of the two teachers who completed the same questionnaire, 1 of them planned for likely feedback from students, whilst the other did not. This outcome shows that most teachers do not plan for likely feedback from students. This calls for flexibility in the way teachers give feedback to their students, which means anticipating the kind of responses students will give to certain questions and how they could engage the students further by probing them, and giving constructive feedback to move students' learning forward (Alexander, 2008). This is when engagement in questioning and feedback has been achieved as seen in the new model of discourse presented in this thesis (page 102).

This study was designed for students to develop their own questions and give feedback to other students. The students may not have the opportunity like their teachers to anticipate the kind of responses other students will give to their questions before the lesson. That is the purpose of students being given a wait time to respond to other students' questions (Black et. al., 2003; Ecclestone, 2008) as this played an important role in the quality of feedback produced by the students. This wait time had an impact on the levels of engagement of the students in the tasks, a view argued by Black et. al. (2003) that when the wait time is not appropriate, it will reduce the number of students taking part in the feedback process. An analysis of how long teachers wait to get a response from questions they ask students (appendix 12) shows that 8 teachers considered a wait time greater than or equal to 7 seconds as appropriate, and 4 teachers considered a wait time less than 7 seconds as right. This shows that deciding the wait time during questioning could be an issue for professional development needs of the teachers sampled. In line with engagement of students, the data obtained from the interview analyses (table 4.1, page 79) shows that students Sharing ideas/teamwork/socialisation with a frequency score of 7 was considered important in sustaining their engagement in the discourse (Clarke, 2008; Black et. al., 2010). This view is further supported by Clarke (2008), who argues that the use of talking partners in order to socialise students would help them engage with questions in the lesson. In addition to socialising students to engage them in questioning and feedback, Alexander (2008) argues that teachers who focus on the social aspect of talk in lessons will not help to develop students' cognitive knowledge, another factor found to constitute students' engagement with a frequency of 10 (table 4.1, page 79). Other factors that encourage students' engagement in learning will be highlighted in detail in this section.

From table 4.1 (page 79), a frequency of 53 was achieved for questioning and feedback confirmed by the teachers as the best means to engage students. This is a view supported by the outcome from the questionnaire analyses (appendix 12), where all teachers sampled agreed that questioning and feedback can have an impact on students' engagement and attainment. This view of engagement of students through questioning and feedback is supported by Black et. al. (2010) and Cowie et. al. (2011), as being capable of improving students' attainment in science. Engagement and Attentiveness with a frequency of 22; and Involvement and Participation of students in their assessments with a frequency of 11 were also considered to be forms of engagement of students (Fielding-Wells et. al., 2008). Thinking skills/Cognitive development (Adey et. al., 2010) with a frequency of 10, was considered as a means to improve students' engagement, a view supported by the interviewee who stated that:

> *"In this activity the students were positively challenging what they were talking about at the same time they were thinking is that right or wrong. It kind of removes any form of personalisation"* (Teacher interviewee 1).
>
> *"Especially looking at this activity they were constantly having to be aware and thinking, and it was not like they could switch off for a while. They were not being disruptive-they were all working-but in a normal lesson most of them would be totally disengaged. In this project it was different because they were processing information constantly, and because they knew they would be asked questions and may be required to answer them. This made them to be on task completely and with full attention"* (Teacher interviewee 1).

The comments above clearly demonstrate that both the teacher and students were aware of the students' engagement in the activity due to the questions and feedback. This shows that such activities may be encouraged in science lessons. In the same data on table 4.1, page 79, Student motivation (McCombs et. al., 2007) with a frequency of 8 was considered as a means of engaging students; Metacognition with a frequency of 5, and Clarity with a frequency of 5 were rated as having the same levels of engagement of students. However, when Metacognition was grouped with Thinking skills/Cognitive development it gave a combined frequency of 15 which can be rated higher than Involvement/Participation of students in terms of engagement. Challenging others' views/Stimulation/Probing; Willingness; Time spent on tasks (Newton et. al., 2011); Facilitating Learning; and Assessing/Monitoring learning all had a frequency of 4. This shows that the interviewees rated these factors as similar in engaging students. The following factors, each with a frequency of 3 were rated as similar in engaging students in their learning. Knowledge creation/Prior knowledge (Olitsky, 2007; Cowie et. al., 2011); Interests/Readiness of students; Planning resources which involves the use of research materials (Aguiar et. al., 2010; Cowie et. al., 2011); and Repetition/Repeat activity. Students' enjoyment; Attainment (Nicol, 2007); Good behaviour (McCombs, 2007); Problem solving (Simon et. al., 2006); Practice; Active listening (Black et. al., 2010); High expectations on what to do; and Building confidence (Osborne et. al., 2010), each with a frequency of 2, were all classified on the same level in engaging students.

Most of the factors that constitute students' engagement from analyses of the interviews confirmed similar views shared by other authors as highlighted. However, two factors that constitute students' engagement have evolved from this study and had not been identified in my literature review. These will contribute towards the body of knowledge in this study. The factors are Repetition/Repeat activity and Practice. Repetition/Repeat activity with a frequency of 3, was rated higher than Practice with a frequency of 2 (table 4.1 page 79). At this point, it is important to bring to the fore, the context with which the two factors (Repetition/Repeat activity; and Practice) were coded from the words of the interviewees in the interview transcripts (appendix 8).

Repetition/Repeat activity: the comments made by the interviewees under this category are:

"This is something we should be doing".

"It will be interesting to see how they get on with doing it over time and again".

"Yes I think the students would like to do this activity again"

Practice: the comments made by the interviewees under this category are:

"But we need to start building up the skills and structure to begin with so that they can start practising it and get used to it early, and how to do presentations".

"They are practising asking questions and looking at new materials".

Based on the comments from the factors stated above, that are part of students' engagement (Repetition/Repeat activity; and Practice), it can be seen that these factors have some elements of planning for resources which was also considered as contributing to students' engagement as earlier mentioned. In addition both factors provide students with an opportunity to practice questioning and give feedback in lessons over a period of time so that they can become accustomed to it. The teachers' role as a facilitator of learning was also acknowledged in the comments. However, it can also be argued that most of the factors that constitute students' engagement in this study were linked to questioning and feedback which had the highest frequency of 53 (table 4.1, page 79). I will now make a summary of the discussions from this chapter in the next section.

4.1 Conclusion

Evidence from this study shows that students are capable of leading the Initiation, Response, and Evaluation model of discourse (IRE model 1, page 43) and other forms of interactions in the classroom. This is contrary to the IRE model being led by the teacher, which Van Dijk (2001) and Reinsvold et. al. (2012) argue may lead to a social power relationship because the teacher may dominate the discourse and assign roles to the students. The ability for the students involved to take ownership of their learning, considered as one of the ways to engage students, was responsible for the progress they made in developing their own questions and giving feedback to each other. Questions and feedback led by the students was rated as the best form of engaging students in science lessons compared to other forms of engagement identified in this study. This study also shows that students are capable of developing good questions (high level questions), and giving quality feedback to other students, just like their teachers, a view supported by Min (2008), who indicates that students can be trained to give effective feedback like their teachers. The students were involved in a dialogue and contributed to the discourse, talking in each other's zone of proximal development as well as challenging other students' views and assessing their learning. This is a constructivist learning approach which may be lacking in most science lessons (Savasci, 2012). This student-student interaction improved their engagement (Nicol, 2007; Wilson et. al., 2011) and attainment as shown in the end of unit science test results with 92% of the students achieving their target levels (appendix 10), and 98% of the students being engaged in the questions and feedback (appendix 11).

The idea of teachers being facilitators of learning in this study also created opportunities for the students to be more engaged in asking questions and giving feedback to other students by assuming the role of the teacher. This enabled the students to build confidence in expressing their scientific knowledge and applying How Science Works in solving problems. This was not perceived as taking authority out of the teacher's hand, by controlling the classroom discourse, but rather it created an opportunity which favoured an "interactive and dialogic communication" (Aguiar et. al., 2010:185) led by the students. However, the teacher was involved in giving feedback in situations where no student could respond to a question. More questions were developed under the low level questions (Knowledge and Comprehension), which are merely factual recall and may not be considered to engage students in thinking compared to the high level questions. However, some improvement in creating the high level questions (Synthesis and Evaluation) by the students was demonstrated. These high level questions engaged the students more and also influenced the quality of the feedback (Hodgen et. al., 2008) they gave to other students. Although this study shows that questioning and feedback skills among students must be developed, when both were compared (questioning and feedback), the percentage of students achieving good or outstanding in questioning was 54%, while feedback was 44%. This shows that the students performed better at questioning than giving feedback. The quality of students' questions and feedback are very important in determining their engagement in the task set (Engle and Conant, 2002). Therefore, more effort is required by science teachers to support students in developing their questioning and feedback skills. Unfortunately this study shows that eight out of the twelve teachers sampled (67%) do not use Bloom's taxonomy in developing questions in lessons, making it difficult to support students in this aspect of their learning. The implication of this will be discussed in chapter 5.

An issue that arose was in the aspect of clarity of questions developed by the students in some situations, despite being given Bloom's taxonomy question prompts as a guide. This is because the students had to think through the process before creating their own questions, something they are not used to doing. In view of this, wait time during questioning has also been identified as an important factor to be considered in order to engage all students in the classroom discourse (Black et. al., 2003; Ecclestone, 2008). This can also influence the quality of feedback produced by the students. I reiterate that clarity in students' questioning is a problem which has raised some elements of professional development for science teachers and will be reflected upon in chapter 5 of this thesis. Although an argument can be put forward here that engaging other teachers in this study, as justified in my methodology which involved lesson observation on students, enabled the teachers to share their experiences and consider areas that may require further development to support students' learning and teacher development. Therefore, this study argues that urgent attention is required for science teachers to involve students in leading their learning because evidence from the interview (appendix 8) and field notes (appendix 9) showed that the students appreciated the teacher's effort in involving them in their own assessment and allowing them to ask questions and get feedback (Cowie, 2005), which may not be common practice in the science classroom. This implies that teachers' perceptions in the use of questioning and feedback to engage students in science lessons is very crucial. In addition some factors that constitute engagement of students have emerged from this study, which are in line with the literature as stated earlier. However, two factors which were not identified in my literature review as part of students' engagement have evolved. These are Repetition/Repeat activity; and Practice. These factors referred to elements of planning for resources by science teachers (Parkinson, 2004), which will enable them to build questions and feedback into their lesson plans. This created opportunities for dialogue among students and allowed them to probe each other and give constructive feedback as seen in the new model of discourse presented in this thesis (page 102).

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This study focuses on the use of student-led questions and feedback to improve students' engagement and attainment in Key Stage 3 secondary science. In this chapter I will show how my research has met the aims and objectives of this study and answered the research questions. I will highlight the new model of classroom discourse developed in this study and how the pupil's voice has influenced students' learning, engagement and attainment in science. I will state how this research has made an original contribution to knowledge, and how the EdD research process influenced my professional development in the area of Assessment for Learning. I will conclude by making recommendations for professional practice and a further suggestion for the development of future research.

The purpose of this study is to find out how students' awareness of the use of questions and feedback can improve their engagement in their learning, and to examine students' contribution to the classroom discourse through developing their own questions and giving peer feedback, and how this can improve their attainment. This study also sought teachers' perceptions on the role of questions and feedback in engaging students in science lessons. The main research question was:

- How can both student-led questions and feedback be used to enhance students' engagement and attainment in a Learner-centred Key Stage 3 science classroom?

The subsidiary research questions are:

- How can student-student interaction in questioning and feedback be used to improve students' engagement in science lessons?
- What is the nature of teachers' perceptions in the use of questioning and feedback in engaging students in science lessons?

5.1 Conclusions

The question and feedback used in this study is considered to be a focused form of assessment for learning (Harlen, 2009) that enhanced students' learning and attainment, and empowered them to take ownership of their learning (Nicol, 2007). Evidence from this study has shown that students are capable of leading the Initiation, Response and Evaluation (IRE) model 1 of discourse (page 43), which gave them autonomy over their learning. This improved the students' engagement and attainment as earlier mentioned. Questions and feedback led by the students with a frequency of 53 based on analyses of the interviews (table 4.1 page 79) was rated as the best form of engaging students in science lessons compared to other forms of engagement identified in this study. Evidence from this study (table 4.2 page 84) shows that more low level questions (Knowledge and Comprehension questions) on Bloom's taxonomy were developed by the students, and these low level questions involved factual recall which does not engage students in thinking (DFES, 2004), a view considered by Blumenfeld et. al. (2006) to be a common practice in science learning among science teachers. This practice may require some adjustment in order to improve students' engagement and support their learning, where high level questions are developed and used. However, an improvement in creating the high level questions (Synthesis and Evaluation) by the students showed a positive result (table 4.2 page 84 and figure 4.1 page 86). These high level questions engaged the students more, and also influenced the quality of the feedback (Hodgen et. al., 2008) they gave to each other.

It is important to state here that other studies have shown that students are more engaged in asking questions and giving feedback in subjects such as Drama, Physical Education, English and Art lessons unlike in science lessons (Darlington, 2012; Turner et. al., 2010). Therefore, there is a need to adopt strategies in science lessons to support students in asking questions and giving feedback to peers. This type of engagement of students in questions and feedback support a constructivist approach to learning (Blumenfled et. al., 2006; Savasci et. al., 2012) which may improve students' cognitive ability and metacognition, and may lead to an improvement in students' engagement and attainment. Despite the importance of constructivism in improving students' engagement and attainment, Savasci et. al., (2012) pointed out that lesson observations in science shows that constructivism has not been implemented by teachers in their classroom. However, these same teachers admitted that it is a good form of learning and engagement of students. In view of the importance of constructivism in the science classroom, which also forms the theoretical framework of this study (Clarke, 2005; James et. al., 2006; Adey et. al., 2010), science teachers therefore, have the task to plan for ways to engage their students through questions and feedback as used in this study. This is because evidence from this study shows that the students were engaged in creating their own knowledge (table 4.1 page 79), which allowed the teachers and students to find out what the students already know. This challenged the students to think and express themselves, in order to add to their existing knowledge (Chin, 2006), and reshape their thinking processes.

This study also shows that over 98% of the students' were engaged in the questions and feedback (appendix 11), which enabled them to overcome barriers to their learning (Harlen et. al., 2012; Waind et. al, 2012) as highlighted in my literature review (page 49). This engagement was also responsible for the improvement in students' attainment (Nicol, 2007; Wilson et. al., 2011) with over 92% of the students achieving their target levels in the science end of unit tests. The students were engaged in a discourse as seen in the new model of discourse presented in this thesis (page 102). This involved supporting each other and correcting misconceptions arising from the use of scientific keywords and explanation of scientific ideas as well as improving their understanding of How Science Works (Millar, 2012; Golabek et. al., 2013), which they have been able to apply to real life situations in some cases. This claim can further be supported as evidence from this study shows that students were capable of developing high level questions (table 4.2 page 84), and giving quality feedback to other students, just like their teachers, a view supported by Min (2008) who indicates that students can be trained to give effective feedback like their teachers. In addition the quality of questions the students asked influenced the kind of feedback they received from peers, as good questions (high level ones) elicited quality feedback (Earl et. al., 2008; Hayes et. al., 2008; Hodgen et. al., 2008). An example of this is shown on page 117, where a student asked a Synthesis type of question (considered as a high level question) and the feedback received created awareness among the students that they had learnt a new concept from another student which led to knowledge creation in the classroom discourse.

The high level questions developed by the students have been considered by Zheng et. al. (2008) to bring about an improvement in students' thinking skills and engage better thought processes among students, a view which is supported by the outcome of the questionnaire analyses (appendix 12), with all teachers agreeing that they "encourage students to express their own unique thoughts and beliefs in lessons". The feedback which evolved from such discourse led to an improved attainment among the students (Black et. al., 2010; Dillon et. al., 2010; Miller et. al., 2007) as shown in appendix 10. The outcome from this study shows that students enjoyed the idea of leading and taking charge of their own assessments (questions and feedback) facilitated by the teacher. This evidence was based on the analyses of questionnaires (appendix 12); interview analyses (table 4.1 page 79); and field notes (appendix 9). The teachers involved in this study created awareness of the importance of high level questions in students' learning which they shared with the students in order to motivate them. However, other studies have shown that students are aware of formative assessments taking place in their classrooms but they have not been fully involved in their own assessments (Cowie, 2005; Black et. al., 2006; Dhindsa et. al., 2007) by their teachers. This situation where students are not involved in leading their own assessments as earlier mentioned may be considered as a weak aspect in teaching and does not support students' learning and engagement.

This study will serve as a model to science teachers who wish to engage students in taking charge of their own assessments through questions and feedback as seen in the new model of discourse presented in this thesis (page 102), which has led to an improvement in students' engagement and attainment (Harlen, 2009; Hog, 2010; Wilson et. al., 2011). Therefore, this study relied on oral feedback as a means to encourage student-student interaction from the questions developed, a view expressed by Adey et. al. (2010) that the oral feedback will improve students' metacognition and social construction. This view is also supported by evidence from the questions developed by the students, where the quality of response and feedback from the high level questions (appendix 7) demonstrated the ability of the students to engage with more complex scientific processes, and not just the recalling of facts. In addition to this view, Sawyer (2006:2) indicates that:

> *"Students learn better when they express their developing knowledge either through conversation or by creating papers, reports or other artefacts and then are provided with opportunities to reflectively analyse their state of knowledge"*.

This study therefore, shows that questioning skills can be developed among students by using Bloom's taxonomy, although evidence from the questionnaire analyses (appendix 12) shows that most teachers do not use Bloom's taxonomy in developing questions in their lessons. Whilst this is not encouraging, I have discussed some reasons that may prevent teachers from using Bloom's taxonomy in lessons and also highlighted this as an area for future research, in my recommendations section (page 145).

This study has highlighted factors that may lead to students' engagement in science lessons apart from science practical work. The factors identified are consistent with literature in the field of Assessment for Learning. This includes time spent on task (Newton et. al., 2011), with a frequency of 4 (table 4.1 page 79). Here the interviewees indicated that the students spent more time doing the activities and were more engaged than in a normal lesson. Other forms of engagement involved students using their prior knowledge and creating new ideas in assessment (Cowie et. al., 2011), and using research materials (Aguiar et. al., 2010; Cowie et. al., 2011) to support their learning, all of which have been confirmed by the findings in this study. This study also shows that clarity of instructions given to students (Darby, 2005), and attentiveness and willingness of students to learn and be involved in their own assessments can lead to students' engagement (Fielding-Wells et. al., 2008). Students' attitudes, commitment and behaviour also constitute engagement in learning (McCombs et. al., 2007). In addition to the factors leading to students' engagement, Black et. al. (2010) indicate that active learning which involves students listening and contributing to discourse in science lessons is a form of engagement, which is also supported by the interview analyses (table 4.1 page 79). These forms of engagement enabled the students to improve their understanding of the Nature of Science and How Science Works (Toplis et. al., 2009; Windale, 2010), relating their contributions in the discourse to everyday life experiences (Grime, 2012; Millar, 2012), which involved using prior knowledge to solve problems. In addition two other factors associated with students' engagement which were not identified in the literature search has evolved from this study and contribute to the body of knowledge. These are Repetition/Repeat activity; and Practice. The factors referred to elements of planning for resources by teachers, and also giving students some opportunity to practice asking questions and giving feedback to each other over a period of time.

5.2 The new model of discourse presented in this thesis

Studies have criticised teachers' dominance in the classroom discourse involving questions and feedback (Van Dijk, 2001; Chin, 2006; Reinsvold et. al., 2012). Although questions and feedback have been identified as leading to an improvement in students' engagement and attainment in this study, there is a need to further engage students in leading questions and feedback to improve the classroom discourse as stated in my recommendations section. I reiterate in my literature review (page 44) that this study borrowed ideas from two models of discourse and stated that a new model would evolve. In order to justify my claim for a new model of discourse presented in this thesis (page 102), I made reference to the four models stated in page 43 of my literature review. In models 1, 2 and 3 (IRE; I-R-P-R-P-R-E; and I-R-P-R-P-R respectively), where I represents initiation of question, R is response, P is prompt and E represents evaluation, the questions are initiated by the teacher. In model 4 (question-answer), the question is initiated by the students. In all four models, students are not given an opportunity to probe, prompt or evaluate other students' responses. All of this is done by the teacher. This shows that in all the models, students are not in control of their own assessments, and the pupil's voice becomes a concern for professional development of teachers as stated in my recommendations section in this chapter. The dynamics of these models are contrary to the purpose of my study which allowed students to lead the discourse combining models 2 and 4. Therefore, my claim that a new model of discourse has been developed and presented in this thesis is justified.

The new model involved student initiation of a question (SI), student response (SR), student probing (SP) and student evaluation (SE). This model is represented as SI-SR-SP-SP-SR-SP-SR-SP-SP-SP-SR-SP-SE and presented in page 102, based on students' questions and feedback. However, there are other situations in this study where the question asked by a student did not involve probing and evaluation as seen in the low level questions (Knowledge question, page 111). This implies that the kind of question a student asks can determine the model of discourse and may fall into the new model presented in this thesis. The contribution to knowledge here is that the new model of discourse is student-led and gives them autonomy over their learning. The new model enabled the students to talk in each other's zone of proximal development as highlighted earlier in chapters 2 and 4. This enhanced their learning, engagement and attainment. However, in order to engage students in questioning and feedback in science classrooms, evidence from the interview and questionnaire analyses (table 4.1 page 79 and appendix 12 respectively) makes it clear that science teachers are required to do a lot of planning (Parkinson, 2004). This will create opportunities for dialogue among students and help to move their learning forward (Alexander, 2008). I will be considering how pupils' voice may contribute to their learning.

5.3 Pupil's voice

Evidence from this study shows that students liked the idea of the teacher allowing them to take ownership of their learning and lead the classroom discourse (Blanchard, 2008; Cowie et. al., 2011). This allowed the students to be engaged in the discourse and share ideas with each other that were valued by the teachers (McGregor, 2013). This type of scenario enabled the students to apply knowledge gained in the questions and feedback, in addition to using their prior knowledge to solve problems, to improve their understanding of scientific concepts and applying How Science Works in the classroom discourse. Therefore, evidence from this study with students taking ownership of their learning with a frequency of 5; and students sharing ideas with others with a frequency of 7 (table 4.1 page 79) shows that the pupil's voice is a key to enhancing learning, engagement and attainment in science. This was exemplified in the way the students assigned roles to each other in their groups and took turns in developing questions, and choosing other students to respond to the questions and giving feedback. This eliminated any form of social power relationships associated with the normal forms of interactions in the classroom (model 1 of discourse Initiation, Response and Evaluation) which is always dominated by the teacher (Van Dijk, 2001; Reinsvold et. al., 2012) who assigns roles to students.

The idea of students leading the learning was a focus in this study which empowered them to take ownership of their learning (Nicol, 2007) as stated in my literature review and methodology chapter. In addition to this, flexibility was considered in planning the lessons to allow the students to have a choice in their assessments which gave them greater autonomy over their learning (Wilson et. al., 2011; Darlington, 2012) facilitated by the teacher. This encouraged the students to work harder than their teachers and discouraged the teachers involved in this study from doing too much talking and leading the IRE model of discourse (model 1) as mentioned earlier. This idea of encouraging the pupils' voice in science lessons resonates with the views of other studies highlighted in this work that encouraged student talk in lessons (Hog, 2010; Wilson et. al., 2011; Waind et. al., 2012). This has been linked to improvement in students' engagement and attainment. Therefore, it can be concluded that the pupils' voice is in line with the new model of discourse presented in this thesis (page 102) which made the students feel appreciated and valued in their contribution to the formative assessment process.

5.4 Original contribution to knowledge

The results obtained show that introducing 13 years old students (year 8) to the use of Bloom's taxonomy in science lessons led to an improvement in their learning, engagement and attainment. This is because the students were involved in leading their assessment by asking questions and giving feedback to each other. This idea of the students taking ownership of their learning is contrary to the closed chain model 2 of discourse (page 43) that is, Initiation, Response, Prompt, Response, Prompt, Response and Evaluation (I-R-P-R-P-R-E) by Scott et. al. (2006), which is normally led by the teacher. Although this study is based on the closed chain model, in this case the students are in charge of leading the sequence of interactions. Despite an exhaustive search of literature using SwetsWise; Routledge; Sage journals online; and hand searching, I have found no other study that has used similar aged students to lead this model of interaction which is normally teacher led. Therefore, the new model of discourse presented in this thesis was developed and led by the students, SI-SR-SP-SP-SR-SP-SR-SP-SP-SP-SR-SP-SE, where SI represents student initiation, SR is student response, SP is student probing and SE is student evaluation, as highlighted in page 102. This model, although adapted from an existing one, has created an awareness among the science teachers and informed professional practice in a way that has changed perceptions around the methods used to engage students in science lessons. This has enhanced independent learning among the students involved.

In continuation of the discussion above, evidence from this study also shows that engaging Key Stage 3 science students (13 years old) in the new model of discourse is responsible for improving their skills in developing their own questions and giving peer feedback. The students were able to develop high level questions (Fisher, 2009; Williams, 2011) and identify the different types of questions using Bloom's taxonomy, and discover how this can influence their learning and attainment through the quality of feedback that emerged from such questions. This is supported by the fact that 35% of the students were considered as good or outstanding in developing questions and giving feedback, and 56% as satisfactory. In other situations (chapter 4), I compared the quality of feedback students gave to each other with the type of feedback the teacher would give if asked a similar question. I found out that the students' feedback was the same as the teacher's in some instances but different in others. This evidence also show that engaging the students in the new model of discourse presented in this thesis was responsible for an improvement in their ability to give quality feedback to other students. In addition to this, some factors that constitute students' engagement in learning are highlighted (table 4.1, page 79) and in line with literature on Assessment for Learning. However, other factors that enhanced students' engagement have evolved from this study, and have not been identified in the literature review. This included Repetition/Repeat activity and Practice, which has contributed to the body of knowledge. These factors are crucial towards students' engagement and attainment by creating opportunity for students to practice questioning and giving feedback to each other.

The factors highlighted above requires that giving students opportunity to practice questioning and feedback should be done in the classroom over a period of time so that students can get used to it (questions and feedback). This view is supported by the interviewees who agreed that in order for teachers to assist students in practicing questions and giving feedback, it should be incorporated into the Key Stage 3 science schemes of work for specific lessons. This will allow for consistency among science teachers when planning their lessons to engage students in this aspect. Having highlighted the contributions to knowledge, I will now consider the limitations of this study.

5.5 Limitations of the study

This study is an action research one designed to address teaching and learning in Key Stage 3 science to improve students' engagement and attainment through the use of student-led questions and feedback. The sample size is limited to the group of students involved in the study (Cohen et. al., 2007; Gray 2009) as mentioned in the methodology section. However, given that an action research has a specific focus on solving problems (Cohen et. al., 2007), I will argue that the sample size, although small, may still present a valid and reliable finding as compared to a larger sample size in a similar study. This is due to triangulation of the data (Torgerson, 2003; Gray, 2009; Newby, 2010). In addition Torgerson (2003:74) suggested that a study like this which involves collection of data from more than two sources will help to reduce "random errors" associated with data from one source. Although Torgerson (2003:82) makes it clear that if the data collected is "homogenous", for example in this study the teachers were given the same levels of training to engage students and the students were also given similar interventions, then the data can be "pooled in a meta-analysis". This is only possible when it involves quantitative data (for example using raw scores from the end of unit science tests rather than using the levels attained by the students).

The problem of generalising outcomes from this type of research has been identified (Scott et. al., 2007; Gray, 2009) because it involves an intervention for a specific case. However, Abrahams (2009) argues that general conclusions that evolve from this type of study could be transferred to another organisation similar to the one where this research took place. Therefore, the success of this study on students' engagement and attainment may not be conclusive in all situations. Adopting an action research has enabled me to generate large amounts of data to support triangulation of my results. However, Gray (2009) makes it clear that the problem with producing large amounts of data is that it may make the report writing difficult. That is why careful thought was given to the best methods used in addressing my research questions as suggested by Gray (2009) and pointed out in my methodology. In addition to these limitations and given enough time, I could repeat the study in another academic year, using a different topic in either year 7 or 8 schemes of work, and compare the outcome of students' engagement and attainment with the current findings. This comparison would enable me to improve in my methodology in future work.

5.6 Recommendations

There are five recommendations from this study for professional practice and a further three suggestions for the development of future research.

For professional practice:

5.6.1 Students' ownership of learning

This study shows that model 1 of discourse, that is, Initiation, Response and Evaluation (IRE) can be led by the students. The interview with teachers shows that the students were more engaged in the discourse than when it is led by their teachers. This is a view supported by Chin (2006) who indicates that when the IRE is teacher led, it will limit the way students think and respond to questions, and can affect how they construct their knowledge. This implies that opportunities should be created in science lessons where students are engaged in questions and feedback, sharing knowledge and ideas with other students (McGregor, 2013) as seen in this study. This resonates with the views of Scott et. al. (2007) who indicated that the students involved must be given a voice whilst the voice of the researchers (teachers involved in the study) becomes passive. Therefore, the new model of discourse presented in this thesis (page 102) gave students ownership of their learning in science. This is in line with model 2 (I-R-P-R-P-R-E) of the discourses in page 38, however, the initiation (I), response (R), probe (P) and evaluation (E) were done by the students instead, under the guidance of the teacher who acts as a facilitator of learning. This gave the teacher opportunity to monitor students' learning and assess their current state of knowledge and support them to get to the next stage of their development (ARG, 2002). This involved checking that students' questions and feedback were appropriate as seen in this study. In addition, this will give the teacher more planning time for resources and other activities that may be used to engage the students in the lesson.

5.6.2 Pupil-led questioning and feedback

This study shows that questions and feedback are the best form of engaging students in science lesson compared to other forms of engagement identified in this study, based on the interview analyses (table 4.1 page 79) and evidence from the questionnaire analyses (appendix 12). The role of the teacher as a facilitator of learning is crucial in this process. A reflection on the type of questions developed by the students showed that more questions were created under the low level questions on Bloom's taxonomy (table 4.2 page 84). The teachers' intervention as a facilitator of learning encouraged the students to develop high level questions (Williams, 2011) using Bloom's taxonomy question prompts provided, which led to an improvement in the number of high level questions developed by the students. This is because the teachers created awareness of the importance of such high level questions to provide an improvement in students' thinking abilities and metacognition (Zheng et. al., 2008; Adey et. al., 2010; Maynard, 2012). This is a view confirmed by the interview analyses that questioning and feedback with a frequency of 53 (table 4.1, page 79) were the most important factors in enhancing students' engagement. However, the findings from this study show that students were better at developing questions than giving feedback to their peers (with 54% good or outstanding in developing questions, and 44% good or outstanding in giving feedback).

Evidence from this study also show that students are capable of giving feedback to other students just like their teachers (Swaffield, 2008) when they are encouraged and trained to do so (Min, 2008). Hence engagement of students in giving feedback to other students could be an area that may be exploited in the science classroom to support students and develop their skills in this aspect. This is because studies have encouraged the use of talk in the classroom (Alexander, 2008; Gielen et. al., 2010; Waind et. al., 2012) as it can close the gap in students' knowledge, and is also linked to improvement in students' engagement and attainment as seen in this study. This will also promote a Constructivist classroom learning (Savasci et. al., 2012) where students are engaged in leading both questions and feedback, which is a weak area in teaching and learning in the science classroom (Turner et. al., 2010; Darlington, 2012) when compared to other subjects like the creative arts. Therefore, I recommend that these activities should be developed into the science schemes of work to enhance students' learning, a view supported by an interviewee with comments such as:

> *"Yes I think this is something we can incorporate in our schemes of work but we need to start building up the skills and structure to begin with so that they can start practising it and get used to it and how to do presentations. This is something we should be doing. They learn well enough from each other and I will be interested to see how they get on doing it over and over again. It will also help them develop transferable skills not just for science but to transfer to other subjects"* (Teacher interviewee 1).

5.6.3 Engagement of students

Students can be engaged in lesson in different ways and most of the attributes of students' engagement in lessons based on the outcome from this study are highlighted in table 4.1 (page 79), which is also confirmed by literature as discussed earlier. However, two factors have been identified to be associated with students' engagement which have not been identified in the literature search. They are Repetition/Repeat activity and Practice. These factors involve teachers planning for resources and giving students opportunities in lessons to engage in developing questions and giving feedback to other students. This is an area that could be encouraged in science lessons to support students' engagement and attainment however, assessment criteria should be clarified so that students are aware of what is expected from them.

5.6.4 Clarity in assessment criteria

This study shows that a lack of clarity on assessment criteria and instructions given to students can affect their learning (Darby, 2005; Dhindsa et. al., 2007). This may also involve clarity on the type of questions asked in lessons. This lack of clarity was experienced in some questions developed by the students, for example the Comprehension question (page 112), which was not clear enough for the respondent and prompted another student to reframe the question before it was answered. This study is student-led with a learner-centred approach to learning (McCombs et. al., 2007), which implies that students are supported in understanding the types of questions they should ask in lessons (low level and high level questions), and to know when such questions should be asked. This enables them to distinguish between facts and to be able to describe scientific processes. I would propose that careful thought is given when students and teachers are developing questions and using Bloom's taxonomy as a guide, as the quality of questions asked can influence the type of feedback that is received (Hodgen et. al., 2008). In addition to clarity, an issue raised on page 116 in response to a student question on the differences between the structures of the small and large intestines shows that students sometimes do not understand the question asked, and this can also affect the quality of feedback given.

5.6.5 Knowledge creation

This study shows that students are capable of creating their own knowledge (table 4.1 page 79, and appendix 7) based on engagement in the questions and feedback together with applying prior knowledge (Cowie et. al., 2011) to solve problems. This includes students correcting misconceptions arising from the wrong use of scientific key words in a discourse. This view is supported by the interviewees who considered the students to be *"constantly thinking about the questions and feedback processes, and processing information which made them attentive and more engaged in the questions and feedback than in a normal science lesson in the classroom"*. This view is in line with my theoretical perspectives of a constructivist classroom learning environment which gives the students opportunities to lead their learning.

For future research:

5.6.6 Consistency in the use of Bloom's taxonomy

Using Bloom's taxonomy question prompts has been identified in this study as the best means to engage students in developing their own questions. However, evidence from this study shows that most of the teachers sampled do not use Bloom's taxonomy in developing questions (appendix 12). This may be because some of them are not aware of the relevance of Bloom's taxonomy in supporting students' learning and others may not have heard of it. In addition, some teachers may not be prepared to spend the extra time in planning for its use in their lessons. This revelation is shocking and needs to be addressed if we want to engage our students and improve their attainment in science. This implies that more research will be required to improve students' engagement in science (ASE, 2006; Reiss et. al., 2011), and to design and deliver high quality learning experiences in a variety of ways suitable for our students. This can be seen in this study where questions and feedback led by the students were responsible for the improvement in their engagement and attainment (table 4.1 page 79; and appendices 10 and 11). In view of this, experienced teachers can be used to support less experienced teachers in their professional development in the area of planning for resources to create a better learning experience for students through questions and feedback. I will now consider gender issue in science.

5.6.7 Gender issue in science

Reflecting on the interview transcripts (appendix 8), one of the interviewees stated that the boys asked more high level questions than the girls, whose questions were mixed. This interviewee also claimed that the boys were more engaged than the girls in the questions and feedback. The second interviewee considered boys and girls may have asked the same levels of questions, however, the interviewee claimed that the girls were more engaged than the boys, given that there were more girls than boys in that group. These findings show that further research would be required to look at the contributions of boys and girls in questions and feedback and other types of classroom discourse, in order to further develop their skills in this area. Although I collected data on the levels of contribution of boys and girls in the questions and feedback, this will not be reported in this study. The findings from this study have opened up opportunities for further research that would encourage other forms of assessments in science (questions and feedback led by the students) apart from the use of science practical which has been considered to favour boys rather than girls (Dillon, 2010; Hetherington, 2010). Therefore, the outcome from this study shows that boys can be engaged in this type of assessment (questions and feedback) which may not have previously been perceived to be the case.

5.6.8 Pupil's voice

The new model of discourse presented in this thesis shows that students took control of their learning and assessment (questions and feedback) which is contrary to the four main models of discourse controlled by the teacher (page 43). This is because this study was designed to be student-centred (McCombs et. al., 2007) to support independent learning, and evidence has shown that this led to an improvement in students' engagement and attainment (appendices 10 and 11). The students assigned roles to each other, developed questions and gave peer feedback. Therefore, the progress associated with this study shows that further research may be required to include students in their own assessments by way of leading the lesson or recommending improvement in the assessment structure delivered by the teacher. In the next section I will reflect on my experience of carrying out this research and how it has contributed to my professional development.

5.7 Personal reflection

The EdD programme has opened up an opportunity for me to develop as a researcher and to pursue my interests in the area of Assessment for Learning in science which I believe needs more research on how to engage students and improve their learning in science (ASE, 2006; Reiss et. al., 2011). In addition to this, assessment is a national issue of concern in schools in England with a view to finding the best ways to support students' learning. However, decisions have been made in most cases without reference to research outcomes in assessment (Harrison, 2012). This is because a teacher's view of an assessment means it has to be done in a specified way rather than taking into account the combination of strategies that may be used to support students' learning (Harlen, 2009) to improve their engagement and attainment. Therefore, the outcome from this study will be made available to colleagues as a reference point towards improving their professional development. The EdD programme has developed my knowledge and skills in planning a pilot study and understanding its relevance to my research. Also, how this can be applied to structure the main research to support my aims and objectives. A reflection on my journey in this study is twofold. Firstly, the impact of the study on my professional development, and secondly on that of the teachers involved in the study, together with sharing the outcome with other colleagues in the science department to support their professional development.

The idea of involving other colleagues in this research has made it more productive (Gray, 2009). In addition we could collectively evaluate the outcome from the strategies used and make any improvements. This view is supported by Cohen et. al. (2007) who argue that this type of study forms an action research and can create dialogue and discourse between participants and improve their scientific knowledge. However, the ultimate goal here is to improve students' engagement and attainment in science, which forms the focus of this study. This study has created awareness for me and other teachers involved in the science department of the need to give students opportunities to develop their learning using Assessment for Learning strategies (questions and feedback). These have been found to bring about an improvement in students' engagement and attainment in this study. However, an issue of concern raised in this study is that most science teachers do not use Bloom's taxonomy to develop questions before and during lessons (appendix 12). This creates a barrier to supporting students' cognitive development which would not have been the case if science teachers used Bloom's taxonomy regularly. I have also been guilty of this practice. However, due to the successes achieved by the students involved, I can conclude that this study has supported me and other teachers to overcome this problem, by using Bloom's taxonomy to support students in developing their own questions, and creating opportunities for students to give feedback to other students. This view is in agreement with that of Cohen et. al (2007) and Scott et. al. (2007) who noted that finding solutions to problems as well as involving practitioners in the process fulfils the criterion of an action research.

The reasons stated above justify why this study sought teachers' perceptions on how they felt their interaction with students through questioning and feedback would engage the students. This allowed the teachers to reflect on aspects of their practices in the classroom that may require some change. I can argue here that this study has informed a new professional learning process and advanced change in how we, the teachers, interact with our students and create opportunities for them to be independent learners. This involves the students leading the classroom discourse through questions and feedback to support their engagement and attainment in science lessons. I can categorically state that my skills in the use of formative assessment has improved right from the outset, whilst conducting the pilot study, through to the end of this thesis. Additionally, the time and effort spent in developing the resources used in this study has been worthwhile. The resources developed will save science teachers 5-6 weeks lesson planning and preparation when teaching the topic used, which will give them time to develop other teaching and learning resources. Due to the success with this study I have been invited by the school I work in, to conduct training sessions to support the professional development of teachers in Assessment for Learning. The knowledge and skills I have developed during the course of this study has enabled me to critically explore the context of my research and consider the aims and objectives in a more transparent and logical way that is worthy of a researcher. This is responsible for the adjustment in the title of my thesis and the main research question, which I feel justifies the outcome from this study. Therefore, I will publish the outcomes from my findings in an appropriate journal reflecting assessment in science education so that other teachers and educators can benefit from this work.

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APPENDICES

Appendix 1: Bloom's taxonomy question prompts

Use the following question prompts to develop your own questions

Knowledge question prompts

Who

What

Why

Can you tell why?

Describe

Comprehension question prompts

State in your own words

What do you think might happen next?

What does this mean?

What is the main idea?

Give an example

Can you define?

Explain

Judge

Classify

What difference exists between........?

Application question prompts

Predict what will happen if.......?

What factors would you change if......?

Judge the effects of.......?

Tell how, when, where, why........?

What questions would you ask of......?

What would result ………

Do you know another instance where..?

Analysis question prompts

How is..........similar to............?

Can you compare your.....with that presented by.........?

Can you state the difference between.......?

What motive is there.......?

What conclusions can you make.......?

What is the relationship between.........?

What are some of the problems of.........?

Can you explain what must have happened..........?

Synthesis question prompts

What would happen if.......?

How many ways can you.......?

Can you create.......?

Can you make up..........?

Can you design a..........?

Can you develop......?

Choose

Evaluation question prompts

Is there a better solution to.......?

Judge the value of...........

Can you defend your position about......?

What changes to......would you recommend?

What do you think about.....?

Find the errors with.........?

Compare or defend........?

Source: adapted from Maynard (2012) Bloom's taxonomy

Appendix 2: Questionnaire

UNIVERSITY of GREENWICH

Questionnaire for Teachers

This questionnaire is developed to address the research question- *How can both student-led questions and feedback be used to enhance students' engagement and attainment in a Learner-centred Key stage 3 science classroom?*

This research forms part of my Doctoral study which is being supervised by Dr. Jackie Farr at the University of Greenwich. Please could you complete the questions as accurately as possible and return to me as indicated in my covering letter.

1. Are you

   Male ☐

   Female ☐

2. Does questioning and feedback improve students' engagement and attainment in lessons? Please tick an option.

   Yes ☐

   No ☐

3. Should students be given opportunity to develop their own questions in lesson? Please tick an option.

   Yes ☐

   No ☐

4. During which part of the lesson do you ask the most questions?

   Starter ☐

Main ☐

Plenary ☐

Throughout the lesson ☐

5. After asking questions, how long do you wait for students' response? Please tick one option.

Wait time less than 7 seconds ☐

Wait time greater than or equal to 7 seconds. ☐

6. Do you plan for questions in advance before lessons or make them up at the time? Please tick an option.

Yes ☐

No ☐

Both ☐

7. Do you think some questions could arise during the course of the lesson that are not planned for or included in your lesson plan? Please tick a box.

Yes ☐

No ☐

8. When planning questions, do you have idea on likely answers the students would give you? Please tick a choice.

Yes ☐

No ☐

Both ☐

9. If you have idea on likely answers from students, have you planned for any feedback through further questioning and guidance? Please tick an option.

Yes ☐

No ☐

Both ☐

10. When compared, which one of these would you consider most effective in supporting your students' learning? Please tick one.

Oral feedback ☐

Written feedback (marking books) ☐

11. How effective is oral feedback in lessons? (Please rate on a scale of 1-5, with 1 being least effective and 5 most effective). Please tick an option.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

12. How effective is questioning in lessons? (Please rate on a scale of 1-5, with 1 being least effective and 5 most effective). Please tick an option.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

13. From your experience using questioning in lessons, which group of students ask high order questions the most? Please tick an option.

Boys ☐

Girls ☐

14. I encourage students to express their own unique thoughts and belief. Please tick an option.

Sometimes ☐

Regularly ☐

Occasional ☐

15. Do your students ask relevant questions in lessons? Please tick one

Yes ☐

No ☐

Sometimes ☐

They don’t ask questions ☐

16. Do you use Bloom’s taxonomy in developing questions? Please tick one.

Yes ☐

No ☐

17. When is it appropriate to use group discussion during questioning?

18. What sorts of questions enable your pupils to learn? Please make comments

19. What sorts of questions do pupils ask during lessons? Please make comments

20. What are the strategies you use in your lesson to ensure students ask relevant questions? List them

21. What are the strategies you use in your lesson to ensure students respond to questions? List them

Thank you for completing this survey.

Adewale Magaji

University of Greenwich

School of Education

Faculty of Education and Health

Avery Hill Campus, Mansion Site

SE9 2PQ

Appendix 3: Teachers' interview questions

These interview questions were developed to find out information on the research question- *How can both student-led questions and feedback be used to enhance students' engagement and attainment in a Learner-centred Key stage 3 science classroom?*

1. What are your experiences in carrying out this project with your students?

2. What are your views in the use of questioning and feedback to engage your students in lessons?

3. Do you think that the students were engaged in this activity?

4. What are your views in students developing their own questions and other students giving feedback- like we have done in this project?
   After teacher's response - do you think this activity is something we can practice more often with our students?

5. How would you describe engagement in this task considering the students you worked with?

6. In the course of this work with your students, did you observe them discussing among themselves and challenging wrong or right answers?

7. Would you consider that scenario where students were challenging themselves- right/wrong answers as engagement?

8. How would you compare this project with normal lessons in terms of discussion, questions and feedback and engagement of students? Do students ask questions in normal lessons than experienced in this project?

9. Does questioning and feedback improve student's engagement and attainment in lessons? Please answer Yes/No.

If response is yes, follow up question- So, why do you think it would improve their engagement and attainment?

10. Scoring criteria- how did you find the scoring criteria used during presentations, was it easy to use and follow? How could it be improved if any? Do you think this scoring criteria can be used in other similar science lessons?

11. Teachers can use questioning and feedback to engage students in Key stage 3 secondary sciences. Do you think this is true?

12. If students are regularly allowed to develop their own questions and give feedback in lessons, this would improve their engagement and develop their thinking in science. Please rate this using the scale below.

Strongly agree=5, agree=4, undecided=3, disagree=2, strongly disagree=1

13. Which one of these would you consider to be most effective in supporting your students' learning?

    Oral feedback/written feedback
    Why did you choose this option? State any reason

14. How do you think the project has affected the pupils' learning, considering that they have done this over several lessons which involved research to solve problems, and presentations of their findings? What effect would you observe on the students', did it had any impact on them?

15. Do you think your students would like to do this activity again? Yes/No
    Why/Probe

16. What are your views, do you think these activities should be incorporated in the science schemes of work, say once or twice a term?

17. Which group would you consider asked higher order questions boys/girls?

18. Which group would you consider to be more engaged boys/girls?

19. What are the attributes of engagement you observed in the lessons generally?

20. As a teacher, what sorts of questions would enable your students to learn? For example considering open/closed questions.
State reasons for your option.

21. What sorts of questions do your students ask in lessons, for example, considering open/closed questions again, and also considering the hierarchy on Bloom's taxonomy?

22. So would you conclude from this session that questioning and feedback from teachers can improve engagement and attainment of students in lessons?

23. How would you support your students to develop their questioning skills or to help them get more engaged in lessons?

Appendix 4: Consent letters

UNIVERSITY of GREENWICH

Student consent letter

2nd May, 2013

Dear Children,

Permission letter

I am seeking your permission for you to be involved in a study related to improving your understanding and thinking in Science. This will take place at The Academy during your normal Science lesson time.

The Head teacher and Head of Science have given permission for the research to be carried out as part of the school's on-going commitment to improve teaching and learning and the raising of students' achievement.

The study is titled: *Classroom discourse with both student-led questions and feedback: Enhancing engagement and attainment of students in a Learner-centred Key stage 3 science classroom.*

This research forms part of a study which is being supervised by the University of Greenwich.

During the lesson, you will carry out research on given topics, group work and discussions, presentations of your work, questioning and feedback on the activities. This will be undertaken during four lessons. You will use two of the lessons to gather information from the research tasks. The other two lessons will involve audio recording of your presentations and questioning and answer sessions using a digital device. No video recording of students will take place in this study. The presentation lessons will be done on the 13th and 14th May, 2013, when Mrs Randall will be teaching the class.

To ensure confidentiality and to protect your anonymity, all audio tapes will be kept securely in line with the school's data protection policy and listened to only by me to enable me to analyse the interactions and discussions that took place in your lessons.

As part of this ethical approach I assure you that:

- You will not be identified or named in this study
- The study will not interfere with your learning.
- You may withdraw from the study at any time

All audio recordings from the study will be kept on a password protected computer and will be destroyed within one year of my study being completed.

Thank you for considering this. If you have any questions about the study please contact me.

I would be grateful if you could complete the permission slip below and return to your Science teacher on or before 10th May, 2013.

Yours sincerely,

Adewale Magaji
University of Greenwich
School of Education
Faculty of Education and Health
Avery Hill Campus, Mansion Site
SE9 2PQ

To: Mrs Randall – Science Lessons 13th and 14th May, 2013

Student Name: ____________________________________

Yes, I would like to take part in the Science discussion and presentations of findings from research. I understand that this will be audio recorded to improve teaching and learning in Science.

Student's signature ________________ Date ____________

Parent consent letter

2nd May, 2013

Dear Parent/Guardian,

Re: Consent letter

I am seeking your consent for your child to be involved in a study related to improving critical thinking skills in Science. This will take place at The Academy during normal Science lesson time.

The Head teacher and Line manager have given consent for the research to be carried out as part of the school's on-going commitment to improve teaching and learning and the raising of students' achievement.

The study is titled: *Classroom discourse with both student-led questions and feedback: Enhancing engagement and attainment of students in a Learner-centred Key stage 3 science classroom.*

This research forms part of a study which is being supervised by the University of Greenwich.

During the lesson, students will be expected to carry out research on given topics, group work and discussions, presentations of their work, questioning and feedback on the activities. This will be undertaken during four lessons. The students will use two of the lessons to gather information from the research tasks. The other two lessons will involve audio recording of students' voices during presentations and questioning and answer sessions using a digital device. No video recording will take place in this study. The presentation lessons will be done on the 13th and 14th May, 2013, when Mrs Randall will be teaching the class.

To ensure confidentiality and to protect your child's anonymity, all audio tapes will be kept securely in line with the school's data protection policy and listened to only by me to enable me to analyse the interactions and discussions that took place between the pupils in year 8. As part of this ethical approach I assure you that:

- Individual children will not be identified or named in this study
- The study will not interfere with children's learning.
- You may withdraw your child at any time from the study
- Your child may also withdraw from the study at any time

All audio recordings from the study will be kept on a password protected computer and will be destroyed within one year of my study being completed.

Thank you for considering this. If you would like to discuss this further with me please do not hesitate to contact me.

I would be grateful if you could complete the consent slip below and return to your son's/daughter's Science teacher latest 10th May, 2013.

Yours sincerely,

Adewale Magaji

University of Greenwich

School of Education

Faculty of Education and Health

Avery Hill Campus, Mansion Site

SE9 2PQ

To: Mrs Randall – Science Lessons 13th and 14th May, 2013

Student Name: ___________________________________

I hereby give permission for my son/daughter to take part in the Science discussion and presentations of findings from research. I understand that this will be audio recorded to improve teaching and learning in Science.

Parent's/carer's signature ________________ Date ____________

Teacher consent letter

2nd May, 2013

Dear Colleague,

Re: Consent letter

I am seeking your consent for you to be involved in a study related to improving students' critical thinking skills in Science. This will take place at The Academy during your normal Science lesson time.

The Head teacher and Line manager have given consent for the research to be carried out as part of the school's on-going commitment to improve teaching and learning and the raising of students' achievement.

The study is titled: *Classroom discourse with both student-led questions and feedback: Enhancing engagement and attainment of students in a Learner-centred Key stage 3 science classroom.*

This research forms part of a study which is being supervised by the University of Greenwich.

During the lesson, students will be expected to carry out research on given topics, group work and discussions, presentations of their work, questioning and feedback on the activities. This will be undertaken during four lessons. The students will use two of the lessons to gather information from the research tasks under your supervision. The other two lessons will involve audio recording of students' voices during presentations and questioning and answer sessions using a digital device. No video recording will take place in this study. The presentation lessons will be done on the 13th and 14th May, 2013, when you will be teaching the class.

To ensure confidentiality and to protect you and your students' anonymity, all audio tapes will be kept securely in line with the school's data protection policy and listened to only by me to enable me to analyse the interactions and discussions that took place between the pupils in year 8. As part of this ethical approach I assure you that:

- Individual children will not be identified or named in this study
- The study will not interfere with children’s learning.
- Students may withdraw from the study at any time.
- You may also withdraw from the study at any time

All audio recordings from the study will be kept on a password protected computer and will be destroyed within one year of my study being completed.

Thank you for considering this. If you would like to discuss this further with me please do not hesitate to contact me.

I would be grateful if you could complete the consent slip below and return to me latest 10th May, 2013.

Yours sincerely,

Adewale Magaji
University of Greenwich
School of Education
Faculty of Education and Health
Avery Hill Campus, Mansion Site
SE9 2PQ

Science Lessons 13th and 14th May, 2013

Teacher’s name: ____________________________________

I would like to take part in the Science discussion and presentations of findings from research. I understand that this will be audio recorded to improve teaching and learning in Science.

Teacher’s signature ________________ Date ____________

UNIVERSITY of GREENWICH

Covering letter for teachers completing the questionnaire

3rd May, 2013

Dear Colleague,

Improving Teaching and Learning in Science

I am conducting a research entitled: *Classroom discourse with both student-led questions and feedback: Enhancing engagement and attainment of students in a Learner-centred Key stage 3 science classroom.*

The questionnaire will address the research question- *How can both student-led questions and feedback be used to enhance students' engagement and attainment in a Learner-centred Key stage 3 science classroom?*

This research forms part of my Doctoral study which is being supervised by Dr. Jackie Farr at the University of Greenwich.

I am asking you to be involved in this study as it is part of the school's on-going commitment to improve teaching and learning and the raising of students' achievement in science. There is no obligation for you to take part in this study. If you are willing to be involved, please complete the questionnaire enclosed and return to the science department technician's tray or drop it in my pigeon hole in the science department staff room by the end of May, 2013. The questionnaire will take no more than 10 minutes of your time to complete. It employs rating scales and asks for your comments and one personal detail. You do not need to write your name, and you will not be able to be identified or traced. That is, confidentiality and anonymity are assured. Information provided will be destroyed one year after my Thesis is completed.

If you wish to discuss any aspects of the study then please do not hesitate to contact me at the school. I very much hope that you will feel able to participate.

May I thank you, in advance, for your valuable co-operation.

Yours sincerely,

Adewale Magaji

University of Greenwich

School of Education

Faculty of Education and Health

Avery Hill Campus, Mansion Site

SE9 2PQ

Appendix 5: Participants information sheets

UNIVERSITY of GREENWICH

Student participant information sheet

Title of study: *Classroom discourse with both student-led questions and feedback: Enhancing engagement and attainment of students in a Learner-centred Key stage 3 science classroom*

Why is this study important to me?

This study seeks to improve your questioning skills and feedback in lessons. It will also help improve your understanding of scientific key words and develop your thinking skills.

What do I have to do?

Participating students will carry out research to solve a problem which has been broken down into leading questions that will enable them to solve it.

You will be allowed by your teacher to choose the members of your groups that you can work well with.

There will be 4 students in a group and each group will be assigned a problem to solve. You will be required to read the task in your groups and ensure everyone in the group understands the task.

You will research the given tasks over **two lessons** and write your findings. You will collect information from science text books, exercise books and internet sources, resources provided by the teacher and from previous homework

Your teacher will be around to give support when needed.

Presentations of findings: lessons 3 and 4

Before presentations you will be allowed 10 minutes in each group to rehearse and read your work together. You should assign roles to each member in the group and present findings together.

Your teacher will introduce you to Bloom's taxonomy which you will use to develop your questions after each presentation.

Each group will now present their work starting with the title of the task while other students listen. After each presentation, other groups will then ask questions using Bloom's taxonomy question prompts and the presenters respond to it. If they could not, other students from the audience could respond. Your teacher will encourage you to use the high order questioning from the Bloom's taxonomy.

All these will be audio recorded using a digital device. No video recording will take place.

You can withdraw from the study at any time.

What are the data that would be collected about you?

- Audio recordings of presentations and questions and feedback from students
- Scores during students' presentations
- End of unit science test scores before and after the study
- Poster papers showing your findings from the research task

How would I use the data collected about you?

I will listen to the presentations and the questions and feedback generated. The quality of questions and feedback from students will be compared for scientific terms used.

I will compare the types of questions generated from low to high order on Blooms taxonomy.

I will analyse the scores from presentations and decide if students were more engaged in the lesson.

The end of units' science test results before and after the study will be compared to see if students have made any progress.

What will happen to the data collected after the study?

All audio recordings will be kept on a pass word protected computer and will be listened to only by me. These will be destroyed within one year of my study being completed.

Data on scorings from students' presentations was collected on paper and each student identified by gender and no names used. This will be locked securely in a cabinet with key and destroyed within one year of my study being completed.

Results from end of unit science tests before and after the study will be collated in electronic form in a password protected computer and will be deleted within one year of my study being completed.

Poster papers with students work would be destroyed within one year of my study being completed.

Parent's participant information sheet

Title of study: *Classroom discourse with both student-led questions and feedback: Enhancing engagement and attainment of students in a Learner-centred Key stage 3 science classroom*

Why is this study important to our students?

This study seeks to improve students' questioning skills and feedback in lessons. It will also help improve students' understanding of scientific key words and develop their thinking skills.

What do I have to know about the study?

Participating students will carry out research to solve a problem which has been broken down into leading questions that would enable them to solve it.

There will be 4 students in a group and each group will be assigned a problem to solve. They will be required to read the task in each groups and ensure everyone in the group understands the task.

They will research the given tasks over **two lessons** and write their findings. They will collect information from science text books, exercise books and internet sources, resources provided by the teacher and from previous homework.

Presentations of findings: lessons 3 and 4

Before presentations, students' will be allowed 10 minutes in each group to rehearse and read their work together. They will assign roles to each member in the group and present findings together.

Students will be introduced to Bloom's taxonomy which they will use to develop questions after each presentation.

Each group presents their work starting with the title of the task while other students listen. After each presentation, other groups will then ask questions using Blooms taxonomy question prompts and the presenters respond to it. If they could not, other students from the audience could respond.

All these will be audio recorded using a digital device. No video recording will take place.

Students are free to withdraw from the study at any time with no consequences.

You can also withdraw your child from the study at any time.

What are the data that will be collected about students?

- Audio recordings of presentations and questions and feedback from students
- Scores during students' presentations
- End of unit science test scores before and after the study
- Poster papers on students' findings from the research task

How will I use the data collected?

I will listen to the presentations and the questions and feedback generated. The quality of questions and feedback from students will be compared for scientific terms used.

I will compare the types of questions generated from low to high order on Blooms taxonomy.

I will analyse the scores from presentations and decide if students were more engaged in the lesson.

The end of units' science test results before and after the study will be compared to see if students have made any progress.

What will happen to the data collected after the study?

All audio recordings will be kept on a pass word protected computer and will be listened to only by me. These will be destroyed within one year of my study being completed.

Data on scorings from students' presentations was collected on paper and each student identified by gender and no names used. This will be locked securely in a cabinet with key and destroyed within one year of my study being completed.

Results from end of unit science tests before and after the study will be collated in electronic form in a password protected computer and will be deleted within one year of my study being completed.

Poster papers with students work will be destroyed within one year of my study being completed.

Teacher's participant information sheet

Title of study: *Classroom discourse with both student-led questions and feedback: Enhancing engagement and attainment of students in a Learner-centred Key stage 3 science classroom*

Why is this study important to our students?

This study seeks to improve students' questioning skills and feedback in lessons. It will also help improve students' understanding of scientific key words and develop their thinking skills.

What do I have to do?

You will inform students that they will carry out research to solve a problem which has been broken down into leading questions that will enable them to solve it.

Allow students to choose the members of the groups they will work well in.

There will be 4 students in a group and each group will be assigned a problem to solve. They will be required to read the task in each groups and ensure everyone in the group understands the task.

They will research the given tasks over two lessons and write their findings. They will collect information from science text books, exercise books and internet sources, resources provided by the teacher and from previous homework.

Presentations of findings: lessons 3 and 4

Before presentations students' will be allowed 10 minutes in each group to rehearse and read their work together. They should assign roles to each member in the group and present findings together.

You will introduce students to Bloom's taxonomy which they will use to develop questions after each presentation.

Each group will now present their work starting with the title of the task while other students listen. After each presentation, other groups will then ask questions using

Blooms taxonomy question prompts and the presenters respond to it. If they could not, other students from the audience could respond. Encourage students to use high order questioning from Bloom's taxonomy. All these will be audio recorded using a digital device. No video recording will take place.

Inform the students that they are free to withdraw from the study at any time with no consequences.

You can also withdraw from the study at any time.

What are the data that will be collected about students?

- Audio recordings of presentations and questions and feedback from students
- Scores during students' presentations
- End of unit science test scores before and after the study
- Poster papers on students' findings from the research task

How will I use the data collected?

I will listen to the presentations and the questions and feedback generated. The quality of questions and feedback from students will be compared for scientific terms used.

I will compare the types of questions generated from low to high order on the Blooms taxonomy.

I will analyse the scores from presentations and decide if students were more engaged in the lesson.

The end of units' science test results before and after the study will be compared to see if students have made any progress.

What will happen to the data collected after the study?

All audio recordings will be kept on a pass word protected computer and will be listened to only by me. These will be destroyed within one year of my study being completed.

Data on scorings from students' presentations was collected on paper and each student identified by gender and no names used. This will be locked securely in a cabinet with key and destroyed within one year of my study being completed.

Results from end of unit science tests before and after the study will be collated in electronic form in a password protected computer and will be deleted within one year of my study being completed.

Poster papers with students work will be destroyed within one year of my study being completed.

Appendix 6: Problem solving tasks and research

The topic used in problem solving is titled Food and Glorious food which forms part of the year 8 National curriculum schemes of work in England.

Task 1: group 1

What is in our food?

You must include the following in your work:

List the 7 groups of foods and state two examples of foods that belong to each group

State the functions of the 7 groups of foods

State any problems that may result from not eating certain nutrients in our food

What is a balanced diet?

Create a menu of balanced diet for the following people for breakfast, lunch and dinner: children in year 8 (13 years old)

State reasons why you chose those foods to create a balanced diet.

What makes a healthy diet? State reasons here

Write out the nutritional information labels on your poster or you may cut out and paste the nutrient information of the foods on your poster.

State any problems people would face when they eat the wrong nutrients in foods

How is this problem prevented so that people don't eat the same nutrients always?

Explain why you think people like to know how much nutrients for example, protein, fats, and carbohydrates are in the food they eat. Look at the food labels provided for help.

What happens if people eat more energy food than they needed?

State the diseases people would suffer from due to lack of vitamins A, C and D

What is Rickets? Explain how Rickets happens, signs and effect on children. How can Rickets be prevented?

Cut and stick the table of nutrients on sheet 8Ab11 onto your poster and create a third column call it ‘Amount in 100g of the new food’ what we think it should be and suggest the nutrients values for each.

Complete questions 1 A to E on sheet 8Ae3

Task 2: group 2

The Mayor of London raised some concerns on the following questions:

How can NHS hospitals be stopped from giving Fatty and Sugary foods to patients?

How can food companies/restaurant be stopped from selling Fatty and Sugary foods to children?

You must include the following in your work:

The 7 groups of foods and two examples of each

State the functions of the 7 groups of foods

How do you know when you don’t eat healthy foods? State any reasons or signs

List some types of healthy and unhealthy foods you know and state reasons for this

List some ways Government can put law to stop food companies/stores/restaurant from selling sugary and fatty foods to people

How can food companies support the law created by the Government?

List some things NHS hospitals can do to stop giving patients fatty and sugary foods

How can parents and carers help their children to eat healthy food and live a good life?

List ways older children (age 11 to 16 years) can be responsible for eating healthy foods

What are the roles of schools in ensuring children eat healthily? State them

What is the role of the Food Standard Agency in checking the foods we eat?

What are the effects to our health when we eat too much fatty and sugary food?

What is Obesity?

Would people face problems when they become Obese?

How do you know when children are Obese?

State the problems obese children would cause to their family and the society

How can unhealthy diet lead to heart diseases? State the process involved.

Disease from eating poor diet cost the NHS £6 billion every year to treat. State how you think people can help prevent the NHS from losing money for treating people.

State reasons why you think a lot of children eat junk or fast foods at home?

State reasons why a lot of children eat junk or fast foods in school?

Why is it important to eat fresh fruits and vegetables?

Complete traffic light questions on sheet 8Ae2

Extra support sheets on the role of FSA, obesity

Task 3: group 3

How can our lifestyles and standards of living affect our health?

You must include the following in your work:

List some factors or things that can affect our health

How can we live a healthy lifestyle? State some ways

State your views on healthy eating and why do people need to eat healthy foods?

List some foods that you may consider healthy for breakfast and lunch. State reasons for choosing these foods

List some diseases that people can develop from eating unhealthy diet

What is the effect of lack of exercise on our health?

What is the effect of low and high metabolic rates on the body?

Do you think people must be rich to be able to afford a balanced diet? Give reasons for any answer you chose.

What do you think the Government need to do to ensure food is cheaper and available for poor people?

Do you think junk and fast foods are healthy for people? State reasons

What do you think the Government need to do to control food companies and restaurants from selling poor food to people?

State the kinds of foods that can lead to heart disease in people and raise their blood cholesterol levels

Why is having a high blood cholesterol levels bad for people?

Suggests factors that may lead to people developing diabetes

James has become overweight in the last few years. He has changed jobs from being an athlete to working in an office. State reasons why you think James has become overweight?

Suggest ways James can change and start living a healthy lifestyle?

Suggest different ways people can prevent themselves from being overweight?

Why is it important to eat fresh fruit and vegetables?

Two people eat the same quantity of foods each day, but one of them put on more weight than the other. Suggest 3 reasons that may explain this difference.

Task 4: group 4

How would enzymes be important in food digestion?

You must include the following in your work.

What is digestion?

Why is food digestion important to our systems?

Name 3 foods that you think digestion is important to take place.

Why is it important for these 3 types of foods to be digested?

Why are minerals and vitamins not digested before they get into our cells?

Describe the process of digestion in our system.

What are the roles of enzymes in digestion? State them

Enzymes act on protein, carbohydrates and fats. State the final products formed when enzymes breakdown these foods.

Describe the functions of fats, protein and carbohydrates in the body?

State any factors that can prevent proper food digestion in our body

Why can’t undigested foods pass through your gut wall into your blood?

Which parts of your body needs the digested foods? State them

In what ways does your body use up foods? State them.

Protein is digested in your stomach. What are the conditions like in your stomach? State the enzyme that breaks down protein. What does the acid in your stomach do?

The following are diseases of the stomach: constipation, stomach ulcers and diarrhoea. Find out the causes of each of these diseases.

Apart from the stomach, mouth and small intestine, name another organ that produces digestive enzymes.

Appendix 7: Audio transcripts from students' questions and feedback

Key: B represents boy and G represents girl

Words in italics are the questions created by the students while the normal font represents the responses and feedback.

What would happen if you don't *have your five a day?* B

You wouldn't get enough nutrition and vitamins and so, you would have an unhealthy diet B

You see the way you said type 2 diabetes, what is that? G

Oh is like when you don't have enough sugar in your body B

Oh yes what are the other type? G same Girl here

Type 1 is the other one- yes, yes B, B, B (all from the same group)

Can you clarify what differences that fruits and vegetables do to our body are they like different? G

In vegetables they contain different vitamins and nutritious like fruits also B

No, I mean like what affect do they have? What do vitamins do in the body? G

Oh, so you mean like what do different vitamins do? B same student trying to answer the question here.

No I mean what does each one do in the body? G

What she meant was can you differentiate their functions? B another student from the audience reframing the question

Fruits would give like vitamins B or C which can help the bones get stronger whereas vegetables can contain different vitamins like A or D.

Can you defend your position about saying that type 2 diabetes, you said that you have no sugar but if you are obese you are fat and fat and must come from sugar G

Yes, there are different types, type 1 would be where like you have high sugar and your blood just got too much sugar and you can have heart strokes a lot B

Yes, but if you are obese G

Teacher try to stop group and said we have not actually learnt this.

A student steps in to try at this point

I don't know the difference but when you have type 1 diabetes you have to have injections every day to help your glucose level, type 2 is not as serious and you can have tablets to help you. G

Teacher now steps in at this stage

Type 1 if you are borne as a child and you don't produce this chemical called insulin which is a hormone and what it does is it tells your body that you are carrying too much sugar in your blood and you need to store it or use it up. So, type 1 diabetes is called juvenile diabetes- because children have it. They will be given injections of insulin throughout the day and that would affect their blood glucose levels.

Type 2 because of your diet you develop resistance to insulin and so, your insulin doesn't work anymore. You need to control this by having healthy diet

Explain why the male body needs more calories than the female? B

Because men do like a lot of exercise, they use more energy they do like building heavy things while girls or women B (chorus or that is sexist), women do less work.

It is to do with the ways their bodies deal with the energy they get in their metabolic rates and how quickly they can breakdown food. Teacher's comments.

How come some people are fat and they don't eat a lot, how come? G

Did you mean they are eating only one type of food? B

No you are not getting me G (same girl)

How come some people do not eat a lot but they are still fat? G (question reframed by another student).

Because they could have been borne where they are like fat and cannot burn off their fat. B

It could be how their body digest food, their metabolic rates in the body. Teacher's comments.

If someone is feeling anorexic, what food advice would you give them? G

I would say they should start eating more a little bit and if they start adding weight then they should start eating more but not until they build more just like eating more to gain more weight. B

What is the most common diabetes? B

Type 1, type 2 B

Is it possible to become fat eating too much fruits? B

Yes not like obese because when you are only eating one type of food like you are not getting energy and all that. So you can't be obese.

Can you explain how the plaque happens because I don't understand your diagram? G

The plaque builds up as a result of too much sugar and sweets in the teeth and it goes back. G

So, why is there a plane tooth there on your diagram? G

I know some people they have all gold teeth. B (laughs other students--) chorus response here.

What would happen if you never had the layer of enamel on the top of your teeth? B

Teacher intervenes and said she wants questions on healthy life styles only.

Yes, but, teeth is healthy lifestyle? B

Teacher, okay go on then

How come some people don't eat a lot of sugar but they eat a lot of fruit but still their tooth are decayed and rotten? G

Because they don't brush their teeth and the oranges may contain acids that can affect their tooth. G

Harry eats lots of fatty foods, in the morning he eats cookies and fizzy drinks, how do you think he stays so skinny after eating all those foods. G

He has unhealthy foods in the morning, I cannot ----. G

Before I used to have a gold teeth, and then it came out and I lost it. B

May be it was gold filled and after a while it just fell out. G

What is the point of having enamel in your tooth? B

If you don't have enamel, acid from your food can go through your tooth and destroy them. G

Does tooth paste work? B

That is the point I am saying, it helps to clean the acid. G

What would happen if your baby teeth never falls off?

Your tooth will be like mine. B

You will just have baby tooth. B

They will be strong because they never fell out. G

While this group was presenting, they raised the following questions to the class:

How many of you have chicken and chips at least twice a week? B. Put your hands up

Some student said once a week G

How many of you eat chocolate three to five times a day? B

Counteraction by two girls (G, G) no, no you should say a week and not a day.

How many of you eat sweets every day? G

How many of you have sugar cornflakes in the morning? B

How many of you guys exercise? G

When eating too much of the same nutrient, is there a better solution to solve the disease that you have? B

For example if you eat too much nutrient like fats and you get ill, how do you get rid of it? B (same student reframing question)

You don’t have nutrients in fats. B (another students contesting the comment from previous student about fats)

What disease do you mean? B

The best way is to eat healthy foods like fruits and vegetables. B

You must do enough exercise. G

What changes would you recommend to eating fat foods? B

Eat small portion of it with salads and drink plenty of water instead of drinks because they are not very healthy for you. G

If you go to the shops buy those things so that when you fry your chips, it sucks out the oil so you get less fats in your body. B

Can you give an example of malnutrition? B

Like eating too much fats for example in developing countries where people eat same food like ‘pounded yam; which is very heavy and may make your stomach very big, your body deforming. B

You eat a lot and all the tissues are going spongy. G

Does that mean if you lose the weight your stomach will become saggy? B

No, it stays the same. G

When you eat normal your stomach will go back to normal because it’s the tissue that was expanding. B

How many ways can you stop obesity? B

Exercise, less fatty foods, eat good portion of every foods, virtually everything. G

What happens if you exercise too much? B

You will get tired, become anorexic, you can’t say after PE in school that is the only exercise you have to do, you can run. B

If we don’t eat any fats what will happen to us? B

You will get fat because you are eating only one type of food, do you watch super skinny versus super fat on TV, the people who are skinny eat the same type of food all the time like chocolate, you can still eat a fat diet and be skinny. This could be bad for you. Too much of everything is bad. You see if you are really skinny people don't think you will get heart attack. G

Can you state the difference between obesity and over weight? B

Obesity is a sickness basically you are fat and look like that person, overweight is basically say like a 12 year old girl weighing 45 or say 52. I weigh 120. B

If someone is obese, they can have big bones. B

You can have different bones from anyone. G and G (two girls are arguing here to show their understanding of the topic being discussed) and make own contributions confirmed right by the teacher in the background

When you get obese is there any causes you can get to your normal self? B

Stuff like Liposuction, you suck the fats out of your body. G

You can cut your stomach also but at some point it's the only thing some people can do to be healthy. G

Some people get balloons put inside their stomach to minimise the food they eat, for the first three weeks they have to take in liquid and porridge. G

What if you are disable and you can't go exercising and you have the operation with gastric band and the band will die and you are really fat? G

Yes you can exercise. G

But you are disable in a wheel chair and cannot walk. G (comment from same girl who asked the question about gastric band and exercise) Seem to be challenging another student's response.

But you can eat healthy first of all, say in the morning you used to eat bread and jam and chips, you can now eat carrots, vegetables, milk and fruits. You can drink Actimel in the morning the one they show on advert that it makes your stomach become small. You can also do eat well plate and then turn back to skinny person. G

For us going to school, when we eat healthy foods it can help our brain work well. If you don't eat good food you can become tired in school. For example if you don't eat breakfast you can be tired in school and cannot concentrate with your work. G

Is there another way to say obesity without exercising? B

You need fat for long life, energy and warmth, even writing is wasting energy. G

You have fat in you now but not too much. G

Can you explain the symptoms of obesity? B

You can get tired easily, bad breathing, lots of fats, chest pain, heart pains, bigger bones. G

How the fats does actually becomes fat in someone's body? B

First of all you are skinny and eat a lot and lot, this takes time and time for all the fat to build up in the body and you become fat. G

For example if I am an energetic person and my body is used to being active and later I become lazy and I still eat like I do, the fat will start building up and it will use it because fat is energy. If I don't use the energy it will run out and if the fat remains on me. G

Without looking on your poster, can you give an example of each food group? B

Vitamin C will probably be like orange juice G

Protein would be like rice, pasta, cheese all those stuffs G

Milk contains calcium G

Water will be water G

Fibre will be pasta, G

Dairy will be another group like milk, cheese. G

Which food group will give the most fats? B

Sugar G

That is not food group B

How would enzymes be important in food digestion? B

What is enzymes? B

Enzyme is one of the most important particle in our body. B

Enzyme are microscopic particle which help us digest food. B

Enzyme as shown in this diagram is basically a cutting machine with this it helps large molecules of food fit through the intestine so that we can then take it out. B

Could you give me more information on enzyme? B

Basically as I said, enzymes as seen on my diagram is a prototype of what they can do. Most enzymes are found in our stomach, they help to break down food molecules. B

Same student answering question now ask others in his group to list all the types of foods. This is like recalling from other peoples presentation.

Carbohydrate, fats, vitamins, minerals, fibre, water and protein. These are the nutrition. Chorus answer by all members (four boys). B, B, B, B.

Can you state the relationship between the large and small intestines? B

One is bigger and one is smaller. B

They are both like kind of have hair in them it's not like the hair on our skin but they have smaller hair. B (Second group member it is called 'villi'. B) Yes and that makes the food go through.

What would happen if we didn't have enzymes in our body? B

Our food would not be able to go through our body. B

I wouldn't be able to create energy. B

This may then cause diseases and one may die. B

Could you precisely describe what an enzyme does without using metaphors? B

An enzyme is a microscopic chemical which help big molecules of food for example potato into smaller ones. However, sweetcorn is a source of fibre but cannot be digested. B

You said that enzymes work in the stomach, if someone is obese, where exactly will this type of enzyme found in their stomach? G

Basically enzymes are from your throat and goes all the way down to your stomach. B. Did I answer your question?

No, because we have other organs in the stomach like the small intestine, upper stomach, I want to know where the enzymes are found. G

No, small intestine is not found in the stomach, they are outside. B (this student begins illustrating using himself as a model and the chart they had). After this the student became clear by saying oh I now know.

What would happen to your organ if you eat stuff that has low nutrition and not balanced diet? G

Basically you get obese. B (same girl above said explain how do I get obese)

A boy says I want you to explain what you mean here

Boy now responds, by eating unhealthy foods like chocolate, burgers, pizza, fat foods. B

When the enzymes cut up the starch molecules, what is left and what is their name? G

A boy requested the question to be reframed here and the girl ask same question clearly

What is left, it makes energy. B

The girl who asked the question did not agree with answer and said, what is left will be sugar molecules. G

Excitement; all students were happy to hear her answer and laughed over it while learning.

At this point, some students took over by appointing people to ask and respond to other students' questions (both boys and girls)

Explain in scientific terms how the body would react if the enzymes were not there? G.

You will not be able to poo and digest food if enzymes are not there and you will die. B

Teacher: we have answered that question already, please move on.

Students: chorus yes exactly, exactly

Do enzymes work differently in different conditions? B

Yes. (By all group members. B, B, B, B.)

How. B

Because they need to work on your body temperature which is 37^{o}C. But if your temperature is over 37^{o}C that means your enzymes are not working properly. G

The temperature in your mouth is 30^{o}C and when it goes down, the pressure increase through, (what is that guy I mean----) the intestine will heat up and it will be easier to burn the fat. B (Note some student were laughing at him here but he went on and later laughed with them) It will be different if its teacher's questioning.

Also enzymes works at temperature of 37^{o}C and if the temperature is over 37^{o}C that means your enzymes are not working properly. B

I will compare both answers in blue colour by the boy and girl

What would happen if you have too many enzymes? B

Well, your digestive system will work better because you will be pooing every day. G

Can you tell me all the organs that produce enzymes? B

Liver, mouth, stomach, there is pancreas, they are the ones that mostly have the enzymes. B

You have a sickness and your body temperature is something like 52^{o}C, what would happen to your enzymes since you said that they don't really work when your temperature is high. G

You will die. B

Basically most of your enzymes would die and. B

Statistically, our body temperature cannot be 52^{o}C

You will have less enzymes. B

What could enzymes have reactions to? G

As we said if there is too much heat, they would not work properly. B

Can you name me an acid which can kill enzyme? G

Acid, acid, you will not want to eat acid (chorus answers here, people not sure why do you want to eat acid, some laughing, some repeating the word acid).

Teacher now says, guys, guys, let one person speak at a time.

You see when the food goes in your mouth, how would you explain that it breaks down. G

Basically, we have saliva in our mouth that contains a little bit of enzymes but not as much as the one in the stomach. The chewing also helps to breakdown the food, enzymes help to break it more as it goes down the oesophagus and our gullet, and ye- that's what the processing is like. B

If your body is -10^{0}C will your enzyme still work? B

Do you mean if our body temperature is -10^{0}C? B

If your body temperature is -10^{0}C to be honest you will probably have a disease and die. B

You will be dead. B

Can you name and draw the type of enzymes? B

Three students here eager to draw diagrams and respond.

What do you mean by draw the types of enzymes? You come out and draw it. B.

Do you mean draw enzymes? B (another student responding to the question feeling the question is not right).

Teacher: can you reframe question with description part as this lesson is recorded.

Can you name the types of enzymes to break up the types of foods? B (the student now reframed the question)

Basically this is an enzyme and it's a microscopic enzyme and you will need a very sharp microscope to look at it. Basically it goes to the food and cuts it up until it comes out. As I said, sweet corn is not fibre and it doesn't get broken down by enzyme, it just comes down as natural. B

Teacher: okay, last two questions as the lesson will end now. This shows engagement as time is been used up in the lesson.

What will happen if you mixed enzymes to like dissolved meat but don't have meat in your body? B

What. B (showing the question is not clear to him)

What will happen if you mixed like enzymes and dissolved meat with another type of food group? (Boy reframed question here for other to understand)

What, can you repeat the question again? (Chorus by 3 students; B, B, G)

There are different enzymes to dissolve different things, what would happen if you mix two of them that don't work together (Boy finally repeats question)

An enzyme cuts up anything or any food molecule, basically, the enzyme travel and want to make the food go through the intestine. B

Basically, it's not just one enzyme, there are different types of enzymes, the one that wants to dissolve that one goes into that one and the other to dissolve that one goes into that other one. G

Back ground noise by another student (that is what I said, that is what you said).

Teacher: be careful using the word dissolve, it should be breakdown.

Student now corrects herself and said breakdown.

What will result if enzymes break each other down? G use this area as one in my work, they have same colour

They wouldn't. B

They will not because from a young age, your enzymes would know how to participate with each other's. B

Now chorus answers from students and laughter across the classroom. It will not happen as response to the answer.

What if it happens, what will result? B (Same girl insisted on question to be answered)

Teacher: right can we just think about it, would that happen? To use

If it was to happen, it wouldn't happen. G

Teacher: no, I mean would that happen?

Enzymes are made to work together. B

Teacher: responds to the student's answer what are enzymes meant to work with?

Teacher: what did James says (pseudonym). Enzymes are specific, so carbohydrates enzymes will only breakdown carbohydrates. If a food is not carbohydrate, carbohydrates enzymes cannot break it down.

You know that saliva contains an enzyme, someone spits on some food which is a carbohydrate, and then you eat it, what will your enzyme do with the enzyme that has been spitted onto the carbohydrate? G

When I say your saliva has enzymes, it is not other enzyme. B

The enzyme in that spit will die because they are not in their own environment. B

Yes, yes it's not in the right temperature.

Teacher: okay we will round it up here, well done every body.

Can you explain to me what a calorie is? B

Calories are like the things which are in food that creates the energy, things which make you fat if you have too much of them. B

Can you defend your position by saying if a man needs 2000 calories a day, that, that is all they have to eat. What if they eat more? G

If they eat more than that like a couple of days more, they start to gain more weight than they are exercising off. Most of the time a man does exercise while working around the thing and for a man is 2500 calories to stay normal. More than 2500 calories they can poo and the fat will start to settle. B

What would happen if the woman ate more calories than the man? E

Basically the woman will start producing fat and start gaining weight. G

You said that the carbohydrate are really good for your body but like what will happen if that is the only food I ate? G

You will get fatter because the carbohydrate contains high calorie as well. For example most people in diet take low cab diets because carbohydrates have more calories in them. B

And you said they were healthy. G

Ye they are all healthy as long as you used the energy of the carbohydrate. If you do not use them, the energy will be stored into fat which is bad for you. B

What is the best way to burn more calories? B

Exercise, other than that you can burn calories by walking. B

How can you amputate the systematic of obesity? B

Don't eat a lot of fat. B

Let's say a person went on a crash diet and after 5 weeks, he goes back to his normal diet. What are your recommendations for the person to eat and put a little bit of weight? G

If you eat some carbohydrates and fats but do some exercise. B

You have to eat more carbohydrates to get energy. B

How is it possible that some really skinny people almost anorexic, have bad diets, eat like only chocolate and stuff but are still skinny? G

Is something to do with their metabolism?. B

They exercise much. B

No they don't exercise, eat chocolates and bad diet but still skinny. .

What are the problems that can be caused by eating unhealthy foods? G

Heart disease, stroke, obesity, diabetes (type 2), B and B, G.

What happens when people eat too much of the same food? B

You will have malnutrition, in some cases when you eat too much vegetables and you don't have enough fibre, you will get diarrhoea. B

What will happen if you don't get all the multi calories? B

You will not have enough energy and will lose weight. B

Is it possible to eat a lot of fatty stuff and not get fat? B

By exercising. B

What human age is more vulnerable to die of obesity? G

I will say children because their heart is younger and they are less able to cope with too much sugar. B and B

Are you saying that old people are better than young people? Same G

Teacher: you need to think of the life style of a child compared to an adult

You don't see like old people eating sweets compared to children. B

Is there a better solution to reduce the fat in our body than exercise? B

Like dieting will be okay, less calories. B

You know like the fat in our body, would it be possible to take it out and use it for energy? G

The fat will become energy but I don't know if it can be taken out. B

I am talking about electricity stuff. Same G above

What do fats do to the cells for instance that any other food group don't do? B

Fat layers block the arteries. B

If a person is allergic to carbohydrates, what will they be given to keep on having same life style? G

You can also eat protein to get some energy. Protein actually contain some energy and it depends on how much you eat. B

Name all the sources of protein. B

Meat, steaks, hamburger, eggs, fish, beans. B, G

When you are fat or obese, there are some things your body stop doing, can you mention some of these things. G

You cannot get up and run around. B

Your body cannot heal itself, for example when you get a cut it might get infected. They end up been amputated. Same G answering herself.

If you are fat and you want to get rid of some of your weight, will there be a side effect? G

You will get less energy for a while because you don’t eat as much as you can. B

What conclusion would you make to say how fat develop in our body? B

Too much eating of fatty foods, fats block arteries. B

Let’s say I want to slim down, what will you recommend me to do? G

You have to diet, exercising. B

Can I comment on that, if he stops eating it’s going to have a bad effect on him because he is used to eating. For example when you are smoking, you cannot just stop immediately and this is the same thing as when you are dieting. The person is really fat and cannot move but has to be gradual. They can also do liposuction. G

If you really fat would you die sooner than anorexia? G

Teacher re-confirm the question: are you comparing extreme obesity to anorexia?

With obesity there are chances of the arteries being blocked up, diabetes, heart attack, and stroke. B, G

You don’t always die of heart attack but there is a high chance. G

What will happen if you never ate sugar? B

Sugar gives you energy but if you eat fruits and other things you can still get sugar. B

You see the way you have to lose certain amount of weight before balloon can be put into your stomach, how much weight do you have to lose? G

It depends on how much you weigh. B

What is the weight restriction to being obese? B

There is no restriction, it’s like age wise also. B

Yes but what is the minimum weight to be obese? B

If you are 13 years now, obese will be about 50-60kg. B

What will happen to a person if they lack some of the nutrients? B

They will cancel that nutrient and cannot have them, if it’s dairy they will not have them. B

What does the pancreas do? B

First the food is chewed in the mouth, the gullet allows it to go down, the liver is there and gall bladder underneath ---- G

The liver takes all the bad stuff from the food B

Teacher: does the food goes to the liver? Chorus answers from students No---no

Teacher: can someone now answer that question?

Teacher, the food does not pass into the liver, the liver get rid of toxic substances.

Do certain food take longer to digest than others? G

If you quickly chew up food they will take the same time. G

What would you say is the pH of the acid in the stomach? B

Well because it’s an acid, I will say about 4. G

What would happen if I wasn’t able to digest food? G

You will pop. G

You will die. G

What is the difference between the small and large intestine? B

One is big and one is small. B

One of them has villi. B

Teacher which one

Another student said small intestine. G

Teacher now ask the student with the good answer, is there anything else to add

Teacher; what is the purpose of the villi?

The villi helps to take the food into the bloodstream. G

Teacher; what does the large intestine do?

Teacher; small intestine helps in digestion and also helps in absorption of water (recall).

Large intestine helps to squeeze them by reabsorption into our body.

How would your body react if it didn't have a digestive system? G

Question not appropriate.

What affect would the liver have if it's not working? B

Yes the toxic in the food will be left and can affect you. G

Before you poo out, there is a part that holds the poo, what is the name of it? B

Long silence

Teacher does anyone know the answer?

Rectum. B

What will happen if our enzymes don't work? B

The food will not breakdown. B

When you have starch molecules, the enzymes cut them down to make sugar molecules that gives you energy. It means if your enzymes not working, you will not have energy. G.

I read that if your stomach doesn't produce mucus in a week it will digest itself, so what will happen? G

You will have nowhere to put your food. B

Teacher; you will need medical attention. Remember, the topic is on food and digestion and to keep your questions on that topic only.

What will happen if you have too many or too few enzymes? G

Too few there will be less digestion and less energy and if you have too many, it will cut up all food quickly. G

What is the relationship between small and large intestine? B

Another student laughed and said not a good question for this topic. G

Teacher supports and said no; it's not enzyme question and we have discussed this before.

Why is there enzyme in the mouth because I thought the teeth in the mouth helps to crush down foods? B

There is enzyme in the saliva that will help breakdown food as well. B

Teacher: enzymes break things down on a microscopic level while teeth breaks down food on a large form. Enzymes is chemical breakdown while teeth is mechanical.

What if you don't have enzymes or acids in your body? G

Your body will not be able to breakdown food and they can't get out. G

If you have a temperature, what affect will it have on your digestion? B

Your body becomes hot and affect your digestion. G

State in your own words what obesity means? B

Obesity means someone slightly overweight. B

What do you think might happen to someone obese? B

If you carry on eating and are obese, you could have heart attack, diabetes and may die. B

High blood pressure. B

What changes do you recommend for an obese person? B

Do more exercise, diet/ balanced diet.

Eat little bit of everything, vegetables and so on. B

Can you explain what must have happened before getting obese? G

Lack of exercise, eating too much. B

Explain why obesity happens? G

Lack of exercise, eating wrong foods. B

Is there any solution you could give to people to help them. G

Eat sensibly. B

What will happen if you get too obese? G

You will get heart attack, diabetes, and stroke. B

What are the difference between obesity and anorexic? B

Obesity is when you are too fat and anorexic too skinny. B

Obesity is when you are overweight. G

Here students are monitoring work themselves and choosing people to answer questions.

What is the main idea of this presentation? B

The main idea is to show how the digestive system works in our body. B

State in your own words what digestion means? B

Digestion means how the body break down food. B

What is the name of the enzyme in the mouth? B

Is called saliva. B

What are other factors that lead to obesity? G

Junk foods. B

No exercise. B

What are the symptoms of obesity? G

Too fat. G

What are the main food to eat and keep fit? G

Fruits and vegetables. G

What do you think about those who are obese? G

They allow themselves get like that and so don’t really care. G

No, it’s not like they don’t care but cannot control their habit. G

People who are obese don’t like themselves and can get depressed about it. G

Is it possible to eat loads of fruits and do exercise and still get obese? B

It depends on how much exercise you do to an extent. G

What is the difference between bacteria and fungi? G

Some bacteria are helpful and viruses are harmful. G

Classify what bacteria are? G

Germs. G

How did you get your answers from for this presentation? B

Text books and other sources. G

If you have fungi how can you cure them? G

Go see your doctor. G, B

If you have disease how can you escape it? B

I don't understand the question. G

Teacher: he's asking about fungi and bacteria.

Teacher: you need to be forming your questions from the word on the board.

Can you define the meaning of obesity? G

It means overweight. G

Can you state in your own words what obesity is? G

Obesity is when you are fat and not doing enough exercise. G

Chorus answers/argument here on obesity

What are the symptoms of obesity? G

You can get diseases. B

No, I mean what are the symptoms?

Tell how, where, when and why obesity can affect you? B

Obesity can lead to heart attack, it can affect you anytime and anyhow. G

Give an example of how obesity can happen? B

Obesity can happen when you are depressed, loss of love one, it can be how you eat. G

Why is it that a rugby player can weigh 10 times bigger than us but he can pace us in a race? B

Basically when you are bigger you can get more hunched up, when you lose fat you become stronger and you don't have to have a fit body to run. G

They also eat more vegetables. G

What conclusion can you make about food? G

Food is useful for energy, some foods keeps us healthy because we can get heart attack from others. G

Explain what food is like. G

Food is like what you eat to stay alive for example, carbohydrates, fibre, and protein. G

Can you state in your own words what obesity is? G

Obesity is when people eat a lot and become overweight. G

Suggest what will happen if a thin/slim person eats a lot of food. B

The slim person will gain more weight. G

Can you explain what a balanced diet is? B

A balanced diet is when you eat equal proportions of the food groups. G

What does protein do? G

Protein contains fish and meat it helps for growth and repair. G

Can you define carbohydrate? B

Carbohydrates is some of the food you can eat such as rice, noodles and bread. B

Is there a better solution of treating obesity? B

If you are fat a have no family, you can explore the different world like walk for miles, make your body used to it so when you are older, you don't get obese. G

Would the body not be overworked? B

No, you don’t have to do it all the time you can do it on a daily basis when it suits you. G

Say you are homeless, how would you live without food? B

If you live without food, your body can store fats to stop you from starving. G

Some people are big and fit, some people are thin and not fit, and why does it happen. B

Some people who are obese, it could be from their parents and not food alone, some can be anorexic. G

What are the ways you can recommend people to lose weight? G

Have a balanced diet. B

What might happen if you eat too much of one food? G

You can start feeling sick and that is why you need to have balanced diet. G

Can you define in your own words how digestion works down the body? B

When you eat the food goes down into your stomach and the acid break down the molecules which pass down your anus. B

What is the difference between small and large molecules? B

Large molecules take longer to breakdown than smaller ones. B

Can you define what the molecules are? B

I don’t know. G

What happens if the food are not digested, where does it go? G

I can’t answer that. B/G

Define digestion? G

When you eat food it has to pass through your body. G

What is the difference between digestion and indigestion? G

Digestion the food gets broken down and indigestion I guess the food is not broken, and it stays in that same shape. B

Where do the undigested food go? G

There is no way that your food can be undigested. It goes the same way down as it has to go through your stomach before getting to the anus. Some food is used by the body and others passed out. B

Some foods go through the digestive system and some parts of the molecules cannot be digested. What happens to that? B

Sorry, I can’t answer your question. B

What is amino acids? B

Amino acids are protein molecules that are broken up. B

What will happen if someone’s artery is clogged up with fats? G

Their heart will have less functioning which mean they will die very soon. B

State in your own words what is the main idea of your presentation? G

Our presentation is mostly about healthy eating, say a person has fat he will not be able to eat healthily, so we are just encouraging people to eat healthily. B

What is cell membranes? B

Is the outer cell coating that protects the inner cells and nucleus. G

How will you stop people from over eating, will we be watching them? G

We can’t watch people or stop them but we can put up presentations like this on TV, radio, online to help them.

Appendix 8: Interview transcripts

Purpose of the interview: to find out what is the nature of teachers' perception in the use of questioning and feedback in engaging students' in science lessons?

I: interviewer

R: response

Responses from Interviewee 1

I: What are your experiences in carrying out this project with your students?

R: I think they quite enjoyed it but at first they were unsure of what they were meant to be doing. That was my fault for not explaining it clear enough but ones they went through it again, they seem to get used to it and engaged very well.

I: what are your views in the use of questioning and feedback to engage students in lessons?

R: is something they do quite a lot. It helps them to think through something rather than just giving them the answer. Questioning them through the process whether its Key stage 3, 4 or 5, helps them think things through instead of just remembering things, they are thinking of how to get the answers themselves.

I: do you think that your students are engaged during the activity questioning and answer sections, presentations.

R: yes my year 8 were very engaged and was surprised how they performed. Especially with the presentation which was two lessons in a row and I thought they will get a bit tired towards the end but up to 5 presentations they were very engaged.

I: what are your views in students developing their own questions and giving feedback like we have done in this project?

R: I think it's something that will be beneficial in the long run and is something you have to practice with them over the time and embed in the lesson. I think some of them wanted to answer the high order questions the more and some still struggle with the low order thinking questions. But with more practice they will get used to it and will help them learn as well.

I: so do you think it's what we can practice with the students and get them used to it?

R: yes definitely, I think that kind of environment as well getting into other lessons. The environment where they are presenting and asking questions as well, and even with new material as well, they are looking at something they have never seen before. They are practicing asking questions and looking at new materials and new knowledge.

I: how would you describe engagement in this task considering the students you worked with?

R: as I said before to begin with their was little confusion on students not clear of what they were meant to be doing but later got engaged when they know what to do. Students were very engaged except for some few who are normally quite in lessons and are not asking questions. You need to be aware of this.

I: in the course of this work with your students did you observe them discussing among themselves and challenging right or wrong answers.

R: in this activity the students were positively challenging what they were talking about at the same time they were thinking is that right or wrong. It kind of remove any form of personalisation.

I: would you consider that scenario from your current comment as part of engagement

R: yes, it took out personalisation as the students were thinking about the task and working together.

I: how would you compare this to normal lessons in terms of engagement, where students develop questions and give feedback here but in normal lesson teachers just teach and ask questions and the students don't ask questions.

R: I think it's more pupil led letting the learning take the direction the students want it to go rather than I am giving them the questions I want them to answer and me choosing the journey I wanted them to take. Their leading it makes them take ownership of the learning and I think is something that should be considered in normal lessons based on this project.

I: I like the word you used taking ownership of their learning

I: does questioning and feedback improve students' engagement and attainment in lessons?

R: yes

I: so why would you think it will improve their engagement and attainment?

R: especially looking at this activity they were constantly having to be aware and thinking and it was not like they can switch off for a while. They were not being disruptive, they were all working but in normal lesson most of them could be totally disengaged but in this project it was different because they were processing information constantly and because they knew they will be asked questions and may be required to answer them. This makes them to be on task completely and with full attention.

I: how did you find the scoring criteria was it easy to use and can it be applicable to other presentations in science lessons?

R: yes I thought the scoring criteria was quite straight forward to follow, and it had more grading points of 1, 2, 3, 4 and 5 with more levels to distinguish between those doing really well and those that may have been lagging behind.

I: teachers scan use questioning and feedback to engage students in key stage 3 science. Do you think this is true?

R: yes definitely

I: if students are regularly allowed to develop their own questions and give feedback to themselves in lessons, this will improve their engagement and develop their thinking skills.

R: I strongly agree with this

I: which one would you consider most effective in supporting your students' learning is it oral feedback or written feedback?

R: I will say oral feedback. I am not sure on how much emphasis the students put on written feedback. Even if you mark their books some of them will look at it and come to me and ask questions about it because they prefer to have the conversations with me rather than just making comments in their books.

I: so the reason why you think oral feedback is good is so that they can get feedback on the spot:

R: yes it helps them get it when they want it and may want to ask questions straight away and get answers rather than writing in their books of which we should be doing. But they don't want to wait instead needs feedback instantly because they can ask several questions and get the feedback directly and they will say ok I get it now and can move on.

I: how do you think the project has affected the pupils given that they have done presentations, questions and feedback, what effect have you observed in the students?

R: they enjoyed it and wanted to do well in it. They like to do things like this again. As I said before I thought they will not be engaged and lose interest but I was wrong as they were all engaged. Normally if we do some task in lesson for an extended period of time they become bored and lose interest but it's different with this project. I was surprised they were engaged for long time in the lesson.

I: do you think the student would like this activity again?

R: yes definitely, they will like to do it again. I: do you think this activity should be incorporated into the science schemes of work say once or twice in a term?

R: yes I think is something we can incorporate but we need to start building up the skills and structure to begin with so that they can start practicing it and get used to it and how to do presentations. This is something we should be doing. They learn well enough from each other and will be interesting to see how they get on with it doing it over time again and again. It will help them develop as well and like transferable skills not just for science but can transfer to other subjects.

I: the idea of transferring to other subjects not only in science like you said is quite good to help their learning.

I: Which groups ask more high order questions boys or girls?

R: boys asked more but the girls was more mixed

I: which groups are more engaged boys or girls?

R: boys

I: what are the attributes of engagement you observed in the lessons?

R: students were listening and asking and answering questions, they were actively listening, watching, paying attention. They were all willing and groups motivated. Before when I have done something like this in class, groups insist they do not want to participate in presentations, but in this case they all wanted to show what they were doing.

I: as a teacher what sort of questions enable your students to learn, for example comparing open and close questions.

R: I think in science their exam questions can be quite close, because there is no right or wrong answers, no interpretations. But the way students get there, we need to open up their minds because in the wider world science can be open subject and there is so much out there that they need to find out and we need to help them find the knowledge they may need for those questions they may get in their exams in a way that keeps their mind open so that they are not just thinking only about facts, facts and I need to know the facts and finding facts but need to keep their mind open. For example with my sixth form students, I tell them don't just remember the facts but remember the process that helps you get there. This will help you outside as well.

I: so you mean open questions help to support the students' knowledge and their thinking skills as well.

R: yes, yes

I: So, what sort of questions do pupils ask during lesson looking at close and open questions and from the hierarchy on Blooms taxonomy

R: I will say generally they are quite close like what is this and so on, just wanting to know facts. Sometimes I get good question that opens up discussion but it's rare and generally they are low order questions.

I: so would you conclude from this session that questioning and feedback from teachers can improve student's engagement and attainment in their lessons?

R: yes, yes

I: how would you develop your students' questioning skills and get them more engaged in lessons?

R: I think it's about the structure. They had question starters and it's about helping them know when to use each type of questions. Some students want to ask high order thinking skills questions and which doesn't make sense. It is about modelling the questions to the students to guide them here, for example, high order questions. This will help them have expectations on what to do.

Responses from Interviewee 2

I: What are your experiences in carrying out this project with your students?

R: some were very engaged, some not and others not sure of what they were supposed to be doing. Once they got told again on what they were supposed to be doing they were okay.

I: what are your views in the use of questioning and feedback to engage students in lessons?

R: I think it's a way of exploring how much the students have learnt and it's a good indicator of whether students are on task or not. And you also can correct students' misconceptions/misperception of things. I quite like question and answers but you also get out of it students questioning as well which broadens the topic.

I: so do you think we should give students opportunities in lessons to ask their own questions?

R: yes, yes

I: do you think that your students are engaged during the activity questioning and answer sections, presentations.

R: as each group presented their work, this further enhance the progress of other students to be more involved especially those not serious initially and lots of them realised they could get more out of the activities.

I: what are your views in students developing their own questions and giving feedback like we have done in this project?

R: I think it's a good idea as it makes students think deeper about the subject they are actually learning. If they can come up with questions and may be a possible answer themselves, this makes a difference to their learning.

I: I think I agree with your comments that this will develop their thinking in science if they can ask questions and answer it themselves.

R: yes, yes

I: how would you describe engagement in this task considering the students you worked with?

R: engagement to me meant that they were actively researching the stuff they had been given and coming up with ideas to put on their posters. Some children took to it straight away and I know those who will do so, there were others that need little bit of help to help them moving. There was instance when one or two students may be disengaged. It is not the whole group but it takes only one or two to be disengaged. Also if a student does most of the work themselves than others in the group they may become fed up.

I: so in this situation would you encourage job roles for each students?

R: yes, yes.

I: in the course of this work with your students did you observe them discussing among themselves and challenging right or wrong answers.

R: yes I observe that in some groups.

I: how would you consider this scenario where children are challenging themselves on right and wrong answers as engagement? Do you consider that as part of engagement?

R: yes I do, I think that stimulation is actually finding out whether they are right or wrong

I: how would you compare this to normal lessons in terms of engagement, where students develop questions and give feedback here but in normal lesson teachers just teach and ask questions and the students don’t ask questions.

R: I will consider it as a good learning platform but I think it needs to be done at year 7 so that every year the students can get better at it so that when they come to their GCSE it comes naturally to them. They are year 8 at the second year of their secondary education, they still have concerns about showing themselves in front of people. I think this sort of work will actually make them realise that presentations and giving good answers is all part of growing up and learning.

R: I like your idea about trying them from year 7 so they get use to this kind of activity

I: does questioning and feedback improve students’ engagement and attainment in lessons?

R: yes

I: so why would you think it will improve their engagement and attainment?

R: when I do question and answer in my class, I don’t do hands up policy, I ask those students that don’t put their hands up in order to get them involved in the lesson so that they know they have to work a bit harder. I think that is why the idea in this study will support the students to be involved.

I: how did you find the scoring criteria was it easy to use and can it be applicable to other presentations in science lessons?

R: I think there was a great improvement in the scoring criteria with grades from 1 to 5 which now makes it easier to score the students. I think it is okay to use.

I: teachers can use questioning and feedback to engage students in key stage 3 science. Do you think this is true?

R: yes

I: if students are regularly allowed to develop their own questions and give feedback to themselves in lessons, this will improve their engagement and develop their thinking skills in science

R: agree with this (check score here) I would have strongly agree but there may be some students that may not want to take part regardless. May be because they lack confidence to do so.

I: which one would you consider most effective in supporting your students’ learning is it oral feedback or written feedback?

R: both I think, oral feedback I think on the spot in the classroom, while written feedback when you are marking their books.

I: so the reason why you think oral is good is good is so that they can get feedback on the spot. Do the students read the written feedback?

R: No I don’t think any of them do read the written feedback, probably 5% of the students read the feedback but they are more interested in the grade they are getting

I: how do you think the project has affected the pupils learning given that they have done presentations, questions and feedback over several lessons, what effect have you observed in the students and did it had any impact on them?

R: I think some of them thought they were learning and that is the more intelligent ones in the class. Simply because they took it more seriously. Though this class is a more able group but we have children that are less able and so, find it a bit harder than the others. They are the ones that are not as engaged as much. I found out that the students that were more engaged finished their research earlier and I had to guide them to add more information on their posters

I: I think the extra support you gave them shows you supported differentiation and this is good.

I: do you think the student would like this activity again?

R: yes I think so.

I: Why do you think so?

R: because the students were engaged in the activity and they are the ones that actually did the better presentations. It is not about them sitting down and writing in their books and listen to me talk but they are actually doing the work and engaging themselves.

I: do you think this activity should be incorporated into the science schemes of work say once or twice in a term?

R: yes

I: Which groups ask more high order questions boys or girls?

R: in that group I would say it's the same amount of boys and girls because of the mixed ability of the students

I: which groups are more engaged boys or girls?

R: I will say the girls because the class is more skewed towards having more girls than boys. Although there was one group of boys that were not engaged, I will say the girls are more engaged.

I: what are the attributes of engagement you observed in the lessons?

R: some had prior knowledge others were quite happy to sit and read and find information and tell others what bits of information to add to their posters. Some children had that I am taking charge attitude, leadership. These attitudes kept them on track.

I: what of motivation? How did you see this among the students?

R: yes some are more motivated than others

I: as a teacher what sort of questions would enable your students to learn, for example comparing open and close questions?

R: open questions definitely.

I: so you mean open questions would help your students learn properly. Why open questions?

R: because if you giving them a closed question, it leads them to the answer while if you give them open questions it makes them think more because you are not actually leading them. Sometimes you do need close questions to get them on the track thinking and then you start asking them open questions. That is when you get all sorts of questions coming back at you because they are thinking deeper. What if miss …... these are questions good for their learning anyway?

I: So, what sort of questions do pupils ask during lesson looking at close and open questions again and from the hierarchy on Blooms taxonomy used in this study?

R: some closed questions and some open questions. Those that asked open questions know why they asked such because they are thinking about the topic and just need some clarification. It’s an open question.

I: so would you conclude from this session that questioning and feedback from teachers can improve student’s engagement and attainment in their lessons?

R: yes

I: how would you develop your students’ questioning skills and get them more engaged in science lessons so that the teacher are not just the ones asking questions in lessons all the time?

R: I think if you give them probably a piece of text and ask if they could come up with questions to ask other people from that piece of text to make sure the other people know what they have read.

I; yes thank you, what you said can be linked to this study where students are given problems to solve and leading to question and answer as you suggested.

Appendix 9: Field notes

Field note 1

I observed all students were very engaged with the activities.

They were researching the tasks and coming up with their answers. They assigned roles to every person in their team.

The students were sharing ideas, some agree with each other's views while others did not.

Some students helped others to reframe their questions if they think it's not well presented.

Some students got confused on what to do, I had to explain to them again, and they got on with the work.

I identified three students whom in normal lesson will not take part in activities, but were engaged with the tasks and asking questions, although it took them a while to do this.

Behaviour was good in the classroom; the students were engaged and asking questions and feedback.

Sometimes I had to control the time, especially for those students who want to go on discussing for longer time. This will allow others to contribute.

The students were thinking and contributing to the discussion.

The scoring criteria were a good indicator to monitor students' involvement in the tasks, and they also know that.

The students were quite happy to present their findings to the class, and show what they were doing. I think this will help me to do more of this type of activities in lesson.

Field note 2

I found out that not all the students understood the task, but after explaining it to them again, they became comfortable to continue

This activity helped the students to assess themselves.

Most of them seem to take ownership of their learning

Some students want to dominate the discussion, but I had to control this. I think they were enjoying themselves.

They were adding scientific information to their posters. Some of the information added, we may not have done them in the classroom, if I was to teach them the whole topic in lessons.

Students were asking questions and answering them. Some students were challenging other students' views.

Some students were using the knowledge gained from other areas of their lives to answer questions

One or two students are disengaged but got on with the work when they saw other students busy.

The students were happy to present their work because it took them long time to research them, and they have put in a lot of effort.

They were eager to hear other students' presentations.

I quite like the idea of using the success criteria to score the students during the presentations. This will make them to be accountable for their actions.

Some students finished their tasks and had to add more information, and the few struggling ones took their time.

Some students were more motivated than others and some students like to lead the

activities.

Students asked both closed and open questions.

Appendix 10: An analyses of science test results showing value added scores for the students

Students	Science Target level end of year 8	Test Score Term 4 Levels	Test score Term 5 Levels	Value added score	Term 5 Science target Levels	Student on target Yes/No
1	5b	5c	6b	4	5a	Y
2	5a	5b	5c	X	6c	N
3	5b	6c	6c	X	5a	N
4	5c	5b	6c	2	5b	Y
5	5c	6c	6c	X	5b	N
6	5c	5b	6c	2	5b	Y
7	5b	5a	6b	2	6c	Y
8	5c	4c	5a	5	5a	Y
9	4a	4a	5a	3	5a	Y
10	4b	4a	5c	1	5c	Y
11	5c	4a	6c	4	6c	Y
12	5b	5b	6c	2	6c	Y
13	5c	5a	6c	1	6c	Y
14	5b	5c	6c	3	6c	Y
15	5c	4a	5a	3	5a	Y
16	5b	5c	5a	2	5a	Y
17	5c	5c	5a	2	5a	Y
18	5a	5a	6c	1	6c	Y
19	5b	4a	5c	1	5c	Y
20	5a	5c	5a	2	5c	Y
21	5a	5c	6c	3	6c	Y
22	5b	5b	5a	1	5a	Y
23	5b	5c	5b	1	5b	Y
24	5b	6c	6b	1	6b	Y
25	5c	6c	6b	1	6b	Y
26	5a	5a	6c	1	6c	Y
27	5b	5c	5a	2	5a	Y
28	5c	5a	6b	2	5b	Y
29	5a	6b	7c	2	6c	Y
30	4a	4c	5b	4	5c	Y

Students	Science Target level end of year 8	Test score Term 4 Levels	Test score Term 5 levels	Value added score	Term 5 Science target Levels	Student on target Yes/No
31	6b	6c	6a	2	6a	Y
32	5a	5c	6a	5	6c	Y
33	5b	5c	5a	2	5a	Y
34	5a	5b	6b	3	6c	Y
35	5a	4c	6b	7	6c	Y
36	6b	5b	6a	4	6a	Y
37	6c	6a	7c	1	6b	Y
38	5a	5c	6b	4	6c	Y
39	5a	5b	6c	2	6c	Y
40	5a	3a	5c	4	6c	Y
41	5b	6c	6a	2	5a	Y
42	5a	5b	6c	2	6c	Y
43	5b	5c	5a	2	5a	Y
44	6c	5c	6a	5	6b	Y
45	5a	5a	6c	1	6c	Y
46	5c	3a	5a	6	5b	Y
47	5b	3a	4a	3	5a	Y
48	6c	5c	6b	4	6b	Y
49	5a	5a	5a	X	6c	N
50	5b	5b	6b	3	5a	Y
51	6c	5c	6b	4	6b	Y
52	4a	4c	5b	4	5c	Y

Key to understanding the table

Students' levels were based on the National Curriculum levels for Key Stage 3. This ranges from level 3 to 8. Each of these levels may be further divided into sub-levels, for example, level 4, can have sub-levels as 4a, 4b and 4c. A student on level 4a is considered to have made more progress than 4b, and 4c respectively. A student on level 4b has also made more progress than a student on level 4c.

The value added scores in this study is calculated by comparing the differences between students' levels attained in terms 4 and 5. For example, in this results table, student 1 scored level 5c in term 4 and level 6b in term 5. This means the student made 4 sub-levels of progress, moving from 5c through to 5b, 5a, 6c and 6b.

For ease of understanding the value added scores in this study, I have represented the value added scores using numbers, as shown below:

Valued added scores	**levels of progress**
1	one sub-level
2	two sub-levels
3	three sub-levels
4	approximately one level of progress
5	one level of progress and a sub-level
6	two levels of progress
7	approximately 2 levels of progress
X	no value added

Appendix 11: Scores from students' presentations and questions and feedback

Student	Presentation skills	Understanding Information (using variety of sources)	Scientific contents in work	Developing own questions	Answering questions/ Feedback	Average student score for all five criteria	Average student score developing questions, and answering/ feedback
1	3	3	2	1	2	2	2
2	3	3	2	2	3	3	3
3	3	3	2	3	3	3	3
4	3	3	2	3	3	3	3
5	1	1	1	2	1	1	2
6	1	1	1	1	1	1	1
7	2	1	2	3	3	2	3
8	3	1	3	2	2	2	2
9	1	1	2	1	1	1	1
10	1	1	2	1	1	1	1
11	2	1	3	2	2	2	2
12	2	1	3	2	3	2	3
13	2	3	3	3	3	3	3
14	2	2	2	2	2	2	2
15	2	3	3	1	3	2	2
16	2	3	3	2	3	2	3
17	2	3	3	3	2	3	3
18	2	3	1	3	2	2	3
19	2	3	2	2	3	2	3
20	2	3	1	1	2	2	2
21	3	3	3	3	3	3	3
22	2	2	2	3	3	2	3
23	3	3	3	2	3	3	3
24	3	2	2	2	2	2	2
25	2	2	2	2	2	2	2
26	3	3	3	3	3	3	3

Student	Presentation skills	Understanding Information (using variety of sources)	Scientific contents in work	Developing own questions	Answering questions/ Feedback	Average student score for all five criteria	Average student score developing questions, and answering/ feedback
27	3	2	2	2	3	2	3
28	4	3	3	4	3	3	4
29	2	2	2	3	2	2	3
30	1	1	1	2	1	1	2
31	2	1	2	1	2	2	2
32	3	2	2	3	4	3	4
33	4	3	3	4	4	4	4
34	3	3	3	3	3	3	3
35	3	3	3	3	4	3	4
36	3	2	3	3	3	3	3
37	2	3	2	2	2	2	2
38	2	2	2	2	3	2	3
39	3	2	3	3	2	3	3
40	3	3	3	2	1	2	2
41	3	3	3	3	3	3	3
42	2	2	2	3	3	2	3
43	3	2	3	3	3	3	3
44	3	2	3	2	3	3	3
45	3	1	2	4	4	3	4
46	3	2	2	3	3	3	3
47	3	2	3	4	2	3	3
48	2	1	2	3	2	2	3
49	2	3	2	2	3	2	3
50	1	1	2	1	1	1	1
51	3	2	2	2	3	2	3
52	2	2	2	2	2	2	2

Key to understanding the codes:

1= Excellent

2= Good

3= Satisfactory

4= Need improvement

5= Poor

Appendix 12: Questionnaire analyses

The questionnaire was analysed in two parts; part 1 is the analyses of questionnaires completed by ten teachers and part 2 completed by two teachers.

Part 1: analysis of questionnaires completed by ten teachers

1a: This table shows the analysis of responses from ten teachers based on questions 1 to 16 used in the questionnaires in this study.

Respondents	Gender	Questioning and Feedback impact	Opportunity to develop questions	Part of lesson most questions asked	Wait time	Planning for questions in advance before or during lesson	Unplanned questions arising during lesson	Idea on likely students' answers	Plan for feedback for likely students' answers	Most effective in supporting learning oral/written feedback	How effective is oral feedback in lessons?	How effective is written feedback in lessons?	Which group of students ask the most high order questions?	Students expressing own unique thoughts and belief	Asking relevant questions	Using Bloom's taxonomy
1	2	1	1	4	2	3	1	3	1	1	4	4	2	2	1	1
2	2	1	1	3	1	3	1	3	2	1	5	5	2	2	3i	2
3	2	1	1	3	1	3	1	1	2	1	5	4	2	2	3i	2
4	2	1	1	1	2	3	1	3	3	1	5	5	2	2	3i	1
5	2	1	1	3	2	3	1	3	1	2	5	5	2	2	3i	1
6	2	1	1	2	2	3	1	1	2	1	4	5	2	2	1	2
7	1	1	1	4	2	3	1	2	2	1	3	3	1	2	1	2
8	1	1	1	2	2	3	1	2	1	1	3	4	1	2	3i	2
9	1	1	1	4	2	3	1	1	3	1	4	4	1	2	1	2
10	1	1	1	3	1	3	1	3	2	1	5	5	1	2	2	2

Key to understanding the results table:

The following code numbers were assigned to the data collected in this study

Gender: male = 1, female = 2

Boys = 1, girls = 2

Yes = 1, no = 2, both = 3

Starter = 1, main = 2, plenary = 3, throughout the lesson = 4

Wait time less than 7 seconds = 1

Wait time greater than or equal to 7 seconds = 2

Oral feedback = 1, written feedback = 2

Sometimes = 1, regularly = 2, occasional = 3, they do not ask questions = 4

For question 15 on the questionnaire; Yes= 1, No=2, Sometimes= 3i, they do not = 4

Scoring scale: least effective = 1, most effective = 5

1b: This table shows the analyses of responses from the ten teachers based on questions 17 to 21 used in the questionnaires.

Questions	Responses from questionnaires	Codes generated
17. When is it appropriate to use group discussion during questioning?	Res 1: in most forms of questioning, it is appropriate, allows pupils to learn from each other Res 2: during detailed discussion where students share ideas. To engage students fully in lessons. Res 3: when dealing with questions that need higher applications. Res 4: during the main activity Res 5: when brainstorming Res 6: when someone gives an incorrect answer. Whenever the answer is dependent on how you view something. Res 7: during extension task for able students and main classwork for less able students. Res 8: when a question requires multiple points of views Res 9: in developing thought processes Sharing ideas and homing. Not short answer Res 10: during high level questions and solving problems. Task that requires thinking and sharing views	Open and closed questions Sharing ideas Engagement Feedback Engagement Metacognition Thinking skills
18. What sorts of questions enable your pupils to learn?	Res 1: open questions allowing them to think more broadly, rather than yes/no or specific answer questions e.g. what colour is the sky? Res 2: open questions requiring them to think and respond Res 3: questions that allows them to think and apply all the knowledge to solve problems Res 4: open ended questions Res 5: open ended questions Res 6: ones that draw on what they know but lead them to something they didn't realise or ones that test the knowledge you have given them or ones where they will give you the wrong answers/ won't know the answer before you tell them.	Open questions Open questions Problem solving questions Open questions Open questions Open questions Open questions

	Res 7: questions on why they did what they did Res 8: developing questions Res 9: all but knowledge based recall, unless the learning is done by a student listening to an answer they did not know. Res 10: open questions just to clarify things	Open questions Developing questions Open questions
19. What sorts of questions do pupils ask during lessons?	Res 1: depends on pupils, some ask very insightful questions, others ask questions just to clarify what has been said Res 2: closed questions, what is this?, what is that?. Just only recalling questions Res 3: questions that do not allow them to think, and sometimes questions that do not relate to the topic. Sir what time is it? Res 4: close ended questions Res 5: closed questions Res 6: they ask about things they have experienced, seen or heard and ask why these things happen or ask if they can relate a new concept to something they know. Res 7: questions involving the use of other methods to solve a given problem. Res 8: once related to the topic in general Res 9: closed questions Res 10: close questions just to clarify.	Insightful questions Depends on pupils Clarification question Closed questions Closed questions Closed questions Closed questions Application questions Questions related to solving problems using other methods Closed questions Closed questions
20. What are the strategies you use in your lesson to ensure students ask relevant questions?	Res 1: highlight key topics Res 2: group work to support them. Tasks where they can solve problems Res 3: guide them to do this by giving them challenging work to do and problem solving Res 4: ask students to come up and demonstrate task. Ask them to create their own questions to ask friends Res 5: questions with focal point. Providing problems to solve	Problem solving tasks and challenging work Group work for support Student modelling task Students developing own questions

Questions	Responses from questionnaires	Codes generated
	Res 6: tell them facts that are interesting and relevant that they will want to know more about, and use other stimuli e.g. picture of a guy who died of small pox. What happened to him? Res 7: I ask them what steps they think we should take to solve a given questions or problem. Why should we take those steps? Res 8: lead and edge them on Res 9: listening to student ideas Questioning is usually used to re-shape thinking from within Res 10: give them challenging tasks that will make them to think and engage more	Telling them interesting facts Students aware of steps to solve problems or questions Questioning to help thinking Challenging tasks to make them think and engage
21. What are the strategies you use in your lesson to ensure students respond to questions and give feedback	Res 1: lolly pop sticks to collect pupils ideas Targeting questions to specific pupils Res 2: getting students to express themselves, targeted questioning Res 3: think, pair and share ideas Res 4: hand up methods, lollypop sticks method Students make a choice of who answer next questions Res 5: success criteria given Time frame given Res 6: pick them at random; offer rewards; offer praise; always encourage; never put down wrong answers Res 7: sometimes direct a question to them Sometimes ask about their views on their peers answers Res 8: bounce question, if need lead them on to get answers Res 9: get them to think about it before answering Res 10: encourage them to not only accept all answers as correct but to engage with other people's answers.	Lollypop sticks to collect ideas Targeted questions Students expressing ideas Lollypop sticks Students appointing others to answer Success criteria Encourage and praise, do not put down wrong answers Targeted question Asking for peers views responses Think about question Do not accept all answers as correct, engage with other students' answers

Part 2: analyses of questionnaires completed by two teachers

2a: This table shows the analyses of responses from two teachers based on questions 1 to 16 used in the questionnaires. The questionnaires were completed after lesson observations.

Respondents	Gender	Questioning and Feedback impact	Opportunity to develop questions	Part of lesson most questions asked	Wait time	Planning for questions in advance before or during lesson	Unplanned questions arising during lesson	Idea on likely students' answers	Plan for feedback for likely students' answers	Most effective in supporting learning oral/written feedback	How effective is oral feedback in lessons?	How effective is written feedback in lessons?	Which group of students ask the most high order questions?	Students expressing own unique thoughts and belief	Asking relevant questions	Using Bloom's taxonomy
1	2	1	1	4	2	3	1	3	1	1	4	4	2	2	1	1
2	2	1	1	3	1	3	1	3	2	1	5	5	2	2	3i	2

Key to understanding the results table:

The following code numbers were assigned to the data collected in this study

Gender: male = 1, female = 2

Boys = 1, girls = 2

Yes = 1, no = 2, both = 3

Starter = 1, main = 2, plenary = 3, throughout the lesson = 4

Wait time less than 7 seconds = 1

Wait time greater than or equal to 7 seconds = 2

Oral feedback = 1, written feedback = 2

Sometimes = 1, regularly = 2, occasional = 3, they do not ask questions = 4

For question 15 on the questionnaire; sometimes = 3i

Scoring scale; least effective = 1, most effective = 5

2b: This table shows the analyses of responses from the two teachers based on questions 17 to 21. The questionnaires were completed after their lesson observations.

Questions	Responses from questionnaires	Codes generated
17. When is it appropriate to use group discussion during questioning?	Res 1: I think in most forms of questioning, as it allows pupils to learn from each other Res 2: during detailed discussion where students share ideas. To engage students fully in lessons.	Open and closed Sharing ideas Engagement
18. What sorts of questions enable your pupils to learn?	Res 1: open questions allowing them to think more broadly, rather than yes/no or specific answer questions. Res 2: open questions requiring them to think and respond	Open questions Open questions
19. What sorts of questions do pupils ask during lessons?	Res 1: depends on pupils, some ask very insightful questions, others ask questions just to clarify what has been said Res 2: closed questions, what is this? What is that? Just only recalling questions	Insightful questions Closed questions
20. What are the strategies you use in your lesson to ensure students ask relevant questions?	Res 1: highlight key topics Res 2: group work to support them. Tasks where they can solve problems	Problem solving tasks and challenging work
21. What are the strategies you use in your lesson to ensure students respond to questions and give feedback	Res 1: lolly pop sticks to collect ideas Targeting questions to specific pupils Res 2: getting students to express themselves, targeted questioning	collecting ideas Targeted questions Expressing ideas

Appendix 13: Success criteria used during students' presentations and questions and feedback

Presentation skills	Understanding information (using variety of sources	Scientific contents in work	Developing own questions	Answering questions/relate prior knowledge to information tasks.
1. Presentation confidently delivered by all members of the group, explaining interestingly and in some detail the information contained on each slide/poster. Work clearly that of the group and the group understand well the content. Considerable care has been taken with the presentation. Participation/engagement and attitude to learning by every member is very good	1. Range of information gathered from the internet and other sources, assessed for reliability, all clearly indicated on each poster or seen by teacher. Collaborate with others to share findings and ideas.	1. Identify the lack of balance in the presentation of information. Explain how societies can be affected by particular scientific applications. Applying How Science Works in everyday life	1. Develop more high order questions on Bloom's taxonomy prompts and that involve critical thinking skills. Open ended questions	1. Be able to state better solutions to problems and justify their position with reasons. All group members answered questions confidently Transfer information skills and knowledge to solve problems and make decisions.
2. Presentation was delivered by all members of the group, with each member explaining in some	2. Interpret data in a variety of formats. Draw conclusions	2. Provide evidence to support the scientific argument,	2. Develop some high order questions that are	2. Predict situations, able to develop ideas. Creativity in

detail the content. Work clearly not copy and pasted, and understood by the group. Presentation all within a theme, showing skills with presentation.	that utilise more than one piece of evidence, decide on the most appropriate form to present data or other information	suggest how collaborative approaches to surveys and data collection may improve the evidence collected.	variable on Bloom's taxonomy question prompts.	answering questions and applying knowledge, and can make comparisons
3. Presentation was made by members of the group; some members of the group explained in some detail the content. Some parts of the presentation had a theme, but not all, showing some skill with presentation.	3. Identify patterns in data and information presented. Draw straightforwar d conclusions from data presented or information presented.	3. Use scientific language to communicate scientific ideas, describe some simple positive and negative effects.	3. Develop questions at the middle of Bloom's taxonomy that is, from low to high level questions.	3. Respond to closed questions, define terms, able to classify and state examples
4. Presentation was made by members of the group with inconsistency. More information required to support evidence. Poor presentation skills which needs improvement.	4. Present information in a simple way with limited contents due to the use of limited resources	4. Cannot confidently use scientific language to communicate scientific ideas. Misconceptio n still	4. Develop low level questions that does not involve thinking	4. Sometimes respond to low level questions and lack motivation

		evidenced in students' explanation.		
5. Presentation was dominated by a student in the group because others lack confidence and motivation. Contents of work need more information	5. Lack of variety of sources of information preventing enough scientific contents in work.	5. Lack of confidence in describing scientific process and require constant support to make meaning of his/her idea.	5. Develop low level questions with support from peers and teacher.	5. Sometimes respond to low level question, lack motivation and require reminder to be engaged in the process.

Key to understanding the codes used:

1= Excellent

2= Good

3= Satisfactory

4= Need improvement

5= Poor

Appendix 14: Context data

The classroom temperature was normal 21^0C

The classroom was conducive for learning with science displays and pupils work on the wall to stimulate engagement in learning.

Students have not been subjected to any known lesson observations with other teachers in the week before and during the research.

Teachers involved were not undergoing any forms of lesson observations that may hinder their full participation in this project.

Seating plan was in place to support behaviour for learning. However, students were allowed to choose their working partners.

Class profile of students were studied by me to allow for differentiation in the problem solving activities with reference to the group's strength. However, due to ethical reasons the class profiles of these students cannot be disclosed in this work.

All students were ready to take part and happy to be involved in the project voluntarily. The emotional state of the students cannot be ascertained here.

Number of students on Free School Meal was 16 out of the 52 students involved in the study.

Appendix 16: Representing the themes in this thesis. An overview of studies

Author/ Location	**Date**	**Title**	**Paradigm/ Approach**	**Methodology**	**Aim**	**Sample**	**Findings**	**Critique**
Cowie, B. Curriculum journal, 16: 2, 137-151 New Zealand	2005	Pupil commentary on assessment for learning	Interpretive research Longitudinal study	Interview Observation	Phase 1 Teachers and students' views on formative assessments Phase 2: exploration into the nature of the classroom assessment practices that supported engagement and Learning.	10 teachers 10 classes of students	- Teachers found out about students' learning by talking with and questioning them, by observing them, and by reading and commenting on their work - Teachers providing timely and relevant feedback during informal interactions - Students feel comments such as excellent, very good and well done, grades and ticks or crosses were of limited help in moving their learning	Students preferred teachers' feedback as suggestions in this study. I feel students' feedback to other students would have been considered in this study, to give them autonomy of their learning. Observation is a good from of data collection as it allowed the teachers involved to respond to questions based on the lesson observation. Interview gives good qualitative data but sometimes interviewees may withhold certain information needed for the data analysis. Seeking teachers and students' views on formative assessments is a good idea and will enable the researcher to compare their views, and put suggest interventions to support the students in their own

							forward - Teachers to use language understood by pupils in formative feedback as lack of this leads to poor teacher-student relationship - Students did not like written feedback, and preferred oral feedback which can move their learning forward. - Students commented that a teacher cannot assess each pupil every lesson, and so suggests students must be involved - Help from peers were considered as the best ways teachers could increase pupil opportunities in formative feedback.	assessments.

							- Students do not ask questions for fear of been called ‘dumb’ or ‘stupid’, and may lead to cognitive, affective and social consequences. - Students only ask question when they understood topic, and may be rare.	

Savasci, F. and Berlin, D. Journal of Science Teacher Edu 2012, 23: 65-86 (USA)	2012	Science Teacher Beliefs and Classroom Practice Related to Constructivism in Different School Settings	Mixed method	Questionnaires Lesson observation Survey of classroom learning environment Classroom documents	To gain an in-depth understanding of in-service science teacher beliefs and classroom practice related to constructivism and to identify factors that may influence teacher classroom practice	4 science teachers from different schools	-Teachers embraced constructivism but classroom observation did not confirm this. - Based on a comparison of the five components of; personal relevance, scientific uncertainty, critical voice, shared control, and student negotiation. The most preferred constructivist components were personal relevance and student negotiation and the most perceived component was critical voice. -Shared control was the least	-Seeking teacher's views on constructivism across different schools would give a big picture on teachers' understanding of the term and how it applies to their classroom. - Collecting wide range of data from different sources would support triangulation to ensure validity and reliability of results.

							preferred, least perceived, and least observed constructivist Component. -Teachers have different views on constructivism. - Teachers felt it is hard to make constructivism a reality in their classrooms. Teachers suggested students can learn from each other by sharing ideas.	

Aguiar, O. G., Mortimer, E and Scott, P. Journal of Research in Science Teaching Vol. 47, NO. 2, pp. 174-193 (Brazil)	2010	Learning from and responding to students' questions: The authoritative and dialogic tension.	Qualitative	Lesson observation	Analysis of classroom interactions initiated by students' wonderment questions on the teaching explanatory structure and form of discourse in high school science lessons.	Data from 1 class of 7th grade (age 12-13) students 9th grade students (age 14-15) 1 teacher.	-More time spent on teacher-centred activity than student-centred activity The teachers complain that students do not want challenge, for example, doing the inquiry based constructivist learning, they just want to do only worksheets that do not involve high levels of thinking - Students' questions vary due to content of the lesson - Contents linked to media or current, attracted more questions from students - Limited number of students asks wonderment (high level)	- No direct instructions given to students to ask questions, as this may prevent more students being engaged in the classroom discourse and the quality of questions asked may be affected. Also some groups of students may dominate the discourse. - Assumptions were made on the quality of questions students ask, which was considered to be consistently good, and this may not be true in all situations. - Ignoring the low level questions in analysis of the data meant that interventions may be compromised - Conclusion was based on only data collected from

							questions, and other students participated in the discussion from the questions. - Teacher answer questions in some cases and in other times, direct the questions back to the students. - Students' questions provide feedback from students to the teacher, enabling adjustments to the teaching explanatory structure. Need to consider students' intentions and their active participation in the negotiation of both the content and structure of classroom discourse.	lesson observations and so data cannot support triangulation to ensure reliability and validity of results. Although the researcher reported measures to ensure reliability and validity of their data due to extensive experience in reporting outcome from qualitative data. - Total time devoted to asking questions and feedback was recorded, a good way to gauge students' engagement in the tasks. - too much teachers' intervention Meant that the students were not involved in leading their learning.

Chin, C. International Journal of Science Education, 28:11, 1315-1346 (Singapore)	2006	Classroom Interaction in Science: Teacher questioning and feedback to students' responses	Longitudinal study Qualitative	Lesson observation Audiotaped and videotaped	To develop analytical framework for classroom talk and questioning in science, and find out how teachers use questioning to engage their students. To identify various forms of feedback used by teachers in IRF	2 teachers 2 classes of 40 students each	- Relationship between the interactive and cognitive aspects of the discourse helped to identify patterns embedded in the talk, and the teacher facilitated responses from students. - Teachers gave feedback to students following responses from the teachers' questions. - Teacher's response to correct answer from students, may (a) affirm the answer, reinforce it, and move onto expository talk, or (b) accept the answer and then ask another related question. For incorrect answer, (c) the teacher makes correction (d)	- The discourse is dominated by the teacher, asking questions and probing students and giving feedback. This type of interaction does not extend students' learning. - Observation as means of data collection enables the teachers involved to contribute their views based on what they observed in the classroom and may complement the audio recorded data. - Longitudinal studies a good way to collect data and may show changes in outcome overtime, and reduces 'snapshot' effects.

							evaluate comments or reformulate the question and challenge via another question. Feedback types (a) and (c) did not encourage students' input, (b) and (d) encouraged students' responses and stimulate thoughts processes	
Cowie, B., Jones, A., and Otrel-Cass, K.	2011	Re-engaging students in science: Issues of assessments, funds of knowledge and sites for	Qualitativ e Longitudi nal	Lesson observation	A reflection on the challenges and solutions emerging from within science education in New Zealand	2 year project. 10 teachers Year 7 to 10 classes 3 year project.	- Students' engagement and learning is supported when they are given opportunity to show what they	- Longitudinal studies a good way to collect data and may show changes in outcome overtime, and reduces 'snapshot' effects.

International Journal of Science and Mathematics Education 9:347-366 (New Zealand)		learning			with view to improving students' participation, engagement and achievement in science, particularly through consideration of notions of identity.	12 teachers years 1-8 classes 1 year study; 10 teachers, years 1 to 8 classes 2 year study with 3 teachers of years 1 to 8 classes	know and can do, and share ideas with others. - A focus on assessment for learning directs attention to the value of students being able to access multiple sources of knowledge and feedback as part of their active engagement with ideas and participation in classroom activities. The engagement needs to be structured so that students can develop an understanding of the disciplinary norms of science	- The study is complex and involves a large number of students and classes, which can be argued, may lead to triangulation of data obtained to get valid and reliable results. However, this is a longitudinal study and a follow up from previous study which links up to other studies to compare complex variables. The pitfall is that a huge amount of data can be generated from this study and the researchers may be confused on which sets of data meets their aims.

Miller, D. and Lavin, F. The Curriculum Journal, 18: 1, March 2007, pp 3-25 (UK)	2007	'But now I feel I want to give it a try': formative assessment, self-esteem and a sense of competence	Quantitative Qualitative Mixed method	Interview, Group discussion, Standardized questionnaires	To investigate whether formative assessment strategies incorporated by teachers into their daily routines were associated with change in children's self-perceptions.	I6 teachers and their classes, In 4 LA. Primary six or seven students (aged 10-12 years)	- Improvement in students' self-esteem, self-worth and self-competence. - Teachers found students to be more confident in discussing their views and more positive. -students taking autonomy of their work and taking more control of their learning now. - Students working towards clear goals and success criteria - Boys self-esteem improved more than the girls - Teachers not sure if the formative assessments favoured one group than the other (boys or	- Triangulation of methodology and data collection would ensure reliability and validity of results. However, this can generate a lot of data. The researcher must be careful in selecting those data that meets the aims of the research. - Group discussion backed up with participants' views from interviews and questionnaires would ensure certain groups do not dominate the discourse as common with group discussion/focus groups. - Isolating students' responses from the questionnaires and that of the teachers meant that any forms of bias in data collection may be reduced

							girls). Both the low and high ability students show significant gains in overall self-esteem driven by gains in their self-competence, the middle ability students show increase in self-esteem but did not achieve a significant level.	

Buhagiar, M., A. The Curriculum journal vol. 18, No. 1, March 2007, pp39-56 (Malta)	2007	Classroom assessment within the alternative assessment paradigm: revisiting the territory	Qualitative Alternative assessment paradigm	Class room assessment and recall of literatures	How classroom assessments embody all forms of assessment based on the alternative assessment paradigm.	Review of literatures Between 1991-2004	-The quality of classroom assessment is better when formative assessments are made to favour the students. - Assessment reform has been an issue in many countries of the world but literature shows that assessment has not changed greatly in these countries. - Teachers do not review the assessment questions that they use and do not discuss them critically with peers, so there is little reflection on what is being assessed. - Classroom learning focus on items of recall, that is knowledge which students	-Alternative assessment paradigm encourages formative assessments of students as they are given opportunity to say what they know and can do, and does not limit their potentials. Whereas summative assessment may limit students' potentials in this regard. - A concern has been raised on summarizing students' performances based on summative assessments, and sometimes teachers' formative assessments of students have been ignored.

							easily forget -Learning is best served when classroom assessment is guided by the principles of AfL	

Kasanda, C., Lubben, F., Gaoseb, N., Kandjeo-Marenga, U., Kapenda, H. and Campbell, B. International journal of Science Education vol. 27, No. 15, 16 December 2005, pp. 1805-1823 (Namibia)	2005	The Role of Everyday Contexts in Learner-centred Teaching: The practice in Namibian secondary schools	Qualitative Constructivist	Audio-taped teacher learner interactions, non-participants field notes Lesson observation	To describe teachers' use of everyday contexts infused into their science teaching.	29 junior and senior science classes 12 teachers 6 schools	- Everyday experiences linked to science in the classroom were used more in the junior secondary schools than in the senior secondary school. - Everyday experiences linked to science was higher in the physical sciences than in biology in the junior secondary, whereas it occurred more in the biology lessons in senior secondary. - Limited range of types	- Great idea for teachers and pupils to link everyday experiences to explaining scenarios in the lesson as this can support the view of How Science Works required to enhance students' learning. - The use of prior knowledge would enable the students to share their ideas with others and this can lead to knowledge creation. - A criticism arouse from the findings which encourages teachers to link students questions to

							of everyday contexts is used.	industry or the relevant discipline to further strengthen students' knowledge development. - Questions can be developed by both teachers and students, however, students should be given greater autonomy in developing own questions.
Dhindsa, H., S., Omar, K. and Waldrip, B. International jornal of Science Education, 29: 10, 1261-1280	2007	Upper secondary Bruneian Science students' perceptions of assessment	Mixed method	Interview Lesson observation Questionnaires	The aims of this study were to evaluate reliability and validity of the Students' Perception of Assessment Questionnaire (SPAQ), to	1,028 upper secondary science students from 4 districts 14 science classes	- Students acknowledge assessments taking place in their classrooms but feels they are not informed to the extent about the ways the	-Assessment tasks that required students' application of knowledge was minimal and so, students learning cannot be extended.

(Australia)					evaluate students' perception on assessment, and to evaluate gender-based, grade-based, and ethnicity-based differences in students' perceptions.		assessment tasks will be graded. - Students are given choices in test questions to attempt. - Teachers tell students about assessment tasks but no marking schemes given to students. - Students' input into the assessment data was not visible. - Teachers often think that providing information to students regarding when and what type of	-Students were not given opportunity to lead their learning and the students are aware of this themselves. - Most times students were confused of the assessment criteria to be used on them because no success criteria were used and shared with the students in the lessons observed. - Mixed methods used in this study ensured large amount of data is collected to support triangulation-

							assessment is consultation. - Teachers should think of ways to involve student input in their assessment tasks. -Assessment of students was limited and no room for differentiation of learning tasks. - No gender differences in students' perception of assessment. Statistically significant differences in favour of male students were	validity and reliability of the results. - Opportunities must be created for differentiated learning in the classroom. -A simple study with complex statistical analysis making the findings in some cases difficult to interpret and losing the focus.

							observed but the differences were treated as of low importance. - Students' perception of assessments on the basis of their race was different	

Abrahams, I. International Journal of Science Education (UK)	2009	Does practical work really motivate? A study of the affective value of practical work in secondary school science.	Mixed method	Case study Interviews recorded on tape Lesson observation Field notes	To examine whether practical work can be said to have affective outcomes, and if so in what sense	8 schools Key stages 3 and 4 students 96 students	-Practical work can generate short-term engagement. It is relatively ineffective in generating motivation to study science post compulsion or longer-term personal interest in the subject, although it is often claimed to do so. -Almost all of the students questioned liked practical work but with further probing in many cases the students did not like practical work except some pupils in year 7.	- Observing practical tasks associated with all 3 subjects in science would enable the researchers to compare students' performances and motivation levels in all areas. - Restricting observation to only those tasks not used for assessments meant that the data may be screwed towards making conclusion from one aspect of the students' learning and engagement. - Students' views on other areas of assessment other than practical work could be sought for in this work.

							Interests in practical work starts falling from years 8, 9, 10 and 11 Science practical is based on situational interests, that is, for that particular lesson and may not last or support students' further interests. - Practical work was reported by teachers to help in behaviour management and if no practical, students are discouraged. The researchers found out that the low ability students are used to this behaviour	

							and do not wish to study science as a career. - Sometimes students do not learn anything doing just science practical in lessons.	

Reinsvold, L. A. and Cochran Journal of Science Teacher Education, 2012 23: 745-768 (USA)	2012	Power Dynamics and Questioning in Elementary Science Classrooms	Qualitative	Lesson observation Audio recorded interactions	To use discourse analysis to identify and describe elementary science classroom episodes and interactions where the teacher and students use power and questioning strategies to discuss what they know about science.	Purposeful sampling 21 students Third grade classroom 1 teacher Field notes	- Teacher talk was twice as frequent as students' talk. - Questions were primarily closed-ended and task oriented, and students ask few questions. High frequencies of teacher's question was observed - Teacher exercise power by keeping activities organized and conventional - The interactions resulted in limited student subject matter discourse that seemed dependent on closed-ended questioning. Although the students were talking science but	Only one teacher's lesson was observed to make a report in this study. Although the outcome can be applicable to a similar organization with similar problem, however, I would argue that the data collected would be insufficient to make a conclusion based on the outcome from this study. The data collected was few and cannot be supported by triangulation.

							- Teachers must be supported in creating specific types of open-ended questions and the specific contexts in which the questions might be asked. - Detailed analysis of teacher-student interaction is needed if teachers are expected to meet students' needs and to enhance science understanding for all learners.	

Author/ Location	Date	Title	Paradigm / Approach	Methodology	Aim	Sample	Findings	Critique
Reiss, M., and Ruthven, K. International Journal of Science and Mathematics Education, 2011 9: 239-241 (UK)	2011	Enhancing the participation, engagement and achievement of young people in science and mathematics education: Introduction	Content analysis	Review of other studies Content analysis	A review of students' attitudes to science and mathematics, and how to improve their engagement and attainment	Past studies from different authors	- The authors suggested that further opportunities are required into research on how to enhance the participation, engagement and achievement of students in science and mathematics - Paper reviews to focus on factors that will shape students' current engagement and future participation in science and mathematics. - Students' interests in science may be influenced by their images of scientists. Their engagement in science-related activities outside school and the	- This is a good review on literatures dealing with issues of engagement and participation of students in science and mathematics from the views of different authors. However, I was concerned when reference was only made to Physics, which is just one area of science, may be because of its link to mathematics. -Reference was made about students creating their own identity in science as means to support their learning, a good idea. -The authors made reference to another work from a different author which clearly identified the following as a form of engagement in science lesson;

							attitudes to science of their parents.	Reconceptualising assessment, building on student funds of knowledge and breaching the classroom walls. -This is just a report of other people’s work and did not contain enough information to support the argument put forward.

Blanchard, J. The curriculum Journal Vol. 19, no. 3 Sept 2008, 137-150 (UK)	2008	Learning awareness: constructing formative assessment in the classroom, in the school and across schools	Qualitative Longitudinal studies	Observation Interventions Audio recordings	Strategy aimed at raising standards among students through assessment for learning strategies	University team members, schools, 66 teachers LA advisers, school leaders	-Teachers reassured of their importance in assessment for learning -Implementing AfL in the classroom allows for communication and dialogue between teachers and students. It helps students to develop greater self-awareness, self-confidence and independence, leading to autonomy in students' learning. - In Interactive classrooms; pupils have a sense of their own purpose and progress, work with peers and helping each other, welcomes difficulty and Trial and error, apply their	- A partnership between schools, university and the local authority's (LA) School Improvement Service, meant that a huge and wide variety of data were collected and analysed to inform a robust study and outcome. However, study involving such organisations may be prone to participants withholding crucial evidence required for the data analysis. - A combination of lesson observations, interviews and audio recordings will allow triangulation of data collected. It is also good to seek first-hand information from the teachers involved in the study whose lessons were observed.

							learning to a new context. - Development of AfL led to confidence, independence and peer cooperation, learning about learning and attainment against subjects’ cognitive and skill criteria has been boosted among students. -The quality of students’ performances depends on the extent to which teachers enable their pupils to participate in, and take responsibility for, decisions that inform their activity.	- Longitudinal studies a good way to collect data and may show changes in outcome overtime, and reduces ‘snapshot’ effects.