Insights into Secondary Students’ Attitudes towards School Science in Bangladesh

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Abstract

This PhD sought to understand secondary students’ attitudes towards school science by focusing on students’ voices. Most of the previous studies measured attitudes using Likert-type attitude scales, where the given statements and choices are prepared by researchers and thus the statements mostly reflect their ideologies. Being receptive to student voices, this study therefore conducted five Focus Group Interviews (FGI) with 32 purposively selected secondary students (Grades 9 and 10) of an urban school in Bangladesh to develop an open-ended questionnaire that was used to understand the general pattern of attitudes of all the students of the same school. After distributing the questionnaire among 450 students, 141 questionnaires were returned with responses. A hybrid approach to thematic analysis consisting of a combination of inductive and deductive approaches was followed in analysing the data. Findings revealed that most of the students considered science as an interesting subject whereas most of the students in developed countries reported science to be boring. Students in this study at the same time found science difficult to study, which is consistent with other research in developed countries. Students found science teaching to be conducted in mostly transmissive styles where students remain passive recipients. An overloaded science curriculum was another characteristic of school science of Bangladesh reported by students, which is also a common characteristic of school science worldwide. Students noted that their science textbooks, the de-facto curriculum in Bangladesh, were dominated by large amounts of content that needed to be covered in a very short period of time. The content in science textbooks was also reported as being outdated and presenting science as factual knowledge. Language used in science textbooks was seen as highly sophisticated, thus inappropriate for their age. The current assessment system required students to memorise
the abstract content in science textbooks and recall exactly the same in exam papers. As a result, the assessment practices left little space for developing the higher order skills of Bloom’s Taxonomy, such as application, analysis or synthesis skills. Such an assessment system also limited the scope for hands-on teaching and learning; teachers reportedly relied on promoting student memorisation. Despite having a number of negative experiences, students were still interested in engaging with school science and science related careers in future. The common reasons for choosing science were to facilitate a future career and to satisfy parental and societal demands. Behind this lies a strong cultural belief that studying science is a pathway to respect in the community and better long term employment opportunities. These in-depth insights revealing students’ attitudes could help change students’ classroom experience. Curriculum and pedagogy would benefit from taking account of students’ expressed needs and perceptions rather than relying on a score obtained from scales measuring attitudes. The findings could also help understand the differences in needs in science education in developing country contexts.

Given that most of attitudes studies are quantitative and ask students questions that researchers feel it is important to know about, this PhD contributes to the methodology of attitude studies by showing the application of an innovative method of inquiry and capturing student voices. Data gathering instruments were also developed to best access their voices. Such a methodology would help in providing new directions in studying attitudes. While a few qualitative studies have been done on perceptions about school science in developed countries, this study is a unique contribution for less developed or developing countries. The literature on attitudes related to science and school science is dominated by Western contexts with little exploration of how non-Western students deal with Western science. This study showed qualitatively how students in a non-Western developing country experienced Western school science.
1.1 Introduction

A well-established aim of school science is to promote student enthusiasm for science as a subject, extend interest in scientific issues in future life (Simon, 2000), and develop scientific literacy (Goodrum & Rennie, 2007). However, evidence shows that the experience of school science leaves many students with the feeling that science is difficult and inaccessible (Goodrum & Rennie, 2007; King & Ritchie, 2012; Simon, 2000; Vosniadou, 2012). Alongside the increasing recognition of the importance and economic utility of scientific knowledge, the reality is that there are falling numbers of students choosing to pursue the study of science (Barmby, Kind, & Jones, 2008; Goodrum & Rennie, 2007; Kennedy, Lyons, & Quinn, 2014; Lyons & Quinn, 2015; Office of the Chief Scientist, Australian Government, 2014). This problem is a great concern for many countries and raises questions about what can be done to increase students’ interest in science. Educators and policy-makers are, therefore, increasingly concerned about the quality of science education and how this relates to the interests of young people (Ainley & Ainley, 2011b; Blalock et al., 2008; Edwards, Perkins, Pearce, & Hong, 2015; Office of the Chief Scientist, Australian Government, 2014; Regan & DeWitt, 2015). As a result of this scenario a number of educators have been interested in researching student attitudes towards science (Regan & DeWitt, 2015). Tytler and Osborne (2012) recognised that the study of attitudes towards science, especially towards school science, should be a central focus in improving the teaching and learning of science.
1.2 Background

As a science teacher at school as well as a past science student, I have had a great interest in wanting to understand better students’ attitudes related to science. Based on this interest, my master’s thesis measured Grade 10 (15-16 years) Bangladeshi students’ attitudes towards science, including learning science in school. I used a Likert-type survey adapted from attitude scales found in relevant literature (Barmby et al., 2008; Caleon & Subramaniam, 2008; Germann, 1988) and administered it to 96 students from eight urban schools in Bangladesh. Previous studies had defined attitude as having three components, cognition, affect and behaviour, and those reviewed studies had used a Likert-type survey to measure students’ attitudes towards science. Following a similar definition of attitude, I conducted the survey with urban students in Bangladesh. A major finding of the study was that the students held positive attitudes towards science (Mojumder & Jahanara, 2009), which was inconsistent with the general findings from other such research (e.g., Barmby et al., 2008). Barmby et al. (2008) argued that inconsistency in findings may occur for two reasons: differences in survey instruments and/or differences in the contexts in which the study is being conducted. In completion of the research, I realised that the survey instrument did little to help in understanding why Bangladeshi students held attitudes that were different from those of others. This is important to consider as the study was conducted in the context of a developing country while most of the studies reviewed were conducted in developed countries.

Contextual difference could be the reason for differences in student attitudes and this has been explored in the study of Relevance of Science Education (ROSE) (Sjøberg & Schreiner, 2005; Sjøberg & Schreiner, 2010). In this study, students from developing countries showed more positive attitudes towards science than did students from developed countries. Sjøberg (2002) noted that in developing countries, students had strong positive
images of science and scientists, seeing them useful and important for everyday life and society, and as an important way of improving their living standards. Students viewed the scientist as a very heroic person, brave and intelligent; scientists were viewed as helping people, curing the sick, and improving the living standards of citizens. Sjøberg also suggested that developing countries are to a greater extent concerned about raising the material standards and achieving a general improvement of living conditions, so that students viewed science as a vehicle for social wellbeing and economic development as well as for their own social mobility. As a result, these views of students in developing countries influence their motivation and willingness to engage in science. In contrast, students in developed countries, which depend more on science and technology, did not share these notions of science and scientists. They expressed, in their responses, sceptical and negative attitudes and perceptions towards science and technology. Such findings in terms of contextual differences in student attitudes drove me to re-examine Bangladeshi students’ attitudes towards school science, but this time in more depth to gain a clearer understanding of the impact (or not) of contextual differences on attitude development.

Student attitudes towards science have been measured, in most studies, through the use of Likert-type attitude scales (see, for example, Caleon & Subramaniam, 2008; Francis & Greer, 1999; Morrell & Lederman, 1998; Şentürk & Özdemir, 2014). In most attitude scales, the statements and choices given are prepared by educators or researchers, therefore, these statements reflect their (researchers/educators) ideologies and are based on what they believe to be the possible responses of the participants (Ryan & Aikenhead, 1992). Glen Aikenhead (personal communication, July 9, 2011) argues that standardised psychometric instruments, like a Likert-type scale, are claimed to be competent in measuring or monitoring students’ science attitudes, but in reality they are not (see also, Aikenhead, 1973, 1988; Aikenhead & Ryan, 1992, for a similar argument). On the one hand, the instruments force students to make a choice within the set options given by the
researchers and thus the findings rely on a number of assumptions and often do not reflect students’ real attitudes (Ryan & Aikenhead, 1992). On the other hand, such instruments had reliability and validity issues. Most of the instruments published were used only in a single study and did not provide any psychometric data as evidence (Blalock et al., 2008). In order to overcome the issues, Ryan and Aikenhead (1992) proposed starting with student interviews and developing the questionnaire or survey instruments based on the interview data. This led me to examine the use of more qualitative strategies to explore and better understand students’ attitudes towards school science in Bangladesh.

1.3 Context of the Study

In Bangladesh, secondary education is comprised of three levels: junior secondary (Grades 6 to 8: ages 11 to 14), secondary (Grades 9 & 10: ages 14 to 16), and higher secondary (Grades 11 & 12: ages 16 to 18). Science is compulsory at all grades of secondary school from Grades 6 to 12. Until Grade 8, all students study a general science subject that includes topics from both physical and biological sciences. At the end of Grade 8 students sit a national examination for promotion to the secondary level (Grades 9 & 10). Usually marks on the Grade 8 national examination (Junior School Certificate: JSC) determine what science subjects students can study in Grades 9 and beyond. When promoted to Grade 9, students choose one of three streams for their studies at secondary level: science, humanities or business studies (Figure 1.1). Students participating in the science stream are required to complete two physical science courses: physics and chemistry. They can choose biology as an optional course (Figure 1.1). Students who enter the humanities or business studies streams are required to take one general science course; they cannot take physics or chemistry and have no optional science courses. After completing Grade 10, students sit a national examination referred to as the Secondary School Certificate (SSC) and on passing this examination they can progress to the higher
secondary education level. Students from non-science (humanities and business studies) streams cannot study in the science stream at the higher secondary level and therefore cannot study science courses at this level and beyond, since they have not done any specialist science in Grades 9 and 10. Therefore, at Grade 9 Bangladeshi students make a choice about whether they will study science in future. This study focused on the secondary students in Grades 9 and 10 from both the science and non-science streams to gain an understanding of their attitudes and experiences of school science.

Figure 1.1. Streaming of and subject choices for secondary students in Bangladesh

As research in science education is relatively infrequent in Bangladesh (Tapan, 2010), it is quite challenging to conceive of a research-based scenario for science education in Bangladesh. Recent research has revealed several issues around science education in Bangladesh which will now be discussed in the following sections. It is worth noting that the following scenario of science education in Bangladesh is based on teachers’
perspective and views, which establishes the need for this research on students’ attitudes of school science.

Large class sizes are a common problem in Bangladesh (Rahman, 2011), since they inhibit student-involved science activities from being used in classes. Rahman found that more than 50% of teachers at junior secondary level (Grades 6 to 8) have to teach more than 60 students in a class, and 90% of teachers have more than 40 students in their classes. There is little opportunity for teachers to get professional development or in-service training to demonstrate them how to teach science in such large classes. While the expectation from the curriculum is for science to be taught using a hands-on approach, teachers need in-service training to be shown what this might look like in their classrooms.

Science teaching in Bangladesh is predominantly enacted as transmission of the expert knowledge found in textbooks. According to Tapan (2010), science teachers in Bangladesh are not well-educated and lack professional development suited to their needs in science teaching. Teachers lack both content and pedagogical knowledge. Tapan (2010) reported that science teachers lack motivation and interest in introducing new methods of teaching and are not confident in trying new teaching strategies or using hands-on activities within their science lessons (Maleque, Begum, & Hossain, 2004). As a consequence, science lessons are dominated by teacher-centred approaches where students are encouraged to memorise textbook content without the need to understand the science concepts (Rahman, 2011).

Textbooks are considered the de-facto curriculum in Bangladesh (Siddique, 2007) as all the teaching and learning activities in the classroom come from government sanctioned textbooks. Sarkar (2012) found that even the assessment items were typically chosen from the textbooks and that answers required text taken directly from the textbooks. Sarkar’s analysis of these textbooks revealed that they were dominated by academic
content and theoretical aspects of science, which held little or no relevance to students’ lives. The characteristics of the textbooks referred to a traditional and dated view of the nature of science compared to textbooks in more developed countries. Sarkar also reported that such science textbooks were a barrier to the promotion of scientific literacy among students.

_The overloaded curriculum_ is another characteristic of science education in Bangladesh (Mst Shaila Banu, 2011; Sarkar, 2012). Sarkar’s (2012) teachers reported that the curriculum was overloaded with content which forced them to rush through the content in a limited way with little opportunity for promoting scientific literacy among students. He further reported that an overloaded curriculum limited the scope of the teaching options teachers had time for and there was no time for discussion of science concepts with students. Similarly, Mst Shaila Banu (2011) found that due to the overloaded curriculum, teachers felt pressure to choose teaching methods that covered the most content in the shortest possible time. Thus they felt compelled to revert to transmissive modes of teaching. Mst Sailing Banu further intimated that the overloaded curriculum does not allow science teachers to allocate time to hands-on activities associated with learning science. As a consequence, students rush through the content without time to contemplate what it means or ask questions for clarification.

### 1.4 Significance of the Study

A statistical report from the Bangladesh Bureau of Educational Information and Statistics (BANBEIS, 2011) showed that in 2004, 34% of the total number of students who participated in the SSC examination were from the science stream whereas in 2014 this percentage had declined to 25%. In 1990 this percentage was 43%. Over the past two and half decades Bangladesh has experienced a steady decline in science participation in the secondary years of schooling. Decline in participation in science has also been experienced
worldwide and has not gone unnoticed by science educators. In many studies attitudes have been identified as one of the key factors influencing this decline (DeWitt, Archer, & Osborne, 2014; Kerr & Murphy, 2012; Regan & DeWitt, 2015).

While students’ attitudes towards science are commonly examined, their attitudes related to their experiences of school science are not often investigated (Osborne & Collins, 2001). Osborne, Simon and Collins (2003) noted that attitude instruments are concerned with views of science in society rather than science as a school subject. Blalock et al. (2008), referring to Osborne, Simon and Collins (2003), argued for a separation between school science and science in general when studying attitudes, and suggested that attitudes toward school science would be a better predictor of student behaviour in relation to science and their participation rates than would attitudes toward science in general. After a careful review of the literature, I found no studies in Bangladesh that have investigated students’ attitudes towards school science. My colleague and I (Mojumder & Jahanara, 2009) have instigated the first research steps towards studying Bangladeshi students’ attitudes towards science generally, including some aspects of school science. However, our previous research did not construct an in-depth understanding of student attitudes towards school science or science-in-general because of methodological limitations. Therefore, part of my drive for conducting this research is to investigate secondary students’ attitudes towards school science more deeply. Such an in-depth understanding of students’ attitudes towards school science would suggest to teachers, policy makers, curriculum developers and education researchers in Bangladesh ways to plan and implement school science informed by how students feel about school science and what their needs are. Taking such considerations into account would hopefully help change students’ experience with science at school, and encourage more students to study and participate in science at school as well as participating more in science in their future lives and careers.
Moreover, as research on students’ attitudes towards school science is infrequent in developing countries, this research would help researchers understand the difference between attitudes of students in developed and developing countries and possibly prompt future attitude research in developing countries.

1.5 Research Questions

The main purpose of this research is to obtain “insights into students’ attitudes towards school science”. In defining the construct of attitude, three major components are always considered: cognitive, affective and behavioural. Moreover an evaluation is considered as the central aspect of an attitude (details of the construct of an attitude is presented in Chapter Two). In order to serve the main purpose, this research has been guided by the following research questions:

1. How do Bangladeshi secondary students justify their evaluation of school science that is Western in nature?
2. a) What are the students’ perceptions of the attributes of an ‘ideal’ science teacher? 
   b) How do these teacher attributes support the enjoyment of school science?
3. What reasons do students give about whether to continue to study science?

Together the answers to the three research questions are intended to provide insights into students’ attitudes towards school science. As a country colonised by the British, Bangladesh has always had a Western influence on its Education (Tapan, 2010). The influence of a Western science curriculum on non-Western contexts such as Bangladesh (see, Sarkar, 2012; Tapan, 2010) has been accepted by researchers and is beyond debates in developing countries.

Question 1 first explores students’ evaluation of different components of science as taught in school and Western in nature, while attitude towards school science is defined as
an evaluation of different components of school science (see Chapter Two). These different components of school science may include science teaching, science textbooks, assessment in science and similar areas that students experience while studying science at school. Then the justifications for their evaluation on different components of school science provide the background of their evaluation, their cognitive and affective experiences related to school science.

Question 2 explores students’ evaluation of their science teachers in comparison with their perceptions of an ideal science teacher, since the teacher is one of the most important variables of school science. The science teacher is the only person who presents school science to the children, so that the science teacher’s interaction with the students and how he or she presents science to students has an important impact on how students experience school science and thus how they evaluate it.

Question 3 focuses on students’ motivations for studying science, as students’ experience with school science is anticipated to direct them to pursue (or not) further science courses or careers in science. This research question will provide information on students’ behavioural tendencies regarding engagement with school science based on their evaluation of school science, it will indicate whether or not they want to continue with science and pursue a career in science. This question will also explore the influence of contexts on students’ attitudes towards school science.

1.6 Outline of the Thesis

This thesis consists of six chapters: Introduction, Literature review, Methodology, Data presentation, Discussion, and Conclusion and recommendations. Following the introduction to the thesis by the current chapter (Introduction), Chapter Two (Literature review) introduces the theoretical understandings of attitude and relevant concepts used in this study. This chapter discusses students’ attitudes and perceived experiences regarding
different components of and issues around school science as reported in the relevant
literature. Issues explored include (but not limited to) science teaching, school science
curriculum, assessment in school science, relevance of school science and motivations for
studying science. The literature is reviewed in order to construct a theoretical basis for the
study and to position it within the existing research focused on these issues. Chapter Three
(Methodology) presents the methods used in exploration of insights into students’ attitudes
towards school science along with the underlying methodological issues around each
method of investigation. The philosophical stance, research approach, research design,
phases of collecting data for this research, data collecting instruments, data analysis
procedures and ethical issues of this research are all outlined in this chapter. Chapter Four
(Data presentation) presents the data that was collected from the instruments described in
Chapter Three and the qualitative analysis of data. Since data was collected in two
different phases, the first section of this chapter starts out with the qualitative analysis of
the data obtained in the first phase and the details of the development of an instrument
(open-ended questionnaire) that was used in the second phase of data collection. The
following section illustrates the qualitative data obtained in the second phase of data
collection. Chapter Five (Discussion) offers a critical discussion on the main theme of the
study, students’ attitudes towards school science in Bangladesh. The results presented in
Chapter Four are discussed in this chapter, in light of the research literature presented in
Chapter Two. Chapter Five is divided into several sections, each section discussing an
individual theme or issue, in terms of the literature, as reported by the students. The key
themes around school science reported by the students are: students’ evaluations on the
nature of school science; science teaching at school; science curriculum being overloaded;
science textbooks; content of school science; assessment practices in school science
education; relevance of school science; science teachers’ attributes; and choices of science
courses and science careers. The final chapter (Chapter Six: Conclusion and
recommendations) answers the research questions of the study and provides insights into students’ attitudes towards school science. This chapter also presents recommendations for science education in Bangladesh based on students’ attitudes, concluding with suggestions for further research related to student attitudes and an account of the contributions of the PhD to science education research and practice.
Chapter 2: Literature Review

2.1 Introduction

Since the main purpose of this study is focused on students’ attitudes towards school science, this chapter first examines the conceptual understanding of attitude including all the components of an attitude: cognitive, affective and behavioural. Even after four decades of research (Kerr & Murphy, 2012), it is still difficult to define the term attitude. Nieswandt (2005) suggested that attitude is not a unidimensional term; rather it is multifaceted, thus the definition of the term will depend on the research and the research objectives. This literature review attempts to clarify the concept of attitude as conceived for this research. The theoretical discussion on attitude includes the concept of evaluation as the central aspect of attitude, and the relation of attitude to belief as a relevant concept. The chapter then presents how other research, including that focused on international assessments such as TIMSS and PISA, has viewed student attitudes and comments on their findings related to student attitudes to science and school science.

As this research particularly focuses on school science, the chapter presents what the literature says about the ideal vision of school science. In comparison to this, the actual picture of school science education as reported by research is then reviewed. This comparison is organised into several sub-sections linked to the major components and issues of school science education such as the relevance of school science, school science curriculum, and assessment in school science.

As the second research question looks at students’ perceptions of an ideal science teacher and their evaluation of their existing science teachers, the following section presents a review of the attributes of an ideal science teacher and what students worldwide have reported as their perceptions of their science teachers.
Since the third research question looks at students’ motivation for studying science, which is likely to create the pathway to pursue science careers, the literature is reviewed critically on students’ motivation for studying science, and their perceptions of science courses and careers based on their experience of science at school.

Finally, some common research findings relevant to students’ attitudes and perceptions of school science are presented. These help understand the findings of this research in relation to others’ research findings.

2.2 Attitude

When considering the construct of attitude, it is common to focus on three components: cognitive, affective and behavioural (see Breckler, 1984; Eagly & Chaiken, 1993; Kerr & Murphy, 2012; Raved & Assaraf, 2011). Thoughts or beliefs that people have about an object are commonly regarded as the cognitive component of attitude, while feelings or emotions that people experience in relation to an object are the affective component, and behavioural tendencies towards an object are considered as the behavioural component (Eagly & Chaiken, 1993). However, my understanding of attitude to some extent differs from the common conceptions of attitude. Therefore, in the following sections, I discuss and justify my understandings of these three components of attitude and how my understandings converge with and diverge from the common understandings of the three components of attitudes. Finally, I will present my complete conceptual understanding of attitude.

2.2.1 Cognitive component of attitude. The cognitive component of attitude refers to what one knows in relation to an object (Eagly & Chaiken, 1998). A person’s knowledge, experience, and/or conceptions about an object form the cognitive base of an attitude. This suggests that to form an attitude about an object, we have to have some knowledge or cognitive experience about that object, which then acts as the cognitive base
for our attitude. Some attitude researchers (e.g., Raved & Assaraf, 2011; Shrigley, Koballa, & Simpson, 1988) strongly consider beliefs to be a cognitive component of attitude. Therefore, I will clarify the term ‘beliefs’ and the relationship of beliefs to attitudes.

According to Fishbein and Ajzen (1975), beliefs are the association of an object with various attributes such as characteristics or ideas. Consider the following two examples of beliefs: (1) the sky is blue and (2) the benefits of science are greater than the harmful effects. In the first example, the object ‘sky’ is associated with the attribute or characteristic ‘blue’ and in the second example the object ‘science’ is associated with the attributes of ‘benefits’ and ‘harmful effects’.

In the first example, information about an object is presented. Our senses or experiences confirm the validity of this information and, as a consequence, we can be very certain about the information given (Shrigley et al., 1988). This kind of information is regarded as a belief by some authors and has been labelled as a ‘descriptive’ or ‘factual’ belief (Koballa, 1989; Rokeach, 1970; Shrigley et al., 1988). Descriptive or factual beliefs present the concept of beliefs as an alternative form of knowledge, fact or information (Nisbett & Ross, 1980). This interpretation suggests that beliefs are cognitive in nature (Rosenberg & Hovland, 1960) and do not take into consideration any personal evaluations.

In the second example, a person associates science with some related attributes. This is not only a presentation of information like the first example, but also an evaluation of a particular object such as science and its related attributes. Here, a person evaluates the object and related attributes based on some previous knowledge about science, in this case the benefits of science, and harmful effects of science. First, he/she retrieves knowledge about the objects and their attributes from his/her memory, and then judges or evaluates them as a way of making them part of his/her many beliefs. This is also contestable and not certain like the first example – that is, sky is blue – as the person is likely to have both
positive and negative experiences associated with the objects. So, the belief depends on a person’s prior knowledge, experience, and the evaluation based on the prior knowledge and experience. Considering this approach, Oskamp (1977) introduced the notion of evaluative beliefs. Evaluative beliefs are formed through an evaluation or judgment of an object, event or issue and its related attributes. Prior knowledge, experience or information about the object, event or issue form the cognitive base of evaluative beliefs. Evaluation cannot take place without having some prior knowledge about the object of the belief. It is also acknowledged that people have emotional commitments to beliefs they hold (Nisbett & Ross, 1980). During the evaluative process, they incorporate their emotions with their evaluation of the object. This is seen as the affective component of beliefs.

Considering these two examples and the types of beliefs discussed above, descriptive or factual beliefs can be regarded as an alternative form of knowledge and so, I believe, for the sake of clarity for this research, they will not be regarded as a belief. Beliefs should not only be a representation of information, knowledge or fact. I argue that there needs to be some evaluation of the objects and their attributes as well as an integration of emotion for a belief to be strongly held.

In summary, I reason that beliefs are formed from an evaluation of an object and its attributes, and are based on cognitive and affective components. Our prior knowledge and experiences form the cognitive components of beliefs and the emotional commitment that we have to our beliefs contributes to the affective component of beliefs.

Moreover, as beliefs about an object are formed based on evaluation, and at the centre of attitudes is the evaluation of an object (Ajzen & Fishbein, 2000; Eagly & Chaiken, 1993), it is also important to recognise that sometimes beliefs about a particular object are indistinguishable from attitudes towards the same object (Oskamp & Schultz, 2005). For instance, consider the following statement: “learning science is important for
all”. This belief statement is somewhat indistinguishable from a person’s attitude towards learning science. A person might strongly believe this statement and respond in line with this statement whenever he or she encounters this statement and/or similar statements and/or the ideas/cues related to the object (learning science). From his/her response, his/her attitude could be determined in relation to the object. For example, “I would like to take the science course at school” could be an attitude statement based on the person’s belief that “learning science is important for all”. Here the second statement expresses the person’s belief as well as attitude, but the first statement is somewhat different from the belief statement and articulates the person’s attitude based on his/her belief.

2.2.2 Affective component of attitude.

Affect and evaluation

Early theorists in attitude research used the terms ‘affect’ and ‘evaluation’ interchangeably (see Fishbein & Ajzen, 1975; Rosenberg & Hovland, 1960). That is, affect was defined as an evaluation of an object in early research. However, evaluation and affect are not identical terms (Ajzen, 2001). An evaluation is the judgment of an object, person, concept, event or behaviour along a dimension such as favour or disfavour, good or bad, like or dislike, or anything similar. On the basis of a judgment, a person approves or disapproves of a proposal, likes or dislikes a person, ascribes a label of good or bad to a piece of work. To judge an object, we often have to have knowledge or experiences of that object, which suggests that evaluation could have a cognitive base. On the other hand, affects are feelings or emotions that a person experiences in relation to an object, a person or an event (Oskamp & Schultz, 2005; Schimmack & Crites, 2005). Based on some affective experiences, people may evaluate an object. Therefore, evaluation could also have an affective base. For instance, a person may feel relaxed whenever he or she visits a particular botanical garden. Based on his/her feelings he/she might judge the botanical
garden as a very relaxing place. So, affect could be considered as being a base component of evaluation. This suggests that based on some affects, a positive or negative evaluation can be produced. Therefore, evaluation and affect are two distinct terms, and thus, I believe, are not interchangeable.

**Evaluation and attitude**

Prominent attitude researchers have come to a common agreement that the central aspect of attitudes is evaluation (see Ajzen & Fishbein, 2000; Eagly & Chaiken, 1993; Oskamp & Schultz, 2005). This study also considers evaluation to be at the centre of the construct of attitude. My understanding is that an attitude develops on the basis of an evaluative response; a person does not have an attitude until he or she responds *evaluatively* to an object. Evaluative responses are those that express approval or disapproval, favour or disfavour, liking or disliking, satisfaction or dissatisfaction, approach or avoidance, attraction or aversion, or similar reactions (Eagly & Chaiken, 1993). If such evaluative responses are made by a person towards an object, then it could be considered that the person has formed a particular attitude about that object. Moreover, a mental representation of the attitude toward that object (based on the evaluation) may be stored in memory and can be activated anytime by the presence of that object or cues related to it. Finally, it is my contention that evaluation is at the centre of the construct of attitude and that since evaluation could have an affective base, attitudes, as a result, could also have an affective base.

**2.2.3 Behavioural component of attitude.** The behavioural component of attitude consists of one’s behavioural intentions or tendencies to perform a particular behaviour in relation to an object. Behavioural intentions or tendencies are therefore based on the probability that a person will perform a particular behaviour regarding an object (Fishbein & Ajzen, 1975). However, it is worth noting that the overt behaviour may not necessarily
be consistent with the expressed intentions regarding the same object (Eagly & Chaiken, 1993). For instance, ‘I would like to read science magazines if I could get one’ could be a person’s statement expressing his/her behavioural intentions towards science magazines but this may not provide an exact understanding of his/her behaviour towards science magazines. This combined with similar statements provide an idea of a person’s attitude as the person evaluates the object in a way that provides a predictive notion of their future behaviour regarding the object. Worth noting is that some behavioural intentions or tendencies can also be formed based on a person’s beliefs (Ajzen & Fishbein, 1980), as beliefs are formed based on an evaluation (see Figure 2.1). In relation to the statement above regarding science magazines, a person could have a belief regarding science magazines such as “science magazines are a great source of knowledge”. Based on this belief the person would respond with the above behavioural tendency statement. This suggests that a person would express his/her behavioural tendency based on his/her own beliefs towards that object.

Additionally, behaviour is the explicit action performed by an individual and is very much dependent on the stimulus given. Therefore, in two similar situations a person might perform different behaviours because of the different stimuli presented to him/her. As a result, it cannot be determined with certainty that a person will always behave in the same way towards an object even if it can be determined exactly what his or her intentions are towards that object. At this point, I would like to share an example from my experience. I once had a great interest in an educational research book and I had a strong desire to buy that book. I suggested to my friends that they should read and buy this book. Finally, I went to buy the book from my university bookshop. Up until that point, my attitudes towards that book and buying that book were strongly positive. But when I saw that the price of the book was $242, I changed my mind. I thought that the book was too expensive! I could not buy that book as I did not have that much money. However, I still
have a positive attitude towards buying that book; it is just that I am not able to buy that book yet. What I am suggesting from this example is that attitudes are not always consistent with the behaviour performed. Attitude can be considered as only one predictor of a particular behaviour (Simon, 2000).

In summary, behavioural intentions provide an understanding of the attitudes a person may hold, but are not necessarily always consistent with the behaviour performed related to that particular object.

2.2.4 Understanding attitude. From the earlier discussion, evaluation is seen as the central aspect of attitudes. Evaluation takes place based on some cognitive and affective components (see Figure 2.1). As beliefs about an object are formed based on the evaluations that a person makes, some beliefs can be indistinguishable from the person’s attitudes towards the object. Moreover, some attitudes have behavioural tendencies as a component, where a person might have an intention or tendency to perform a particular behaviour towards an object. Behavioural intention or tendency could also be formed based on a person’s beliefs, which suggests that a person could express his/her behavioural tendency based on his/her own beliefs towards that object. Figure 2.1 shows the relationships between the different components and concepts related to attitude.
2.3 Difference between ‘Attitudes towards Science’ and ‘Scientific Attitudes’

When researchers (Osborne et al., 2003) discuss science attitudes, two different concepts often feature in the discussion; ‘attitudes toward science’ and ‘scientific attitudes’. My understanding of attitudes towards an object (science) has already been presented in the previous section. According to the conceptual understanding, attitudes
towards science are the evaluative judgment of various aspects of science including school science (Kind, Jones, & Barmby, 2007), which could include “interest, satisfaction, and enjoyment” in various aspects of science (Gardner, 1975, p. 2). For example, Kind et al. (2007) proposed that asking about someone’s attitude towards science is, in fact, asking how they judge various aspects of science and involves their interest, satisfaction and enjoyment in science. “Science is fun” or “Science is boring” would be an example statement in the attitudes towards science category (Germann, 1988).

On the other hand, scientific attitudes is “a complex mixture of the longing to know and understand, a questioning approach to all statements, a search for data and their meaning, a demand for verification, a respect for logic, a consideration of premises and a consideration of consequences” (Osborne et al., 2003, p. 1053). The National Curriculum Board of Australia (2009a) suggests that scientific attitudes include “the valuing of evidence, the ability to suspend judgment as a consequence of little evidence, willingness to change opinion in the light of new evidence, adherence to truth and honesty, and healthy scepticism that seeks evidence before making decisions” (p. 2). Later research (Kerr & Murphy, 2012; Tytler, 2014) defined scientific attitudes as the attributes that a scientist should have while working in science, such as curiosity, critical mindedness, respect for evidence, objectivity, open-mindedness, empiricism, determinism, parsimony and so forth (Mayer & Richmond, 1982). For example, someone would not argue about whether it is raining outside – but rather they would check this empirically, by sticking a hand out of the window; this is in principle, a scientific attitude (The Kansas School Naturalist, 1990). “I am willing to change my ideas when evidence shows that the ideas are poor” - would be an example statement of scientific attitudes (Fraser, 1982).

Although attitudes towards science include school science or learning science at school as a component of science, this study particularly focuses on students’ attitudes
towards school science. Moreover, as I was a science teacher at school, my interest is to
know more about the attitudes that students hold towards school science rather than
science out-of-school (other than when related to school science). Understandings of what
school science represents for this study are discussed in the following section.

2.4 School Science

School science basically deals with science as a subject and focuses on the
teaching-learning related activities that occur in, as well as outside of, school. According to
Reiss (2007), school science is not restricted to the science education that literally takes
place within the physical boundaries of schools but to the science education that takes
place during the time when students are usually in school (from about 4 to 7 years of age
upto 15 to 19 years, depending on the education system of the particular country) and
where some sort of official curriculum exists. Reiss (2007) therefore includes some out-of-
school sites that are used as part of school education, such as science museums, science
learning centres, botanic gardens and zoos as well as wherever fieldwork occurs.
Whenever these sites are being used intentionally as part of school education, they become
a part of school science. To be specific, Reiss’s notion of school science is science that is
usually guided by an official curriculum (or formal curriculum) but not limited to the
school boundaries.

Based on the presence or absence of a formal curriculum, Hein (1998)
distinguished the terms ‘formal’ and ‘informal’ in relation to learning. In terms of formal
learning, Hein noted that “schools provide primarily formal education; they teach a
specific, hierarchical curriculum, and they usually have rules about attendance, time spent
in classes, classmates, and requirements for successful completion” (p. 7). Other
researchers (Crane, Nicholson, Chen, & Bitgood, 1994) on the other hand, have identified
that,
informal science learning refers to activities that occur outside the school setting, are not developed primarily for school use, are not developed to be part of an ongoing school curriculum, and are characterized as voluntary as opposed to mandatory participation as part of a credited school experience (p. 3).

Rennie (2007, 2014) suggested that the difference between formal and informal learning usually refers to the differences between the contexts, environments and settings where science learning opportunities arise. They argue that learning itself is an ongoing cumulative process thus it cannot be divided into formal and informal subclasses. As Rennie (2007) suggested, learning in the school context is more compulsory in nature, structured curriculum-led, competitive, assessed and graded, whereas learning outside of school is learner-led and intrinsically motivated, where involvement with learning is of free-choice and the activities are non-evaluative and non-competitive.

Glen Aikenhead (personal communication, July 9, 2011) suggests taking an operational definition of school science for this study. He defines school science as the “instruction found primarily in schools related to an appropriate taught science curriculum”. Further, Aikenhead writes that ‘instruction’ includes all the formal teaching-learning activities in and out of school, which in this instance is similar to Reiss’s (2007) notions of school science. He also mentions ‘primarily’, because some activities can take place at home, but are determined by the school’s science teacher (discussed in earlier paragraphs). He gives flexibility over what constitutes an appropriate science curriculum, which will be the context for the study. He points out that depending on the context, different aspects of the science curriculum – intended, taught or learned (see, Glatthorn, 1987, for the definitions) – could be found and chosen for this study. However, his definition rests on what is actually taught by a science teacher, although there would be an intended curriculum present. Although the previous discussion (in the earlier paragraphs)
has been based mostly on a formal curriculum, I agree with the points raised by Aikenhead and will focus on school science in terms of what is actually taught by a science teacher in formal settings, which may extend beyond the classroom. I have made this choice because in Bangladesh the practice is that the national curriculum is not made, in most cases, available to the teachers and students. The only available curriculum materials are the syllabus (list of content) and textbooks. Science teachers teach science mostly in their own ways with the help of the textbooks in formal settings. Hence the intended formal curriculum is not a concern of this study. The actual teaching and learning activities (the taught curriculum) in formal settings will be considered as school science for this study.

In summary, school science is considered in this study as the actual teaching and learning activities (the taught science curriculum) taking place in the formal learning settings provided by schools (but not limited to the school boundaries) in Bangladesh.

As mentioned earlier, few studies have been carried out in the area of attitudes towards school science; rather, most of the attitude studies have focused on attitudes towards science per se. While studying attitudes towards science most of these studies have included school science or learning science at school as a component of science. The following sections will now review research on students’ attitudes towards and perceptions about science that have included school science or learning science at school as a component of science. Research on students’ attitudes and perceptions of school science per se will also be reviewed.

2.5 What Research Says about Student Attitudes towards School Science

2.5.1 International assessments

2.5.1.1 Trends in International Mathematics and Science Study (TIMSS).

“Trends in International Mathematics and Science Study” (TIMSS) is an international
assessment of student achievement in mathematics and science at the fourth and eighth grades that has been conducted every four years since 1995. In 2011, nationally representative samples of more than 600,000 students in 63 countries and 14 benchmarking entities (regional jurisdictions of countries, such as states) across the world participated in the TIMSS assessment (Martin, Mullis, Foy, & Stanco, 2012). In addition to assessing students’ achievement trends in mathematics and science, TIMSS collects information about students’ backgrounds and attitudes as well as their home, school, and classroom contexts for learning and instruction. Nonetheless, Bangladesh has never been included in this international assessment.

TIMSS focuses mainly on the trends in achievement in science and mathematics, dedicating only limited attention to student attitudes towards their school science. Hypothesising a bidirectional relationship, in which attitudes and achievement mutually influence each other, TIMMS 2011 set out to measure student attitudes towards science using a Likert-type scale. Attitude statements basically asked about students’ liking or disliking of science subjects (for example, “I enjoy learning science”), however TIMMS 2011 did not ask students to evaluate science teaching, curriculum and assessment practices. Additionally, the TIMSS assessment only asked how students value science for their daily life or future career (for example, “I think learning science will help me in my daily life”). This was done using statements asking for specific answers about how students value science in their lives. The TIMSS assessment has not focused on understanding the complex nature of student attitudes nor their multiple experiences about school science, science teaching and assessment practices (see Martin et al., 2012).

TIMSS 2011 included scales about three motivational constructs: intrinsic value (interest), utility value, and ability beliefs. Intrinsic value refers to doing an activity because it is interesting or enjoyable. Therefore, the scale Students Like Learning Science
was developed to measure students’ interest in and liking of learning science. In this intrinsic value scale there were seven statements, whereas TIMSS 2007 included only three statements (Martin et al., 2008). The statements asked students to choose ‘agree a lot’ to ‘disagree a lot’ on a four point scale. The statements were:

1) I enjoy learning science (was included in TIMSS 2007)
2) I wish I did not have to study science
3) I read about science in my spare time
4) Science is boring (was included in TIMSS 2007)
5) I learn many interesting things in science
6) I like science (was included in TIMSS 2007)
7) It is important to do well in science

The TIMSS 2011 assessment (Martin et al., 2012, p. 331) found that on average, more than half (53%) of the fourth grade students internationally liked learning science, whereas only 12% students were found not to like learning science. The remaining fourth grade students (35%, on average) were found somewhat liking learning science. On average, internationally, students who liked learning science had higher average science achievement than those who only somewhat or did not like learning science. Compared with TIMSS 2011, students in TIMSS 2007 reported more positive attitudes towards science. TIMSS 2007 assessment found 77% of fourth grade students indicated a high level of positive attitudes towards science (Martin et al., 2008).

Compared with the fourth grade students, substantially fewer eighth grade students reported positive attitudes towards learning science (integrated into one general science subject) in TIMSS 2011. At the eighth grade, on average about one-third (35%) of the students (65% in 2007) internationally were found to like learning science, and about one-fifth (21%) were found not to like learning science. Similar to the fourth grade students, on average, internationally, eight grade students’ liking of learning science was also found to be positively correlated to their achievement in science.
Across the countries where science is being taught as separate subjects (e.g., biology, earth science, physics and chemistry), the average percentages of students liking individual subjects were found to be lower than the percentage of eighth grade students liking the integrated science in other countries. Percentages of students liking learning biology, earth science, physics and chemistry were 36% (66% in 2007), 33% (58% in 2007), 26% (50% in 2007) and 25% (50% in 2007) respectively. In all four science subjects, the students who liked learning the subject had higher average achievement than those who only somewhat liked or did not like learning the individual science subject.

The TIMSS 2011 assessment found that East Asian students (e.g., Chinese Taipei, Japanese and Korean), who had the highest level of achievement, nevertheless reported a less positive attitude towards learning science. This tendency of most East Asian students reporting a less positive attitude is consistent with previous TIMSS assessments (Martin et al., 2012). Martin et al. (2012) suggested that children in these countries have a cultural tradition of being passionate about learning and because of this they performed well in achievement tests. On the other hand, the students’ less positive attitudes, may partially have resulted from the high level of difficulty of science that they study (Martin et al., 2012).

2.5.1.2 Program for International Student Assessment (PISA). Since 2000, every three years the Organization for Economic Cooperation and Development (OECD) administers an international assessment called the Program for International Student Assessment (PISA), measuring 15-year-olds’ performances in reading literacy, mathematics literacy and science literacy. PISA 2006 was the third PISA assessment with a primary focus on scientific literacy among students. Nearly 400,000 students across 57 countries participated in PISA 2006 (OECD, 2009). Bangladesh was never included in the PISA assessment.
PISA 2006 (OECD, 2009) recognised that one of the goals of science education is for students to develop attitudes that make them likely to attend to scientific issues and subsequently to acquire and apply scientific and technological knowledge for personal, social, and global benefit. Therefore, in order to assess student’s attitudes towards science as a component of scientific literacy, PISA 2006 looked into how a student responds to scientific issues (interest, support for scientific enquiry, responsibility). The survey’s attention to attitudes towards science was based on the belief that a person’s scientific literacy includes certain attitudes, beliefs, motivational orientations, sense of self-efficacy, values and ultimate actions (p. 35). PISA’s assessment of students’ attitudes towards science, however, was not an assessment of students’ attitudes towards school science programs or science teachers.

The framework for PISA 2006 (Bybee, McCrae, & Laurie, 2009; OECD, 2006) acknowledged that the inclusion of attitudes with the specific scientific issues selected were supported by and built upon Klopfer’s (1976) structure for the affective domain in science education. Although the attitudinal component in the PISA framework was named *attitudes towards science*, it draws basically on Klopfer’s structure of measuring *scientific attitudes*. Scientific attitudes have clearly been distinguished from attitudes towards science in the above section on difference between attitudes towards science and scientific attitudes (Section 2.3). Moreover, the PISA 2006 science student attitude data were not considered in the calculation of students’ scientific literacy scores. PISA 2009 and PISA 2012 did not even include the attitudinal component that was used in PISA 2006.

PISA’s evaluation of student attitudes was carried out in three areas: *interest in science, support for scientific enquiry, and responsibility for sustainable development.* *Interest in science* was described as: indicating curiosity in science and science-related issues and endeavours; demonstrating willingness to acquire additional scientific
knowledge and skills using a variety of resources and methods; and showing willingness to seek information and have an ongoing interest in science including consideration of science-related careers (OECD, 2006, p. 37). PISA selected interest in science because it recognised the relationships between interest, achievement, course selection, career choice and lifelong learning.

Support for scientific enquiry was described as seeking to examine whether students: acknowledge the importance of considering different scientific perspectives and arguments; support the use of factual information and rational explanations; and express the need for logical and careful processes in drawing conclusions (OECD, 2006, p. 37).

PISA claimed support for scientific enquiry to be a fundamental objective of science education, and thus saw it as essential to assess this. Appreciation of and support for scientific enquiry implies that students value scientific ways of gathering evidence, thinking creatively, reasoning rationally, responding critically, and communicating conclusions as they confront life situations related to science (OECD, 2006, p. 35).

Responsibility towards resources and environments was aimed to see if students: show a sense of personal responsibility for maintaining a sustainable environment; demonstrate awareness of the environmental consequences of individual actions; and demonstrate willingness to take action to maintain natural resources (OECD, 2006, p. 37).

PISA included responsibility towards resources and environments, due to this area having been the subject of extensive research for the last four and half decades. It was seen very important for students to consider sustainability of the environment including the society, culture and economy.
All these areas were expected to provide a portrait of students’ general appreciation of science, their specific scientific attitudes and values, and their responsibility towards science-related issues that have national and international ramifications (OECD, 2006).

Findings showed that the majority of students reported that they were motivated to learn science, however only a minority reported interest in a career involving science: 72% reported that it was important for them to do well in science; 67% reported that they enjoyed acquiring new knowledge in science; 56% said that science was useful for further studies; but only 37% said they would like to work in a career involving science and 21% said that they would like to spend their life doing advanced science. Moreover, compared with reading and mathematics, students still following science courses tended to attribute less importance to doing well in science.

The majority of students participating in PISA 2006 valued science generally. According to the findings of the survey, there was a strong acceptance by students that science is important for understanding nature and improving living conditions. Most of the participating students (93%) reported that science was important for understanding the natural world, and the advances in science and technology usually improved people’s living conditions (92%). However, only 57% acknowledged that science was very relevant to them personally (OECD, 2007, p. 6).

PISA 2006 (OECD, 2009) collected more detailed information on students’ interest in learning particular science topics: for example learning about genetically modified crops and acid rain. A set of questions was included to measure students’ level of interest in learning and understanding particular aspects of these science topics. Findings showed that students expressed different levels of interest for different topics. In general, more students showed an interest in the topic acid rain, with an average of 62% reporting high or medium interest in knowing which human activities contribute most to acid rain, 59% showing
interest in learning about technologies that minimise the emission of gases that cause acid rain and 49% wanting to understand the methods used to repair buildings damaged by acid rain. In addition, 46 to 47% of students on average reported high or medium interest in learning more on the topic of genetically modified crops.

In general, students with a more advantaged socio-economic background were more likely to show a general interest in science and a tendency to report more often that they enjoyed learning science than did students from more disadvantaged socio-economic background (OECD, 2009). PISA 2006 results also indicated a tendency for students in low-performing (i.e., low science score) countries to show relatively high levels of interest in science, with students in high-performing (i.e., high science score) countries showing relatively lower levels of interest. For example, Finland, the country with the highest mean science achievement score in PISA 2006, was the lowest scoring country on the interest scale (Bybee & McCrae, 2011). Bybee and McCrae (2011) argue that the science achievement scores and interest in science scores may have a relationship with countries’ geographical locations and developmental status. As mentioned earlier, Bangladesh was never included in the PISA assessment, however students from many Asian countries with similar socio-economic backgrounds participated in this assessment and showed different attitudes and degrees of interest concerning science than did those of more advantaged Western socio-economic background. This review on the PISA assessment will therefore provide international comparison to help understand the status of Bangladeshi students’ attitudes towards school science.

**2.5.2 Ideal and actual picture of school science education.** Goodrum, Druhan, and Abbs (2012), in the national study on *the status and quality of Year 11 and 12 science in Australian schools*, reported the ideal picture of science education under nine key themes. The basis for such an ideal picture of science education was a systematic review
and document analysis (e.g., state, national and international reports), science education literature and curriculum documents, work on professional standards, case studies, and focus group meetings. The nine key themes are grouped around the four focus areas of students, teachers, resources and values as listed in Table 2.1.

Table 2.1

*Ideal Picture of Science Education: Focus Areas and Themes (Goodrum et al., 2012, p. 49-50)*

<table>
<thead>
<tr>
<th>Focus areas</th>
<th>Themes</th>
</tr>
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<tbody>
<tr>
<td>Students and their Curriculum</td>
<td>Theme 1: The science curriculum is relevant to the needs, concerns and personal experiences of the students.</td>
</tr>
<tr>
<td></td>
<td>Theme 2: The teaching and learning of science is centred on inquiry. Students investigate, construct and test ideas and explanations about the natural world.</td>
</tr>
<tr>
<td></td>
<td>Theme 3: Assessment serves the purpose of learning and is consistent with and complimentary [sic] to good teaching.</td>
</tr>
<tr>
<td>Teachers and their Profession</td>
<td>Theme 4: The teaching-learning environment is characterised by enjoyment, fulfilment, ownership and engagement in learning and natural respect between teacher and students.</td>
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<tr>
<td></td>
<td>Theme 5: Teachers are professionals who are supported so that they can reflect and build the understanding and competencies required of best practice.</td>
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<td></td>
<td>Theme 6: Teachers of science including Year 11 and 12 have a recognised career path based on sound professional standards endorsed by the profession.</td>
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<tr>
<td>Resources for Teaching and Learning Science</td>
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<td>Theme 7: Excellent facilities, equipment and resources support teaching and learning.</td>
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<th>The Value of Science Education</th>
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<tr>
<td>Theme 8: Sufficient time is available by which teachers can prepare, teach and assess student science learning.</td>
</tr>
<tr>
<td>Theme 9: Science and science education are valued by the community, have high priority in the school curriculum and science teaching is perceived as exciting and valuable, contributing significantly to the development of persons and to the economic and social well-being of the nation.</td>
</tr>
</tbody>
</table>

Goodrum et al.’s research findings suggest that the actual picture of school science education differs significantly from the ideal picture of school science education. The research involved Year 11 and 12 students across Australia and sought to study and understand the actual picture of what was happening in their science classes. The first finding was the decreasing number of students participating in science. Fewer students were studying science, but these fewer reported they enjoyed the science that they experienced. Students studying science had a very positive view about science and its importance for the society that they live in. The science curriculum was found to be constructed for preparing students for university studies, which resulted in an overcrowded and content-dominated curriculum. Science courses were perceived as conceptually difficult with an emphasis on theoretical and abstract ideas. The content-dominated curriculum was found to be taught using the traditional transmission model. Most of the science students (73%) reported that they spent every lesson copying notes from their science teacher. Teacher demonstrations were common where students observed passively, and the practical work was mostly reported as ‘recipe-based’ where students followed instructions to reconfirm the known results. Lyons (2006a) reported similar experiences of
school science in his study of high school students in three different countries: Sweden (Lindahl, 2003), England (Osborne & Collins, 2000), and Australia (Lyons, 2003). Comparison between student narratives from the three interpretive studies (Lindahl, 2003; Lyons, 2003; Osborne & Collins, 2000) revealed several core themes relating to critical contemporary issues in science education. Three major themes around the experiences of school science reported by the students were: transmissive pedagogy, de-contextualised content and the unnecessary difficulty of school science (Lyons, 2006a).

As Lyons (2006a) reported, the first theme related to the transmissive pedagogy of school science, where transmission of content from expert sources—teachers and texts—to relatively passive recipients frequently occurred. This teaching option required students to spend time sitting still, listening, copying the blackboard and filling in the stencils (Lindahl, 2003) and consequently failed to engage students with the science subject, leaving them with disappointing experiences of school science at high school (Lyons, 2006a). Based on participants’ responses the transmissive approach described here appeared to be an inherent characteristic of teaching science. Possibly as a result of this, a number of students in the three studies found they were unable to engage satisfactorily with the ideas of science being introduced. Although some students from these studies (Lindahl, 2003; Lyons, 2003; Osborne & Collins, 2000) acknowledged the value of the transmissive mode, they (the participants) were overwhelmingly critical of its use as the default teaching option (Lyons, 2006a). Frequent use of a transmissive pedagogy left the students in these studies with the impression that “science is a body of knowledge to be memorized” (Lyons, 2006a, p. 595). This style of teaching was not only regarded as unfavourable for understanding scientific concepts, it also made students frustrated even when they found some of the science topics interesting. The frustration associated with the way science was taught contributed to some students’ perceptions of it as a difficult subject (Lyons, 2006a).
Transmissive pedagogy was also reported by the students of Raved and Assaraf’s (2011) study. Their student participants in Israel reported that their science teaching methods were monotonous and lacked variety. According to the students, the dominant teaching method was the traditional lecture-based mode, where teachers would stand at the centre of the classroom to deliver a structured unit of science. Students also commented that the teachers only talked, with no demonstration of science experiments. As a result, students were encouraged to participate as inactive listeners who did not enjoy the lessons, which made them disinterested and bored. One of the students commented: “In school, the teacher lectures and it’s boring, we fall asleep in class from boredom” (p. 1231).

Another theme reported by Lyons (2006a) was de-contextualised content. Science content was reported as irrelevant and boring by the students in the three studies. Lindahl (2003) reported that students found science irrelevant and boring because of the way it was presented in school. She found students reporting that in school it was never made clear why they needed to learn particular content in science. The issue of the relevance of school science will be discussed in greater detail in Section 2.5.3 Relevance of school science.

Additionally, Osborne and Collins (2000, 2001) found some commonly reported characteristics of school science:

- Science was considered an important subject of study and to have a legitimate place in the curriculum. Science was seen as a prestigious subject and valued for the understanding it offered of the natural world.

- School science was being valued for career aspirations rather than as a subject of intrinsic interest.
Lack of perceived relevance to students’ lives has frequently been reported. Students found it hard to make the connections between school science and their everyday lives.

Many aspects of school science have been perceived as ‘hard’ or ‘difficult to understand’, which in turn made them uninteresting.

The curriculum was content dominated.

The curriculum was rushed.

There was too much repetition of content that students had previously encountered.

Students required too much ‘copying’ during science lessons; were given less opportunities for discussion; and the teaching was fragmented leaving them without any overview of the subject.

The actual picture of school science varies from the ideal picture of school science education in terms of a number of aspects. As per Lyons’s aforementioned second theme, science content was reported as de-contextualised, where students found little or no relevance of school science to their personal and social lives. School science reported as irrelevant to students’ lives was a common finding across studies (e.g., Goodrum et al., 2012; Lyons, 2006a; Osborne & Collins, 2000). Now the following section discusses this common issue of school science together with what it means to researchers and to students.

2.5.3 Relevance of school science for students.

Science [as a subject] is in the curriculum because it is relevant and, it should always be added, relevant to people. Relevance is the very reason for its existence, and it should be the very backbone of science teaching (Newton, 1988, p. 7).
Relevance has been reported as one of the most influential factors that affects the quality of science education. Researchers (Lyons, 2006a; Osborne & Collins, 2001; Osborne et al., 2003) have found that students are insufficiently interested and motivated in learning science subjects. A major reason often mentioned by students is that science as taught in schools is ‘irrelevant’ both for themselves and for the world in which they live (Dillon, 2009; Lyons, 2006b; Stuckey, Hofstein, Mamlok-Naaman, & Eilks, 2013; Tytler & Osborne, 2012).

What exactly is meant by ‘making science learning relevant’ has been a question asked by some researchers such as Newton (1988), and Stuckey et al. (2013). According to Newton (1988), “the notion of relevance in science education seems fraught with inconsistency, obscurity and ambiguity” (p. 7). Sometimes it is seen as a criterion for selecting topics or approaches in science courses which have value for students. At the same time, it is seen as a process of looking for ways to prepare students effectively to apply what is learnt in school to life outside of school. It is also seen as a way to build relationships between students’ existing ideas in science and the learning experiences provided (Newton, 1988). Newton argued that relevance should include applicability, where applicability was used to denote both the practical and the cognitive utility of science.

In recent years, Stuckey et al. (2013) noted that a generally accepted definition of what is meant by ‘relevance’ is still lacking in science education at both the research and curriculum development levels. Their research found that the term relevance has been used as a synonym for terms such as ‘interest’, ‘importance’, ‘enjoyment’, etc. Therefore, Stuckey and his colleagues (2013) grouped the meanings of the term relevance and its connection to other psychological terms in science education literature into five categories. Differences between the categories are not always distinctive; very often they overlap:
1) Relevance used as a synonym for student interest;
2) Relevance used as students’ perception of meaningfulness for understanding contexts connected to their lives;
3) Relevance used as connected to student needs, which has been used as a synonym for importance or usefulness of science education;
4) Relevance viewed as real-life effects for individuals and society, for example, growing prosperity and sustainable development by the application of science and technology to societal, economic, environmental, and political issues;
5) Relevance viewed as multi-dimensional and applied as a combination of selected elements from categories 1-4.

So, it seems that the meaning of ‘relevance’ in science education is broader than the meaning of other terms like ‘interest’ or ‘meaningfulness’. Drawing on a range of studies and their uses of the word relevance, Stuckey et al. (2013) proposed a model for the term. According to their model, science learning becomes relevant whenever learning has positive consequences for students’ lives. Such positive consequences can include meeting students’ personal interests or the educational demands of which students are aware. Positive consequences may also include the anticipation of future needs, but students are not necessarily aware of these. Their model of relevance in science education suggested three dimensions of relevance: individual, societal and vocational, all of these existing on a time spectrum from present to future value and from intrinsic to extrinsic points of view. The intrinsic dimensions included student’s interests and motives while the extrinsic dimension covered ethically-justified expectations of students’ personal environment and the society in which they operate and live. For example, the individual dimension included ‘good marks in school’ as an extrinsic element while ‘satisfying curiosity and interest’ was considered an intrinsic element (Figure 2.2). Similarly, ‘behaving as a responsible citizen’ was considered an extrinsic element of the societal dimension of the model, while
‘contributing to society’s economic growth’ was regarded as the extrinsic element of the vocational dimension of the relevance of science education (Figure 2.2).

Figure 2.2. Model of three dimensions of relevance in science education (Stuckey et al., 2013, p. 19)

According to Stuckey et al. (2013), relevant science education must contribute to students’ intellectual skill development, promote learner competency for current and future societal participation, and address learners’ vocational awareness and understanding of career opportunities. Individual dimensions of relevance satisfy curiosity and interests of individual students for the present time, develop useful skills for coping with everyday lives today and in the future, and contribute to the development of intellectual skills. The social dimension focuses on the preparation of students for self-determination and a responsibly-led life in society by understanding the interdependence and interaction of science and society, and developing skills for social participation and competencies for contributing to society’s sustainable development (Stuckey et al., 2013, p. 18). Finally, as
stated by the model, the vocational/professional dimension offers students an orientation for future professions and careers, preparation for further academic or vocational training, and opens up formal career opportunities.

This model presents a research and curriculum development perspective which needs to consider all the dimensions of students’ lives. However, from students’ points of view, the definition of relevance could be different. Jenkins and Nelson (2005) argued that relevance of science curriculum or teaching has mostly been defined with reference to adults’ or educators’ views rather than considering how students view the relevance to them of science curriculum or teaching. Therefore, they suggested including students’ views of relevance while defining the term. Newton (1988) had much earlier considered the psychological development of young children and suggested that younger children tend to be more egocentric and narrow in their view of what constitutes a social group than older children. Therefore, younger children tend to consider relevance to the individual, to family and friends rather than to society at large.

The Relevance of Science Education [ROSE] (Schreiner & Sjøberg, 2004), a widely cited research study on the relevance of science education, recognised the problems associated with defining the term relevance as well the importance of doing so. In the ROSE report, Schreiner and Sjøberg (2004) stated:

The word relevance is chosen in the project title of ROSE. The obvious follow-up questions are then: Relevant for whom? Relevant for what? Relevant for students who are aiming for S&T studies and careers? Relevant for student careers in general? Relevant for promoting economical growth? Relevant for qualified citizenship? Relevant for high TIMSS/PISA test scores? Relevant for more enjoyable science lessons and everyday life in schools? Relevant for sustainable
development? Relevant for handling everyday tasks? Relevant for creating concerned, empowered and autonomous individuals? (p. 20)

In order to clarify the term for their research, the authors considered relevance from “the angle of the learners - what the young people themselves express as their concerns” (p. 20). Their aim was to achieve a better understanding of a series of aspects that are related to young people’s relationship with and emotions towards science and technology: their interest, perceptions, experiences, attitudes, plans and priorities.

In a similar way, this study focuses on students’ points of view about the relevance of their school science: their perspectives, attitudes and experiences related to the relationship between their school science and aspects of their lives and society.

Context has been recognised as the most important element of a science curriculum that strives to be relevant for students. According to Goodrum et al. (2012), science curriculum has to be relevant to the needs, concerns and personal experiences of the students. The point is however that the needs, concerns and personal experience are not universal. They vary from culture to culture; context to context. The needs of students in developing countries vary from the needs of students in developed countries.

National Curriculum Board of Australia (2009a) suggested that a balanced and engaging approach to teaching science will typically involve context, exploration, explanation and application. Wherever appropriate, students should be actively involved in the science concepts being taught. To help students become actively involved with the concept, a context or point of relevance is required, by which students can make sense of the ideas being learnt. The context may vary between students, schools or locations. Having set the scene, the teacher would provide opportunities for science activities where students can explore the ideas, using language with which they are familiar. Science
teachers would use this exploration and experience as a foundation on which to introduce the science concepts and scientific terms in a way that has meaning for students. Together with these explanations and science language, the teacher can then provide activities through which students can apply the science concepts to new situations (National Curriculum Board, 2009a, p. 11).

Corrigan (2006) has argued that science educators should provide a bridge between science and science education in order to make science learning relevant. She further explained that science should help us make sense of what is around us. In order to make science lessons relevant she suggested a number of principles that need to be considered:

- The context matters and it needs to be meaningful;
- Purposeful learning and the applications and use of knowledge in different ways matters;
- Purposeful teaching matters;
- Doing science matters; and,
- Science is making sense of what’s around you, using your knowledge, skills and abilities to create meaning (p. 51).

In her previous research (Corrigan, 1999), she indicated that when technology and industrial tasks were introduced into chemistry curricula in Victoria, Australia with the purpose of introducing contexts that were relevant and meaningful to students and of bringing the world of chemistry into the real world of learner, the success of the curricula was limited for a number of reasons:

- For chemistry teachers the contexts in which they were teaching chemistry content were neither familiar nor meaningful. Curriculum shift to technology-dominated contexts meant that these contexts were unfamiliar to them.
• In terms of industrial tasks that were introduced into chemistry curricula, chemistry teachers did not see industry as necessarily bringing chemistry into the real world of the students; rather chemistry teachers did see industry as offering chemistry students opportunities to experience particular characteristics of the industry itself, and by extension, some experience of the life of industry work.

As a result of teachers’ lack of familiarity with how a scientist actually works, teachers and students saw industry visits as a glimpse into the way industry works, but failed to make the connections between chemistry knowledge and the use of this in industry (Corrigan, 2006). Corrigan (2006) further argued that it can be problematic to introduce contexts that are meaningful. For a context to have meaning implies that there is a shared understanding of the context among those involved. If the contexts used to create meaning are not familiar, as the chemical industry was unfamiliar for many chemistry teachers, then teachers will develop their own limited understanding of such contexts, often acting as filters, and deliver the curriculum that is within their experiences to help create meaning for their students. For students, the curriculum they receive will depend on this filtering process. If the intentions of the curriculum are well articulated, understood and within the experiences of teachers, then relatively little filtering is expected to occur (Corrigan, 1999). The curriculum received by students then will represent the intended curriculum.

Similarly, Holbrook (2008) noted that relevance is about the usefulness of the learning and about engaging students in meaningful learning. His previous research on the relevance of chemistry teaching suggested that usually the more personal the set scenario (context) for science activities is, the more the student will be able to identify with the situation and hence find science content more relevant (Holbrook, 2005). He further
suggested three aspects of chemistry teaching that can help one better understand the issue of relevance of chemistry teaching. These aspects are also relevant to other sciences:

- What are we trying to do?
- How to guide teachers?
- What could be relevant teaching materials?

In addition, the relevance of chemistry (or other sciences) needs to embrace:

a) a subject relevant education philosophy;
b) a relevant curriculum;
c) relevant teaching approaches to the teaching of the science subject;
d) relevant assessment and evaluation strategies;
e) relevant professional development for teachers (p. 2).

Holbrook further explained that two important skills need to be developed in students in teaching for relevance: (a) scientific problem-solving and (b) socio-scientific decision-making. The first is practised by involving students in investigatory activities in which the ultimate goal is to enable to identify the scientific question, plan the investigation, predict the likely outcomes, identify and control variables, undertake the observations or recording of measurements, decide on a variety of strategies/technologies for observation and measurement, determine how to record the data, interpret the findings, and present them along with the conclusions of the investigation in a suitable format (p. 9).

The second important skill is being able to make a justifiable decision based on the scientific conceptual learning gained through the teaching material and on other social factors relevant to the decision. The decision is not static. The actual decision could change with time, location, new knowledge and the attitude of the persons making the decision (Holbrook, 2005, p. 9).
Williams, Stanisstreet, Spall, Boyes, and Dickson (2003) recommended strategies for making the teaching of physics more relevant for students. Their research found that students were less interested in physics than biology. Therefore, Williams et al. (2003) recommended making physics less daunting to school students while retaining its essential nature. To make physics more relevant, they suggested exemplifying less popular content with more popular events existing in real life. For example, force and energy could be presented using space and spacecraft since space was found to be a popular topic among students. Williams et al. also recommended that science teachers place more emphasis on interdisciplinary links, for example in biology lessons, raising circumstances in which physics is relevant to popular areas of biology.

Williams et al. (2003) noted that students tend to choose for further study those subjects in which they anticipate they will be able to perform well. Their research explored why secondary students were less interested in studying physics compared to biology. Their survey with 317 Year 10 students in the UK revealed that the main reasons given by students for finding physics uninteresting were that physics was a difficult and irrelevant subject. Students reported physics content as boring and lacking relevance. On the other hand, students mentioned several curriculum areas of biology that they found interesting due to their relevance to their own lives, namely, the human body, the facts of life and personal health issues such as smoking and drinking. Students also reported a clear link between finding a subject boring and perceiving it as difficult. Their perception of physics as being difficult resulted in the development of a generally negative attitude to physics.

Students in addition reported that practical exercises in physics and biology were interesting, but they lamented the dearth of practical activity. Due to an overloaded curriculum and the uses of examination results to measure teachers’ success, teachers had to avoid practical work since it is time consuming and expensive. Williams et al. (2003)
therefore argued that the cutbacks in practical work not only reduced opportunities for experiential learning, but also influenced the overall popularity of science subjects.

While Corrigan (2006) contended that doing science matters, Osborne and Collins (2001) had previously argued that the transmissive style teaching instead of doing science is to some extent a response to an overloaded curriculum within which students have no time for reflection on their learning. Therefore, addressing and developing skills such as scientific problem-solving and socio-scientific decision-making within the school science curriculum to make science curriculum and teaching more relevant for students would not be an easy task. They reasoned that an overloaded science curriculum would always hinder such practices. The next section therefore discusses the issue of the school science curriculum being overloaded.

2.5.4 School science curriculum. Danaia, Fitzgerald, and McKinnon (2013) noted that science teachers have to cover the science curriculum within a specified timeframe to ensure that students are prepared for the norm-referenced tests. As a result the way science is taught at school and the content covered often reflects traditional approaches such as an over-emphasis on teaching content and few opportunities for scientific inquiry or developing understanding of the applications of science. They also noted that though this picture of school science was noticed by researchers about 30 years ago it still prevails.

Danaia et al.’s (2013) research on Australian secondary students’ perceptions of school science indicate that students frequently copied notes and had few opportunities to investigate topics of their interest. This finding was consistent with an Australian national study (Goodrum et al., 2012) with Year 11 and 12 students. As previously reported, Goodrum et al. found that science at Years 11 and 12 in Australian schools is still taught in a traditional way where students are involved in copying notes from their science teachers and completing recipe-based practical work to reconfirm the known results. Osborne and
Collins (2001) argued that such ‘copying’ offers students “little control over their own learning, and ultimately leads to boredom, disenchantment and alienation” (p. 451).

Osborne and Collins (2001) contended that the traditional transmissive style of teaching is the least effective teaching style in helping students gain knowledge and understanding of science subject. They reported that due to the overloaded curriculum British students “were being frog-marched across the scientific landscape, from one feature to another, with no time to stand and stare, or absorb what it was that they had just learnt” (p. 450). Students’ responses suggested that “a broad syllabus covering physics, chemistry, biology, earth sciences and basic astronomy, coupled with the exigencies of limited time, left little space for reflection” (p. 450).

Sarkar’s (2012) research in Bangladesh have confirmed similar findings in the Bangladeshi context where science teachers reported that they were forced to rush through the content of the overloaded science curriculum in a limited time and had little time for reflection on their teaching (just as students in the UK had little time for reflection on their learning). Such overloaded science curriculum also restricted them from engaging in a stimulating discussion with students and monitoring students’ learning. In the context of Bangladesh, Mst Shaila Banu’s (2011) research similarly revealed that the secondary physics textbook, the de-facto curriculum, is overloaded, with 25 chapters of theories and concepts of physics while only one chapter was dedicated to practical experiments. Such an overloaded curriculum has left little or no scope for science teachers to include hands-on activities in their science lessons.

Ranade (2008) reported that curriculum developers in India responded with adding more topics of science to the curriculum and pushing subject matters that are intended for higher level students down to lower levels as a result of the explosive growth of the information in science. She further commented that in Indian schools science is being
taught as a collection of disjointed facts as the curriculum focuses on stuffing students with must-learn science topics wherever possible. Her research found that the overloaded curriculum was seen as a burden for students and resulted in the incomprehension of science among students. One of the root causes she mentioned was that students and teachers were unable to see any difference between “understanding” and grabbing “information” (p. 102).

In the Korean context, Kim (2005) reported that the overloaded curriculum was responsible for a decline in students’ interest in science. Hong, Shim, and Chang (1998) observed that the overloaded science curriculum caused science teachers not to focus on students’ psychological and social needs. As a result, teachers reverted to a transmissive style teaching, focused on delivering the content only.

Koul and Fisher (2002) related the overloaded curriculum to the strict examination regime in India. They reported that the classrooms in India are teacher centred, where the students appear to have a very passive role. The examination-driven nature of the science curriculum has forced teachers to finish the prescribed course content in a limited time-frame. The time allocated for science was further cut by the socio-political issues in the country which made teachers push the students hard to finish the course content and prepare for the examinations. Considering the strict examination regime, Koul and Fisher found that a transmissive teaching style was deemed most suited for the teachers in India.

Examination-driven curriculum seems to be an issue pertinent to school science education worldwide, affecting teaching and learning processes. The next section discusses the assessment in science education.

2.5.5 Assessments in school science. Corrigan, Buntting, Jones, and Gunstone (2013) recognised that assessment is closely linked with classroom teaching and learning
of science. It is a fundamental issue in the development and implementation of science curriculum. The National Curriculum Board of Australia (2009a, p. 12) suggested that assessment should serve the purpose of learning. Assessment should encourage longer-term understanding and enable the provision of detailed diagnostic information to support student learning. It should show what students know, understand, can demonstrate and where they need to focus to improve. A variety of assessment approaches are required in order to assess the important aspects of science learning such as scientific skills and attitudes as part of science capabilities.

Pellegrino (2012, p. 839) suggested that one form of assessment does not serve all purposes of learning; it is inevitable that multiple assessment approaches be required to serve the varying educational assessment needs of different students. His research suggested that in the current assessment system of the United States, external large-scale assessments still dominate over classroom assessments. He reported evidence that assessments measuring school performance and accountability negatively impacted classroom instruction and assessment. Such evidence suggests that coordinated systems of assessment are needed that collectively support a common set of learning goals.

Black and Atkin (2014) advocated formative assessment since formative assessment is much neglected and they posited how formative assessment can guide the pedagogy of science. They argued that the negative effects of assessment and testing are not inevitable if the role of assessment in pedagogy can be redefined and formative assessment emphasised. Cowie (2012) suggested that formative assessment is based on the principle that students become more than consumers of the assessment activity. Its enactment can re-purpose the roles and responsibilities of teachers and students through renegotiation. Cowie (2012) advocated formative assessment or assessment for learning as a means of “increasing student learning motivation, achievement and agency, which are all
important qualities if students are to become active participants in knowledge-rich
democratic societies in which science plays an important role” (p. 687).

With an emphasis on students’ entitlement to assess their own learning, Fensham
and Rennie (2013) suggested six principles of assessment:

- Students are individually entitled to assessment of their learning, both formative
  assessment that contributes to the learning process and summative assessment for a
  significant period of teaching.
- Assessment in science education should involve knowledge of science and
  knowledge about science.
- Each key aim in the curriculum should be assessed, and be assessed as authentically
  as possible.
- A variety of modes of assessment will be necessary to achieve this authentic
  assessment.
- A profile of achievement of these aims will result for each student. Such a profile
  will provide much more information than a single score, enabling appropriate
  advice for further education or for employment.
- The classroom teacher will be the person most likely to be able to make some of
  these assessments in an authentic way, but many teachers will need support to do
  so. (p. 70-71)

Although recent reforms of assessment suggest there should be more of students’
authority in their own learning of science and support the inclusion of more of formative
assessment approaches, the reality is that science education (as well as other education) is
still dominated by external, summative and high stakes assessment and testing. Cowie
(2012) noted that science teachers still cannot use assessment to promote student learning.
One of the principal reasons she claimed was the national and international testing regimes.
Teachers face challenges in both supporting students in their learning and demonstrating their performance for school accountability purposes. These challenges for teachers “play out in the tensions between formative and summative assessment” (p. 682). Cowie further explained that the intention of formative assessment is to enhance student learning (assessment for learning) while the purpose of summative assessment is to sum up and make a judgement about student learning (assessment of learning). This distinction explains why summative assessment continues, not formative assessment.

Cowie (2012) asserted that “curriculum, pedagogy, assessment, learning and what counts as achievement are inextricably linked and mutually influential” (p. 687). Teachers’ pedagogy is to a certain extent being determined by the examination system, as students’ examination scores are the indicator of teacher performance and school achievement (Osborne & Collins, 2001). Osborne and Collins argued that if the examination system emphasises low-level skills and the recall of factual information, teachers must respond with a transmissive pedagogy, which traditionally has been perceived to maximise student achievement in such limited assessments. They concluded that a negative outcome on many students’ enjoyment of science is an unintended consequence of the assessment system defined in the national curricula and teachers’ pragmatic response to the assessment demands (Osborne & Collins, 2001).

Whilst developing countries have attempted to develop and implement learner-centred curricula over the past two decades, they have not concentrated enough on the necessary adjustment of their assessment regimes (Coll & Taylor, 2012). Coll and Taylor (2012) argued that assessment in developing countries is still dominated by high-stakes, external, summative examinations. These examinations largely focus on lower-level cognitive skills, such as recall, which encourages rote memorisation of scientific facts, and thus are inconsistent with learner-centred education.
Sarkar and Corrigan (2012) confirmed similar assessment practices in Bangladesh; indeed, the teacher participants in their research often lamented the fact that they were obliged to prepare their students for high stakes, external examinations that assess students’ capabilities of rote memorisation of scientific facts and information. This obligation resulted in an emphasis being placed on memorising scientific facts and information from the science textbooks. As students’ performances in examinations were used as a determinant of the quality of their teaching, teachers could not overlook the power of these high stakes examinations. Sarkar and Corrigan (2012) concluded that such an examination-driven education system reduced teachers’ autonomy in the assessment of their own students.

Ranade (2008) reported that the education system in India is still driven largely by high stakes external examinations which are set as milestones for certain qualifications and certification, rather than for developing any scientific skills. The primary causes were reported as economic; entry into higher education requires high scores at earlier levels, and higher degrees with higher scores are the pre-requisite for good jobs. As Ranade observed, science is studied solely for the purpose of succeeding in the examinations, so that any material outside the scope of examination is considered irrelevant and ignored by both teachers and students.

By no means is such a picture of assessment practices unique to developing countries. There is evidence in developed countries, as previously mentioned in the USA for example. In the UK Osborne (2005, p. 216) observed that if practical scientific skills do not form part of assessment procedures, science teachers immediately conclude that they are not important. Osborne further argued that a failure to assess practical scientific skills is most likely because it is expensive and the measurement procedures are sometimes lacking.
After an extensive review of the research evidence based on the US education, Madaus and Clarke (2001, p. 86) concluded that: (1) High-stakes, high-standards tests do not have a markedly positive effect on teaching and learning in the classroom; (2) High-stakes tests do not motivate the unmotivated; (3) Contrary to popular belief, "authentic" forms of high-stakes assessments are not a more equitable way to assess the progress of students who differ by race, culture, native language, or gender; and (4) High stakes testing programs have been shown to increase high school dropout rates, particularly among minority student populations.

Madaus and Clarke (2001) further explained that when teachers teach students to prepare for the tests, the teachers pay more attention to the form of the tests and the content that would be helpful for passing the tests. When this occurs, the form of the questions in the tests can narrow the focus of instruction, study, and learning to the detriment of scientific skill development (Madaus & Clarke, 2001). As a result, Coll and Taylor (2012) urged for the introduction of continuous formative assessment. If the assessment system is not reformed with a focus on continuous formative assessment, there would be little prospect of a change in pedagogy, as teachers would continue to employ the transmissive teaching strategies that have always proved successful under the examination regime (p. 774).

Until this point, several common issues around school science have been reviewed. The following section reviews literature on students’ perceptions of their science teachers, since science teachers and their teaching is also a significant element of school science and plays a very important role in developing students’ attitudes, enjoyment and behaviour related to present and future science studies.
2.6 Students’ Perceptions of Science Teachers

Teachers represent a powerful force in society. They are invested with authority to guide the learner’s journey towards knowledge and habits of thinking which determine future identities. (Burke & Grosvenor, 2015, p. 78)

Raved and Assaraf (2011) argued that science teachers and their conduct in science classes is a significant factor in developing students’ attitudes and their behaviour towards studying science. Since the second research question is about students’ perceptions of attributes of science teachers now this section will review the literature related to students’ perceptions of science teachers and how teacher attributes can influence student learning and enjoyment of school science.

Petegem, Aelterman, Keer, and Rosseel (2008) found that teachers who were tolerant but disciplinarian, enthusiastic, created a stimulating environment, used a variety of teaching methods (mostly task oriented), and took students’ physical and emotional needs into account appeared to have a positive influence on students’ self-reported wellbeing. On the other hand, teachers who were more in a leading role, less tolerant and less helpful were reported as not being helpful for student wellbeing. Such teachers were characterised as authoritarian and they were reported as adopting extreme discipline measures and creating fear among students. Their classrooms appeared to be more achievement and competition dominated. Student initiatives were frequently discouraged and individual assignments received little feedback from authoritarian teachers. In sum, such teachers’ interpersonal behaviour in classes was found to negatively influence student wellbeing (Petegem et al., 2008).

Brok, Levy, Brekelmans, and Wubbels (2005) suggested that a high amount of teacher proximity and cooperation through helpful, friendly and understanding behaviours, and a limited amount of dissatisfied and correcting behaviours are important for
strengthening students’ subject-specific motivations. Students in their study reported the
greater impact of teacher proximity on their subject-specific motivation over other factors
such as teacher influence or dominance. The study found a positive and strong effect of
teacher proximity on motivational areas such as pleasure, relevance, confidence and effort.

Meighan and her colleagues (Meighan, Siraj-Blatchford, with contributions by,
Barton, & Walker, 1997), referring to Blishen (1969), reported what students believed
about the ideal teacher. According to their research, typical responses from students of all
ages about an ideal teacher were similar:

They should be understanding, the children say, and patient; should encourage and
praise wherever possible; should listen to their pupils and give their pupils a chance
to speak; should be willing to have points made against them, be humble, kind,
capable of informality and simply pleasant; should share more activities with their
children than they commonly do, and should not expect all children to be always
docile. They should have conscience about the captive nature of their audience;
should attempt to establish links with parents; should be punctual for lessons,
enthusiastic within reason; should not desert a school lightly; should recognise the
importance to a child of being allowed to take the initiative in school work; and,
above all, should be warm and personal. (p. 20)

Everyone remembers a good teacher (Burke & Grosvenor, 2015). Burke and
Grosvenor’s research reported that negative experiences of teacher-student relations are
Korean students’ perceptions of teachers’ interpersonal behaviour reported that students
did not receive adequate support, cooperation and involvement from their science teachers
in the teacher learning process. The interpersonal behaviour of science teachers was found
to be directive, and involved less leadership, helping, friendly and understanding
behaviours. Therefore, H.-B. Kim et al. (2000) suggested that students should receive more teacher support, cooperation and involvement in the teaching-learning process than what they customarily receive. Their research also recommended teachers be more helpful, friendly and understanding in order to cater for students’ interests and improve students’ attitudes towards science classes.

Based on interviews with 10th-grade biology students (n=61), Raved and Assaraf (2011) articulated the attributes of a good teacher. Students were asked what they viewed as important qualities in a science teacher. Their answers were grouped into two major areas, professional and emotional attributes (see Figure 2.3). Raved and Assaraf viewed professional and emotional attributes as two inseparable parts of a whole. Emotional attributes referred to interpersonal relations between the teacher and students. Emotional attributes included all attributes of teacher–student relations (see Figure 2.3) reported by students: personal contact and consideration of students’ needs, equal treatment of students, mutual teacher–student respect, using humour in the class, empowering students’ self-efficacy and encouraging excellence, inciting students’ interest in the subject matter, and teacher’s enthusiasm for the subject (p. 1229). Raved and Assaraf (2011) found that emotional attributes were central to the students’ descriptions. Professional attributes referred to those attributes that show the teacher’s level of teaching expertise, context-wise and pedagogically. As reported by students, a good pedagogue’s attributes concerning scientific learning included—fitting language and learning levels to the students, control in class (discipline), and attention to students’ difficulties while learning (p. 1230). The following Figure 2.3 provides the attributes of a science teacher pointed out by the students of the study.
Findings from Raved and Assaraf’s (2011) study reported that 83% of the students referred to the teacher’s emotional attributes as those of a good teacher. While 57% referred to professional attributes, most students referred to both the emotional and professional attributes. In this study, generally students seek emotional connection to their science teacher, with 62% students referring to personal contact and consideration of students’ needs as a good attribute of a science teacher. On the other hand, of the three professional attributes (fitting the language and learning level to the students, control in class (discipline), and attention to students’ difficulties while learning), the first one was the most important in student interviews, mentioned by 33% of the participant students.
Raved and Assaraf (2011) concluded that students described the ideal science teacher as one who can combine professional and emotional attributes. “A ‘good teacher’, the students claim, is a professional teacher, pedagogically and in terms of content, highly emotionally intelligent, who allows a connection with the students, and has a personal touch” (p. 1230). Of the two types of attributes, students placed greater emphasis on the emotional attributes; their answers indicated that a personal touch is the main attribute they seek. Nonetheless, a combination of both the attributes can influence student attitudes towards study in a science subject and their behaviour concerning future science studies and science related careers.

The third research question deals with students’ motivations for studying science and perceptions of science related careers. Therefore, the following section reviews literature related to students’ motivation for studying science courses and perceptions of science related careers.

2.7 Students’ Motivation for Studying Science and Perceptions of Science Careers

Regan and DeWitt (2015), based on their extensive review on attitudes, interest and factors involving students’ Science Technology Engineering and Mathematics (STEM) enrolment behaviour, highlighted attitudes towards science as a key factor influencing STEM enrolments and subject choices. Their research has highlighted a number of factors impacting STEM choice and enrolment behaviour such as interest. These factors include:

- future relevance or future work career;
- social pressure from parents, relatives and peer groups;
- appreciation and achievement in science;
- self-confidence, difficulty and clarity;
- teaching and learning at school;
• teacher; and
• media, and other informal sources.

Not all the factors equally influence student enrolment behaviour and subject choices. The factors are inter-related, it is also not easy to separate the effect of a single variable from others (Regan & DeWitt, 2015).

Schoon, Ross, and Martin (2007) conducted a longitudinal study involving over 17,000 men and women during the transition from school to work in order to understand the factors and processes facilitating entry into science related occupations. In order to address and assess the role of family, individual and school influences on the uptake of Science, Engineering, Technology (SET) and health related careers, they adopted a contextual-developmental model of career development which predicts the relationships between experiences during childhood and adolescence, and career related outcomes in future life. The model (see Figure 2.4) assumes that adult occupational attainment can be predicted by family social background, school experiences, individual assets, and earlier career choice. The model accounts for socialisation experiences in the family and the school environment, as well as for the influence of individual aptitudes and motivation.

Figure 2.4. Contextual-developmental model of career development (Schoon et al., 2007, p. 131)
The findings of the study (Schoon et al., 2007) confirmed that participants’ aspirations to a career in science had formed early in life. This applied more to women than the men in the study. Family background appeared to indirectly influence entry into science related occupations; its effect is mediated through personal resources, especially mathematics performance, self-rated mathematics ability, and individual aspirations. Encouragement by parents and teachers was found to influence the development of self-concepts and orientations for the future of young people. After controlling for social background and personal assets (academic attainment in Mathematics and English; self-rated mathematics ability; and educational plans), teacher assessments of students’ mathematics ability as well as the number of science related subjects entered into for examination were found to be important elements in encouraging young people to pursue a career in sciences. This finding implies that teachers can play a vital role in students’ science attainment by recognising and encouraging science and mathematics related aptitudes, and by the provision of science courses at school.

The study by Schoon et al. (2007) noted the role of contextual factors in determining career choice and development. Findings indicated that career choices in science did not depend just on individualised choices. The aspirations were socially embedded and associated with gender, social background, the wider socio-historical context and social change. Students’ subject choices and participations in SET related careers involved both the home and school environments, and interactions with the teacher.

Regan and DeWitt (2015) highlighted the influence parents and teachers have on student choices, particularly during the earlier years of schooling. Perceived support from both parents and teachers was identified as the strongest predictor of continuing with a subject. Regan and DeWitt’s (2015) review of research reported that the early years of secondary education are crucial in terms of the impact of the teacher on a student’s views.
about science choices and a career in science. Students who reported negative interaction with teachers were less likely to choose science. Their research also reported that the quality of science teaching is one of the key determinants of student engagement in science subject.

Hipkins, Roberts, Bolstad, and Ferral (2006) studied the factors impacting students’ decision making with regard to their ongoing study of science, both in the final year of secondary school and on transition to tertiary level studies. Focus group conversations and a survey carried out with Year 13 science students in New Zealand revealed that students’ choices of science study was related to a mixture of their personal interests, experience and decision-making orientations, their family background, their learning experiences – both curricular and extracurricular, and the school they attended.

When students were asked, during focus group conversations, why they chose science at Year 13, their responses revealed several reasons for taking science courses at this level: (1) students had a specific science-related career interest, mainly in traditional science careers such as veterinary surgeon, engineer or doctor. These students had been interested in specific science related careers for a long time. For these students, family backgrounds and home worlds appeared to play an influential role; (2) Students had a strong personal interest in science; this was associated with wanting to understand how the world works. Many of these students found in themselves the potential for science study, they discovered an interest or talent in science while they were at high school; (3) Taking science for strategic reasons; this category of students chose science to keep their options open, thinking that taking science would ease the entrance into university courses. These students were not sure whether they were going to choose science for their tertiary studies, however, they thought that if they studied science at secondary level they would meet the
eligibilities for entry to more subjects at the university level and would be able to move to any science or non-science course in their tertiary studies.

Students’ explanations during focus group sessions revealed the important influence of families in encouraging the choice of science, discussing possible science career pathways, and acting as role models for such careers. Many students became interested in science even before they entered high school because they were encouraged by the family to pursue science study and science related careers. Students’ comments suggested that their families were equally as influential as their teachers in encouraging their choice to continue with science. Students who indicated their intention to continue science at tertiary level reported a positive view about science, came from homes where science study was encouraged, and viewed science careers as worthwhile to pursue. In support of such findings, a boy commented, “Mum has been keen on me doing science since I was born. She always gave me lots of science books etc.” (p. 46). Some students in addition reported that their parents or family members had gone to university or worked in the field of science.

Hipkins et al.’s (2006) study reported on a survey of over 496 students, which found that 44% of students were influenced by their teachers or parents in their decisions to study secondary science. For these students, their teachers or parents had encouraged them to take science. These students also took two or more science subjects at Year 13. Findings of the survey data suggested that students appeared to value science more for career directions than for its relevance to everyday life; 68 percent agreed that science was a worthwhile career to pursue, while 58 percent felt that science was important to know about in their daily lives (p. 38).

Quinn and Lyons (2011), argued that students’ attitudes regarding potential science careers are often formed in early high school. They play an important role in the perceived
instrumental value of science subjects for senior high school. As a result, students considering a science career for future life are more likely to choose science subjects as a useful step towards their long-term career goals. Regan and DeWitt (2015) highlighted research confirming that student’s early choice of science was influenced by their interest in the science subject and by their future career plans. Strong relations were found between an interest in learning science, the personal value of science, and the enjoyment of science. Regan and DeWitt also noted that student interest in science often forms at an early age and is an influencing factor in science choice and enrolment behaviour.

Ainley and Ainley (2011a) examined PISA 2006 data to understand students’ interest in science and their present and future participation. Their findings suggested that students who had enjoyed learning science and were aware that science had personal value for them had strong intentions for further participation in science. Such intentions eventually influenced students’ actual behaviour. In support of these findings, Regan and DeWitt (2015) reported that students were more likely to choose a subject that they believed to be useful for a job or career or a requirement for a university or tertiary course, or a subject they found interesting. When students perceive science education as personally useful and when they enjoy learning science and do well in science, a strong motivation and interest in learning science will result. Based on their research findings, Ainley and Ainley (2011a) suggested that science curricula that recognise and focus on the importance of students’ enjoyment and personal value of science are likely to increase students’ participation in the science activities, and in consequence contribute to student participation in further science study, careers and/or involvement in science projects.

Perera, Bomhoff, and Lee (2014) suggested that parents’ positive attitudes related to science and science careers influence their children’s involvement in science studies. Parents’ direct or indirect participation in science activities such as doing science
experiments at home, visiting museum and science exhibitions, supervising science homework and/or buying science books can positively influence children’s attitudes towards science and guide their aspirations in science. DeWitt et al. (2013) found an association between student aspirations with parental attitudes towards science in the UK. Their findings suggested that students who reported having parents with more positive attitudes towards science tended to have higher educational and occupational science aspirations. Their sophisticated statistical analysis (use of multilevel modelling analyses) confirmed that parental attitudes to science had the strongest relationships with student aspirations in science.

Lyons (2006b) study similarly reported that parents’ attitudes towards formal education were strongly associated with students’ decisions about selecting physical science courses. His survey of over 196 high achieving Year 10 (15-16 years) students in Australia revealed that their parents, and in particular their mothers, have the greatest capacity to influence their enrolment decisions in science courses. The analysis of interviews with a small cohort of these participants (14) choosing physical science courses identified three aspects of family associated with their decisions: parents’ attitudes towards formal education, attitudes and responses to science, and the quality of students’ relationships with key family members. Most of the students interviewed described their parents as valuing the strategic importance of formal education for university or career pathways. Such perceptions of parents were more often based on implicit cues, such as their attitudes, behaviours or personal histories. A substantial number of students interviewed referred to a parent’s regret for lost career opportunities including lack of useful qualifications, interruptions to their education or careers because of family reasons, lost opportunities due to immigration or refugee status, and dissatisfaction with employment prospects. Hipkins et al. (2006) found Maori and Pacific Island young people discussing (during focus group discussions) the importance of the role of their family.
They spoke of the importance of success that would make their family proud. Those students viewed being successful as a fair return to the parents for the sacrifices they (parents) made in enabling them (children) to receive a good education.

Koul and Fisher (2002) noted that the society in Indian culture values science education and science related careers very highly. They report that the social fabric of the society was such that only high achieving students who got the highest or nearly highest scores in the examinations were accepted by their peers and respected by their society. Therefore, students always had to produce high results in all their examinations. High grades were mandatory for entry to the university of choice. The entrance to the university of choice was very competitive as the population is much higher than the number of quality universities. In a similar way, Ranade (2008) reported that education in India is still driven largely by the desire of children and their parents to obtain a qualification (or certification) rather than by valuing intrinsic learning or development of thinking and reasoning skills. The primary causes were reported as economic: entry into higher education requires high scores at earlier levels; higher degrees with high scores are also the pre-requisite to well paid jobs. Science is studied by students solely for the purpose of succeeding in examinations.

2.8 Findings of Some Research Relevant to Students’ Attitudes and Perceptions of School Science

Osborne et al. (2003), after an extensive review, noted that there is an apparent discrepancy between students’ attitudes towards science (in particular out-of-school science) and their attitudes towards school science. They commented on some extensive surveys conducted in the UK (e.g., the survey carried out in 1994 by the Institute of Electrical Engineers, London, UK), which found that most students aged 14-16 years considered science as useful for getting jobs, but considered school science a difficult
subject. An earlier similar study in Australia, the Second International Science Study (Rosier & Banks, 1990), supports these findings, showing that students aged 14 perceived school science as difficult, unenjoyable and uninteresting. The reasons for the perceived difficulty of science reported by students were the facts of science to be learnt and the calculations in science to be done, rather than the handling of science apparatus. In contrast, the students had a positive view about the role of science in society.

Barmby et al. (2008) found that students’ (aged 11 to 14 years) attitudes towards school science were expressed in their common characterisation of it as boring, not well explained and not relevant to their everyday life. Similar patterns of attitudes were found in some other studies in Australia (Goodrum, Hackling, & Rennie, 2001; Lyons, 2006a) and Canada (Ebenezer & Zoller, 1993). Moreover, it was found that there was a steady decline in students’ attitudes towards school science as they progressed through secondary school (Barmby et al., 2008). Similar trends in attitudes were also noted by Osborne et al. (2003) and in the USA based studies by Morrell and Lederman (1998) in which the researchers reported that as students progressed through their secondary schooling, they experienced more deeply that the teaching content and materials were irrelevant to their needs, and teaching methods were used in ways where they (the students) remained inactive. As a result, students’ willingness to participate in science in the future were negatively influenced (Barmby et al., 2008; Caleon & Subramaniam, 2008).

Sjøberg (2002) found more positive attitudes towards science (mainly out-of-school science) in students of developing countries over those in developed countries and noted a few remarkable variables for the pattern of students’ attitudes, namely culture and the developmental status of a country. In developing countries, students had strong positive images of science and scientists, which were thought to be useful and important for everyday life and society, and an important way of developing their living standards. They
viewed the scientist as a very heroic person, brave and intelligent; scientists were seen as helping other people, curing the sick, improving the living standards of citizens. As a result, these thoughts of students in developing countries – real or imagined – have certainly influenced the motivation and willingness to engage in science. In contrast, students in developed countries, which depend highly on science and technology, did not share these views about science and scientists (Sjøberg, 2002). In their responses, they expressed sceptical and negative attitudes and perceptions towards science and technology.

In line with Sjøberg (2002), Mojumder and Jahanara (2009) found (after conducting a smaller survey in an urban area of Bangladesh) that students’ attitudes towards school science were moderately positive. It was a small survey with 96 participants and the results were not consistent with the findings of other studies, which suggest that more extensive research related to attitudes towards school science in Bangladesh is required. Therefore, this study follows their (Mojumder & Jahanara, 2009) recommendation for further research exploring students’ attitudes towards school science in Bangladesh. Since there is a lack of research regarding Bangladeshi students’ attitudes towards school science, the findings of relevant studies undertaken in other countries, including developing and developed nations, have therefore helped form a literature base for this study.

2.9 Summary

This chapter has reviewed literature on attitude and its relevant concepts. Based on the review the chapter establishes evaluation as the central aspect of an attitude. Students’ evaluations and perceptions of different components of school science have been reviewed. The critical review will help investigate the first research question which focuses on how students evaluate school science and justify their evaluation by providing reasons and
explanations underpinning their evaluations (Research Question 1: How do Bangladeshi secondary students justify their evaluation of school science that is Western in nature?).

The chapter has also reviewed literature with regard to students’ perceptions of those attributes that make up an ideal science teacher. Findings of the reviewed research examining students’ experience and evaluation of science teachers relate to the second research question exploring students’ perceptions of an ideal science teacher and how an ideal science teacher could support students’ enjoyment of school science (Research Question 2: a) What are the students’ perceptions of the attributes of an ‘ideal’ science teacher? b) How do these teacher attributes support the enjoyment of school science?). Theoretical models for understanding students’ perceptions of a good teacher have also been reviewed in order to develop the theoretical base for investigating the second research question.

Finally the chapter has critically reviewed literature on students’ motivations for studying science, and their perceptions of science courses and careers. Various research studies in this review have identified several factors influencing students’ decision about taking science courses and choosing science careers. Theoretical models for understanding students’ motivations for science courses and careers have been reviewed in order to develop the theoretical background for investigating the third research question. The review illustrates that one factor in particular does not influence students’ motivations and decisions; rather, multiple factors simultaneously impact on students’ decisions. The factors are inter-connected and the weight of a single factor cannot be measured easily. This review of relevant literature will help investigate the third research question of the study (Research Question 3: What reasons do students give about whether to continue to study science?).
Chapter 3 describes and justifies the research methodology used to investigate the aforementioned research questions.
Chapter 3: Methodology

3.1 Introduction

The previous chapter revealed that evaluation is the central aspect of an attitude. Literature related to students’ evaluations, perceptions and attitudes towards different components of school science was reviewed in order to develop the theoretical base for all the three research questions:

1) How do Bangladeshi secondary students justify their evaluation of school science that is Western in nature?

2) a) What are the students’ perceptions of the attributes of an ‘ideal’ science teacher?
   b) How do these teacher attributes support the enjoyment of school science?

3) What reasons do students give about whether to continue to study science?

This chapter describes the methodology that was used to explore the research questions. As part of the description of the methodology, this chapter provides an account of the relevant philosophical stance, research approach, research design, data collection instruments, data analysis procedures and pertinent ethical issues.

3.2 Philosophical World View

According to O'Toole and Beckett (2010), the worldview that underlies the theories and methodologies used in any research is known as a philosophical paradigm. An individual’s world-view can be considered to be the set of beliefs with which they guide their research (Creswell, 2007). All research is subject to and guided by this worldview, which is essentially our basic philosophy and point of view. This research is guided by a ‘constructivist’ paradigm with the next section describing how this philosophy impacts on the research.
As a teacher I have experienced that students learn things in their own unique ways. They construct their understandings of any subject matter based on their own experiences of this, which is basically the core idea of constructivist philosophy. This philosophy recognises that humans construct their own understandings of reality and scaffold their learning based on their experiences as they go along in their lives (O'Toole & Beckett, 2010). Accordingly, this research focuses on capturing the voices of a group of secondary students as a way of exploring their understandings of their experiences regarding school science. Given the constructivist paradigm underpinning this research, the focus was on capturing as much as possible the participants’ views of the situation under study as a way of gaining insights into their attitudes towards school science in the form of evaluation of school science experiences.

3.3 Research Approach

This research is qualitative in nature. Quantitative studies using Likert-type scales to gather data can force students to choose their responses regarding their attitudes and have been found to be problematic in measuring student attitudes (Ryan & Aikenhead, 1992). Since this research sought to understand students’ attitudes towards school science through being receptive to their voices, qualitative approaches better serve this purpose (Osborne & Collins, 2001). Maxwell (1996) suggested that qualitative approaches are particularly suited to studies that intend to understand participants’ perspectives of the events, situations and actions that they are involved with and to gather the explanations that they provide for their lived experiences. Moreover, Miles and Huberman (1994) assert that qualitative data are usually collected over a sustained period of time, which could provide vivid and powerful descriptions of students’ experiences regarding school science.

Johnson and Christensen (2008) have noted that qualitative research does have some inevitable weaknesses. For example, the knowledge produced through this kind of
research might not be generalisable to other people or other settings, the data collection process takes more time compared to quantitative research, and the data analysis can also be time consuming (Johnson & Christensen, 2008). However, according to Miles and Huberman (1994), this time consuming nature can be a strength of a qualitative research as it provides a clearer understanding of the phenomenon under study.

While I acknowledge the weaknesses, I believed that a qualitative research design as opposed to a quantitative approach would provide me with a better opportunity to construct in-depth understandings of students’ attitudes towards school science. A quantitative approach would mostly generate data that are too structured, abstract, superficial and generalised (Johnson & Christensen, 2008), which is not consistent with the purpose of in-depth study of students’ attitudes towards school science. Moreover, Osborne and Collins (2001) noted that most of the previous attitude studies have been reliant on quantitative strategies and attempted to reduce a multi-faceted and interdependent construct of attitude to a few easily measurable quantitative dimensions, thereby attracting numerous criticisms (Osborne & Collins, 2001). Osborne and Collins (2001, p. 443) further argued that from a social psychological perspective much of such research revealed only the “tip of the iceberg” and failed to explore the underlying reasons for students’ complex feelings, views and attitudes. Added to this, as discussed in Chapter 1, a quantitative approach failed to provide a complete picture of student attitudes in my previous study (Mojumder, 2009). In contrast, adopting a qualitative approach would offer an exploration of in-depth insights into the nature and quality of students’ attitudes towards school science. These may be reasons why constructivist researchers mostly subscribe to qualitative strategies (Creswell, 2009).

3.4 Research Design

3.4.1 Context of the research site
For this research, data were collected from an urban co-educational private school. Although private, the school has to follow the national curriculum and textbooks developed by the National Curriculum and Textbook Board (NCTB). Urban schools generally have more resources (physical, human and financial) available than rural schools. Urban private schools have more resources in terms of teacher quality, physical facilities, student achievement, management and administration than those in rural areas largely due to the tuition fees they charge. Urban parents are often more able to support their children’s education financially and thus spend relatively more money and use more resources for their children’s education compared to those in rural areas. Due to extra the facilities, it can be expected that urban students usually have better exposure to school science compared to those in rural areas.

Data were collected in two phases: in the first phase, five Focus Group Interviews (FGI) were conducted with 32 purposively selected secondary (Grades 9 and 10) students of the school. Based on the key ideas found in the FGI data an open-ended questionnaire was developed and administered to all of the secondary students (about 450) in the same urban school. Detailed descriptions of the different phases, participants and sampling procedures along with their purposes are presented in the following sections.

**3.4.2 Recruitment of participants through Purposeful Sampling.** “The logic and power of purposeful sampling derive from the emphasis on in-depth understanding” of participants’ perspectives of the phenomenon under study (Patton, 2002, p. 46). Therefore, to gain in-depth understandings of the attitudes held by Bangladeshi secondary students, one urban private school was selected purposively as the focus of this study. In order to ensure a good representation of participants with mixed abilities, from different grades and streams and from both genders, I had to identify a school that had a substantial number of secondary students from mixed streams (science and non-science), abilities and genders.
In the selected school, students are grouped in four streams: 9 science, 9 non-science, 10 science and 10 non-science. I mentioned earlier in the context section that all students must study a minimum of one science subject regardless of the stream they belong to. So I recruited students from across all streams. While recruiting students, I received help from the science teachers designated for the respective class or streams. Respective science teachers had a good knowledge about their students. I asked them to think about 12 students (boys and girls equally) from each of the four streams in terms of their achievement in science (low, average and high), participation in science classes and potential willingness to share information in a focus group setting. The purpose of searching for students with mixed abilities and gender was to ensure a better representation of a wide range of students in FGIs. At the same time, as the students were to participate in a focus group setting it was important to select students who were willing to express their views and experience in a shared environment.

Following the criteria, science teachers provided me with the names of the representative students so that I could meet with them and invite them to participate in this research. After being briefed and provided with an explanatory statement and consent form for this research, thirty-two students (17 boys and 15 girls) provided their consent, along with that of their parents, to participate in this research. This sample consisted of 12 students from 9 science stream (six boys and six girls), who were divided into two groups; eight students from the 9 non-science stream (five boys and three girls) formed another group; the other two groups, having six participants each, were formed of equal numbers of boys and girls from 10 science and 10 non-science streams. In total, five groups were formed for five Focus Group Interviews (FGI) which are typically made up of four to six people (Creswell, 2008).
3.4.3 Phase One: Focus Group Interview. Using Focus Group Interviews (FGI) is recognised as an appropriate way to generate information to assist with constructing a questionnaire about a particular phenomenon to be studied (Krueger & Casey, 2000). The reason for using FGIs in this research was to identify key ideas and themes on how students evaluate their school science (which will be described later in this chapter) in order to reflect their attitudes towards school science. With the help of the key ideas and themes identified in the FGI data, an open-ended questionnaire was constructed to use in the second phase, which allowed all the secondary students of the participating school to indicate their attitudes towards school science.

Creswell (2008) advocates FGIs, seeing them as useful when a shared understanding about an issue or topic is required. FGIs can help encourage, support and engage participants to talk about a topic or issue as some individuals may be reluctant to provide information in individual interviews (Creswell, 2008). This research used FGIs (see Appendix 4 for the interview protocol that was followed during the FGI sessions) as part of the data collection process to assist participants in the process of voicing their thoughts and experience about school science in a shared and supportive environment.

To start and guide the FGIs, an open interview protocol (Appendix 4) was used and followed in order to provide probe questions. Attitude research has identified three major variables of school science: (a) the student, (b) the science teacher, and (c) the learning environment (Haladyna, Olsen, & Shaughnessy, 1982). The questions in the interview protocol were developed relating to these variables of school science based on the ideas found in the relevant literature (e.g., Allen & Fraser, 2007; Lyons, 2003; Osborne & Collins, 2000). Of course, the research questions also guided the development of the interview protocol. In order to initiate the conversation with respect to students’ experience of school science, four key questions and three supplementary questions were designed and
constructed. For example, the first key question was, “When you think about your science lessons at school, what kind of images or experiences come to your mind?” To supplement this question, when necessary, three auxiliary questions were used (see Appendix 4). For example, one of the supplementary or supporting questions was, “how do you feel when you think about what you learn in science classes?” Being open to hear students’ experiences was a deliberate strategy in order to give them maximum opportunity to express their thoughts, expand their ideas and talk about any sort of experience related to their school science. Depending on their responses each FGI lasted for 50 to 70 minutes.

![Figure 3.1. Phases of data collection](image)

**3.4.4 Phase Two: Open-ended Questionnaire.** Open-ended questions can provide valuable and rich information about a phenomenon being studied when a researcher needs to know what people think about the phenomenon and the dimensions of the variables that are not well defined (Johnson & Christensen, 2008). Creswell (2008) suggested an open-ended questionnaire as an instrument to collect data for qualitative research and to be used in particular to gather extensive data on people’s views and experience. Using an open-ended questionnaire the data collected would be quite unstructured, which would mean analysis would require careful attention and a longer time to process.
Creswell further suggested that an open-ended questionnaire may include some questions that are closed or may include some closed options together with open-ended questions, so as to gather open responses as well as ones that are more specifically related to the preconceived concepts, themes or theories used in the research. The advantage of doing so is that the closed-ended questions can yield useful information to support the preconceived themes or ideas whereas open-ended responses will help explore reasons for the responses to the closed-ended questions. The format could also help identify students’ views and experiences beyond the responses to the closed-ended questions (Creswell, 2008). Creswell explains:

Typically, qualitative researchers look for overlapping themes in the open-ended data and some researchers count the number of themes [or sub-themes or codes] or the number of times that the participants mention the themes [or sub-themes or codes]. For example, a researcher might ask a closed-ended question followed by an open-ended question:

Please tell me the extent of your agreement or disagreement with this statement:

“Student policies governing binge drinking on campus should be more strict.”

__________ Do you strongly agree?

__________ Do you agree?

__________ Are you undecided?

__________ Do you disagree?

__________ Do you strongly disagree?

Please explain your response in more detail. (Creswell, 2008, p.228)
This type of questioning would allow participants to indicate their position with regard to the statement and then explain the underlying reasons for choosing the position. The reasons provided by the students would then be more helpful to the in-depth study of the phenomenon of the research. In order to elicit more dimensions of thoughts about school science from a larger group of students as well as an understanding of overall trends regarding students’ attitudes towards school science, I developed an open-ended questionnaire (see the following section) to be administered among all the students (about 450) at the chosen school. The questionnaire that I developed included questions of a similar structure to that suggested by Creswell above (see Section 3.5.1). The following sections present the procedure used to analyse FGI and questionnaire data along with the details of the development of the open-ended questionnaire.

3.5 Data Analysis Procedure

Since the data were collected in two phases, the data were also analysed in two stages. The data collected in the first phase were analysed first to identify the key ideas and themes, which were then used to develop an open-ended questionnaire. After using the questionnaire in the second phase, the questionnaire responses were analysed. The following sections describe the data analysis procedure followed in each phase and the process of questionnaire development.

3.5.1 Thematic analysis of FGI data and development of the open-ended questionnaire. As qualitative approaches are incredibly diverse, complex and nuanced, Braun and Clarke (2006) have suggested that thematic analysis should be seen as a foundational method for qualitative analysis. Braun and Clarke (2006) note that thematic analysis is a widely-used qualitative analytic method although it is rarely acknowledged. It also offers an accessible and theoretically-flexible approach to analysing qualitative data. Since I wanted to extract from the qualitative focus group data key ideas and themes
related to students’ evaluations of and attitudes towards school science, I followed a thematic analysis procedure to analyse the focus group data.

The focus group data analysis followed an inductive approach to thematic analysis, which is generally used in studies designed to describe a phenomenon, where researchers usually avoid preconceived theory or themes related to the phenomenon and rather allow codes and themes to emerge from the data themselves (Hsieh & Shannon, 2005). According to Braun and Clarke (2006), an inductive approach to thematic analysis means that the themes identified are strongly linked to the data themselves. In this approach, the themes yielded from the data, collected via interview or focus group, may bear little relationship to the questions asked to the participants. The themes would also not be driven by researcher’s theoretical interest in the area or topic. Inductive analysis is therefore a process of coding the data without trying to fit it into a pre-existing coding frame, or align it with the researcher’s analytic preconceptions (p.83).

Creswell (2008) notes some commonly used steps such as transcribing, coding, aggregating similar codes and identifying themes as making up a thematic analysis process, while Braun and Clarke (2006) have suggested six steps of thematic analysis process: (1) becoming familiar with data; (2) generating initial codes; (3) searching for themes; (4) reviewing themes; (5) defining and naming themes; (6) producing the report. Although they have used different terms and words for the process, the core tasks for the analysis are identical.

Following the steps suggested by Braun and Clarke (2006), I firstly transcribed the FGIs before reading them several times to develop a deeper understanding of the information being supplied by the participants. In the next step, I coded the transcripts through locating and identifying segments of text related to students’ evaluation, beliefs and behavioural tendencies regarding school science. I assigned code words or phrases to
these text segments that accurately described their meaning. In this way, many codes were assigned to the transcripts, indicating the various ideas and understandings that students have about school science. Next, similar code words or phrases were brought together to create themes that represented students’ evaluations, beliefs and behavioural tendencies regarding their school science experiences. After reviewing and refining, the themes were finalised and used to develop the questionnaire. The following table provides the step-by-step guide for thematic analysis procedure suggested by Braun and Clarke (2006).

Table 3.1
*Phases of Thematic Analysis (extracted from Braun & Clarke, 2006, p.87)*

<table>
<thead>
<tr>
<th>Phases</th>
<th>Description of the process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Familiarising yourself with your data:</td>
<td>Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.</td>
</tr>
<tr>
<td>2. Generating initial codes:</td>
<td>Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.</td>
</tr>
<tr>
<td>3. Searching for themes:</td>
<td>Collating codes into potential themes, gathering all data relevant to each potential theme.</td>
</tr>
<tr>
<td>4. Reviewing themes:</td>
<td>Checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic ‘map’ of the analysis.</td>
</tr>
<tr>
<td>5. Defining and naming themes:</td>
<td>Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.</td>
</tr>
<tr>
<td>6. Producing the report:</td>
<td>The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.</td>
</tr>
</tbody>
</table>
According to Braun and Clarke (2006), this process of data analysis is not a linear process to simply move from one phase to the next. Instead, it is a more recursive process to move back and forth as needed throughout the phases. Therefore, I often had to go back and forth through the steps and go through the data several times during the entire analysis process.

Following the process of inductive thematic analysis, commencing from the detailed data or transcription and concluding with general codes and themes, nine key themes were derived from the FGI data and used for the development of the open-ended questionnaire. The open-ended questionnaire was used to obtain a general pattern of evaluations, beliefs and behavioural tendencies regarding school science to help obtain insights into attitudes of all the students in the school. The themes are as follows:

1. How students find science (boring or interesting, difficult or easy)
2. How science is being taught (following teacher-centred methods or learner-centred methods)
3. Memorisation set against hands-on experience while learning science
4. Pursuit of good grades in examinations
5. Relation of school science to learners’ everyday life
6. Huge science syllabus set against less time to finish
7. Experience related to the science textbooks
8. Effect of teachers’ personal qualities on students’ science learning and interest in school science
9. Reasons for pursuing science or leaving science.

Students’ voices were promoting both positive and negative views around the themes. During the FGI sessions, animated debate and discussion occurred among the students; while some students talked in favour of an idea/issue, others talked against it. As a result under each theme there are both positive and negative codes related to the school science that they reported experiencing. For example, while a student said, “physics is
boring, I do not like physics”, some other student said, “the class we enjoy most, I mean the subject we understand well, is physics…” This is why the questionnaire was developed in a way that allows participants from both sides to make their stances clear and write their reasons and explanations in support of their stances.

Accordingly, in the first part of the questionnaire, five statements were developed, placing two different issues in each statement in order to place both sides of the views of students regarding their experience with school science. The common tendency of providing a “socially desirable answer” (Johnson & Christensen, 2008, p.186) was also taken into account, since this study is very much related to the school, teachers, families and society of the participants. If the participants were compelled to choose a position in terms of a statement, even though the statement was comprised of two different (or in some cases contradictory) issues, and to write the reasons behind choosing their position, relatively genuine answers could be expected from the participants. For example, ‘science is interesting’ was combined with a different but relevant issue ‘science is difficult to study’, because some of the participants reported that science is boring because it is difficult to study. In this case, participants really had to decide on whether they found science interesting or boring and then whether the reason was that they found science difficult, or something else. Overall, these statements comprising two issues were designed not to limit the participants to some specific thoughts or ideas, but rather to keep the scope open for their ideas and thoughts in their responses.

3.5.1.1 Statement One. The first statement of the questionnaire is, “Science is interesting, but it is very difficult to study”. Each statement was accompanied with four choices: ‘agree’, ‘partially agree’, ‘neutral’, and ‘disagree’. These choices were given to decide a position on which the participants could explain their ideas, thoughts and evaluation in terms of school science as they were asked to explain (with examples) the
reasons behind choosing their position right after the choices (see Appendix 5). Although the statements were presented with four choices, during the analysis of students’ written responses it was found that some responses were ambivalent, which did not indicate student positions clearly. As a result, it could not be determined whether the response agreed or disagreed or was neutral. Such ambiguous responses were counted as “undetermined responses”, however, undetermined responses were not discussed further as they would risk misinterpretation (see also Section 4.2).

The first statement was developed based on the theme how students find science (Theme 1). Students discussed in the FGIs how they liked or disliked science (is it boring or interesting? is it difficult or easy to study?). It was quite unresolved whether science was boring or interesting and/or difficult or easy. Naturally, different students found different science subjects (physics, chemistry or biology) interesting or boring; some students liked physics while others liked chemistry or biology. While some students found physics difficult to study, others felt that biology was very hard to study. Some of the debates presented below give the insights that led to the development of the first statement. While presenting the quotes of students, pseudonyms have been used to protect against identification of participants.

Paul: I find physics absolutely boring…

Sid: I think there are lots of things to learn in physics. What is boring for others, I feel interested in that. We never learn that much in chemistry or biology, as what we can learn in physics.

Sam: to be honest, I have a fear of physics…

David: science topics are so hard…
3.5.1.2 Statement Two. Similar to the first statement, four more statements were developed and presented in the same format in the questionnaire. The second statement was developed based on two major themes: how science is being taught (following teacher-centred methods or learner-centred methods?: Theme 2) and memorisation set against hands-on experience while learning science (Theme 3). Combining the two themes the statement developed was, “Studying science requires me to memorise scientific laws, facts and information for responding to exam questions, but I want to learn science by doing it practically”. According to students’ voices, it appears that science teachers mostly follow teacher-centred methods while teaching science, where students remain passive receivers. Most of the students reported that their science teachers gave lectures in front of them with the help of science textbooks, chalk and blackboard. Students had to follow the lectures and learn science passively. On some occasions teachers use some portable scientific instruments (e.g., a tuning fork in the lecture on sound) in their lectures to help explain science topics. Nonetheless, the use of teacher-centred methods and transmission of knowledge and facts from teachers to the passive recipients (students) is the dominant teaching approach in science classrooms.

Christine: … teacher Marry tries to make us understand, but we do not understand what she teaches. I mean we do not like her teaching style. She reads the book to us aloud… for example, she writes [on the blackboard] something directly from the textbook. Later when we put our lecture notes and textbooks together we see that all are identical. We generally could read the textbooks ourselves. What we need is to understand how the chemical things form, how the reactions happen, how we can balance the chemical equations, what reacts with what… we do not understand what she wants to teach… I mean her teaching style is different.
Most students reported that they did not like this way of teaching, they wanted to learn science by having hands-on experience. It would be worth noting that students used the terms ‘doing practically’ and ‘hands-on learning’ synonymously. Although practicals or hands-on activities in science could be conducted following a recipe, students did not seem to differentiate between recipe-based hands-on, and student-centred or student-initiated hands-on activities as they seemed not to have had much exposure to hands-on science to realise the difference.

*Megan:* Actually we come to school to get good marks. It would be great, if we could avoid it and study science to gain knowledge… knowledge memorisation is of no use… Most important thing is we should understand science by doing it practically.

Some students reported that some teachers taught in ways that seemed like telling stories, and they (the students) enjoyed these classes. Still this way of teaching is teacher-centred.

*Tom:* Teacher Matthew teaches us very well. His teaching on atomic mass, atomic number, valency etc. was totally different. While teaching, it is like he is telling stories but later on [at home] we find that all the things are very well in our memory. We really like his classes.

Another theme, *memorisation set against hands-on experience while learning science,* illustrates that students memorise science rather than learning science by having practical experience. Most of the students reported that they memorised scientific laws and facts, and even the experiments, that they sat for examinations and forgot everything after examinations. Generally, students appeared not to have had the opportunity to go out of their regular classrooms to apply for themselves the science knowledge that they had learnt.
in classroom (e.g., classification of plants, or waves, or nature of light). They had even less opportunity to learn science topics with the help of sufficient scientific instruments or by being active in learning science.

*Stuart*: we cannot see the electronic configuration of atoms for ourselves; we listen to our teachers and memorise it. It is written [in our textbook] that electronic configuration of atoms cannot be seen by regular eyes, even by a simple microscope. Is there any evidence that electronic configuration cannot be seen by regular eyes? We never know that! Or nobody shows us. We can never see that. Nobody shows anything practically. We just hear from their [teachers’] mouths.

*Jim*: …for example, the structure of atoms; there is a nucleus in an atom… we just struggle to memorise these things.

*Lucy*: … for example, simple pendulum in physics; teachers are talking about simple pendulums, but, if they showed us a simple pendulum, its length etc. then we wouldn’t need to memorise these …

### 3.5.1.3 Statement Three

The statement “I study science only to get good grades, it has very little/no use in my life” was developed based on two themes: *pursuit of good grades* (Theme 4) and *relation of school science to learners’ everyday life* (Theme 5).

Many students reported that they came to school and studied at school just because they had to sit for examinations to get good grades to please their parents and teachers. According to the students, most teachers prepared them for the examinations: they taught how to answer the questions in exam papers; they taught what to write on exam papers to get good grades; and how to make an exam paper attractive to the examiners. Most students did not appear to know the use of science knowledge in their lives.
John: … we study, sit for exams, get good marks; this is why we study science, it has no use.

Dan: Nobody tells us about what abilities we would have after passing out of school. We are only told how to answer a question on the exam paper… we are not taught how we can use it [science knowledge] practically in our lives.

3.5.1.4 Statement Four. Based on the themes relation of school science to learners’ everyday life (Theme 5) and how science is being taught (Theme 2), the statement “Science that I study at school is useful for my life, but because of the way that science is being taught I do not know whether school science has any practical use in my life” was developed. Some students recognised that the science they learn somehow has implications for their lives. But as they are not taught the implications of school science to their lives, they do not properly understand the actual relations between the school science and everyday life. Moreover, this statement had also a purpose of triangulating the data from the second and third statements as students reported a relation between science teaching and the applications of school science in real life. Theme 2 (how science is being taught) helped develop Statement Two and Theme 5 helped develop Statement Four; this statement was developed based on these two themes to help students think and report more possible reasons as well as reinforce the previously reported reasons for school science having little or no use in their lives.

Sue: science that we learn in school is being used somehow in our life. But as long as we do not know this, we wouldn’t understand how it’s being used in our life. Until then it seems to us that it’s [science] just for study, just to write on exam papers and get good marks… If we anyhow could see that; ‘yes! it’s being used in this way!’ we would know about its practical uses and we could use it [science knowledge] in our life. But as we do not get any opportunity to see this [use of
science knowledge] practically, it seems to be of no use in our life; it’s just to study and sit for exams. But if we could see this practically, we would see that what we learn in science is being used somehow; unless we see that, we don’t understand that everything [what we learn in science] is related to our lives.

Katie: …we study the pendulum in physics, but we don’t understand where its application is in our life.

John: …more than half of the subject matter in our science textbooks does not have any practical use in our life.

3.5.1.5 Statement Five. The fifth statement “the chapters to be studied in science are huge, and we are always racing to finish them” was developed based on the theme huge science syllabus set against less time to finish (Theme 6). Most of the students reported that they have an enormous study load for the time given. There is also too much content in science courses to be studied. For example, in the physics textbook there are 26 chapters; students have to study all the chapters to sit the SSC examination held in completion of Grade 10. The huge number of topics in science often means that they do not get enough time to cover all the topics properly in the given timeframe. As a result, everyone (students, school authorities and teachers) tries to finish the syllabus in the given timeframe, regardless of what students are expected to learn.

Paulin: In physics we have 26 chapters! Everyone studies 26 chapters for two years and sits for exams, is it possible for us? Not only have you 26 chapters, you have to study chemistry and biology on top of that. Having such pressure, if someone goes to the examination, then what?

Simon: … our syllabus is huge, but the time is very limited. In two months can anybody finish six chapters of physics? Each chapter is so big, we cannot finish
these chapters. Now what to do? We have to memorise everything and pass the exams. This is how we think; anyhow we have to pass the exams.

After developing the first five statements, four open response questions were developed in order to explore students’ experiences regarding the science textbook(s), thoughts about an ideal science teacher and how the qualities of a science teacher would help them like and enjoy school science, and the reasons to choose science or non-science streams after passing Grade 8. The fourth open response question is very general and asks students if they wish to share any other issue related to school science that they feel is important. Details of the development of open response questions are discussed in the following sections.

3.5.1.6 Open-response question One. Based on the theme, experience related to the science textbook(s) (Theme 7), an open question developed was, “Do you like your science textbook(s)? Why or why not? Explain with examples”. From students’ voices it is evident that textbooks are a very important component of their school science experience and have had effects on shaping their attitudes towards school science. According to their responses, the textbooks were somewhat out-dated and there were significant mistakes in science textbooks. They are offered little opportunity to know about recent inventions from their science textbooks. Many students also reported that the science textbooks are quite difficult to understand; presentation of the content and topics, and the use of words and language are inappropriate for them. They always feel that they need someone to help them understand the science textbook(s). For these reasons, some of them feel disinterested in studying science.

Christine: science textbooks are not written in understandable language. They are written in such language that we cannot make sense of what is written. We have to take help from our teachers.
Steve: There are lots of mistakes in our science textbooks. Also there are many words that we have never heard of before.

Jason: Every moment science is advancing. Every day newspapers write about new inventions of science. But the books change after 10 to 15 years. That’s why we are having huge gaps in our knowledge.

3.5.1.7 Open-response question Two. The next open question “What would be the qualities of your ideal science teacher? How would these qualities help you like/enjoy school science?” was developed based on the theme effect of teachers’ personal qualities on students’ science learning and interest in school science (Theme 8). According to the FGI participants, teachers’ personal qualities (e.g., experience, accountability, responsibility, language, voice, behaviour with students) affect their science learning. Some teachers welcome students’ questioning, some do not like questions from students; some teachers are friendly, some are not; while some teachers try to make lessons understandable, some fail to realise this goal and are likely to ridicule students’ limitations of understanding. Students also reported that they do not enjoy classes where teachers are not friendly and insult students, where lessons are not understandable and students cannot ask questions comfortably.

Developing this question was quite challenging, as incorporation of any such question needs to focus on ideal dispositions of science teachers rather than provide an opportunity for critiquing their teachers. In thinking about a question related to science teachers, it was necessary to provide an opportunity to get a general idea about the personal qualities of ideal science teachers rather than specific qualities related to particular science teachers. Based on student voices related to the personal qualities of science teachers along with the thought that the question must not instigate students to write any complaints against specific teachers, this open and very general question was developed.
Marry: Teacher Brian never feels annoyed if we ask him anything. He answers us very easily [with ease/comfortably]. How many times you ask questions, doesn’t matter, he never gets annoyed. He always tries to explain to us gladly.

Jane: but many teachers are not friendly.

Joe: one of our science teachers only gives her attention to a few good students. She only gives attention to those students who are good [studious], who score top, whose roll numbers are on top. Many teachers do so.

[Note: Roll numbers are assigned based on the academic achievements of students]

**3.5.1.8 Open-response question Three.** Based on the theme *reasons for pursuing science or leaving science* (Theme 9), the question “Why did you choose to study science? (for science stream students) OR Why did you choose to study business studies/humanities rather than science? (for non-science stream students)” was developed. It is undeniable that the reasons behind the decision to choose science or non-science streams are very important to understand existing attitudes as well as any shift in attitudes towards school science. In the Bangladesh context, the period between the end of Grade 8 and the beginning of Grade 9 is crucial for the students as they have to decide on whether they choose the science or non-science stream for their further study. This decision does not depend solely on their aspirations towards science study; according to student responses this decision mostly depends on grades/marks obtained in the Junior Secondary Certificate (JSC) examination held after completing Grade 8, especially the grades/marks in science and mathematics. Students who have not achieved the benchmark of grades/marks, especially in science and mathematics, have to choose one of the non-science streams (business studies or humanities). For students who have choices between science and non-science streams, family influences often direct them to decide where to go.
Ross: we were given science based on our results in Grade 8. This is why we are studying science.

Rowan: I think we have to do what our parents decide for us to do. Our mentality is like if they tell us to take science then we have to.

Some other reasons can be inferred from some other responses below:

Natalie: …because the demands of science are huge these days.

Kevin: … to become a doctor, to be an engineer we need to study science. I mean, if we want to have a good profession we need to study science. This is why everybody wants to study science.

Cassy: Everyone says that the best students take science. If someone studies in business group, people would say, “Ooh! You study business!” It means you are not the best student; you are just an average student. They always underestimate the non-science students.

Open-response Question Three, therefore, aimed to provide students with the opportunity to report all the reasons behind their decision to take science or non-science courses.

3.5.1.9 Open-response question Four. Finally, a very general question was developed to give students an opportunity to write other comments that they felt were important. I thought that in this way, some new ideas related to their attitudes towards school science may possibly emerge. The final question is “If you have any other comments related to the science that you study in your school, please write them here”.

3.5.1.10 Finalising the questionnaire. The questionnaire was finalised after a number of iterations. After it was developed, the questionnaire along with the themes
yielded from the FGI data were sent to six other educators who research on education in the same context (Bangladesh). They reviewed the questionnaire and matched the questions and themes by themselves and provided their comments. After again reviewing their comments, the questionnaire was finalised. The questionnaire was then translated into Bangladeshi language (Bangla) and certified by a qualified NAATI (National Accreditation Authority for Translators and Interpreters) translator.

As Creswell (2008) suggested, piloting helps researchers determine that the target participants would understand the questions and be capable of completing the questions, ten students (from both science and non-science streams of Grade 9 and 10) were selected from a different school to participate in the piloting of the questionnaire. These students provided their responses to the questionnaire. After their responses had been received, discussion about difficulty (language used to understand the questions, question structure, answering options etc.) making sense of or responding to the questions was initiated with the participants of the pilot. They mainly raised a few language related issues. In consultation with them, the language was corrected in order to resolve the issues identified by them. At the same time, any inconsistencies between the questions and their responses were resolved to make the questionnaire fully understandable for the target respondents.

3.5.2 Questionnaire data analysis. Questionnaire data were analysed using a hybrid approach to thematic analysis (Fereday & Muir-Cochrane, 2006) to understand the general pattern of evaluations, beliefs and behavioural tendencies regarding school science as a way of obtaining insights into students’ attitudes towards school science. A hybrid approach is a combination of inductive and deductive approaches to thematic analysis. In Section 3.5.1 the inductive approach to thematic analysis has been described. The steps of thematic analysis are similar for both the approaches, though the way of generating codes from the data differs. Braun and Clarke (2006) suggested that in an inductive approach the
codes are generated from the data themselves; they are not generated based on the researcher’s theoretical interest or analytic preconceptions. On the other hand, in a deductive approach pre-existing ideas, text-segments or codes are examined in the data (Fereday & Muir-Cochrane, 2006). The next section describes the process involved in analysing the questionnaire data.

As the questionnaire was developed based on nine key themes derived from the FGI data, these themes were then considered to be the pre-existing themes (Braun & Clarke, 2006; Fereday & Muir-Cochrane, 2006) for analysing the questionnaire data using a deductive approach to thematic analysis. According to Braun and Clarke (2006), a deductive approach to thematic analysis is followed when the analysis is meant to be driven by the researcher’s preconceived theory or themes related to the phenomenon being studied. This approach is more explicitly “analyst-driven” and able to provide detailed analysis of some pre-existing codes and themes in the new data set (Braun & Clarke, 2006, p.84). Therefore, the deductive approach to thematic analysis was followed first in analysing the questionnaire data in order to obtain detailed description of the themes that emerged from the FGI data. The analysis would also verify whether the questionnaire data were consistent with the FGI data. In other words, the responses from the larger group of students who had done the questionnaire would confirm or disconfirm the data that were collected from the smaller group of students responding in a focus group setting.

Following the steps of thematic analysis suggested by Braun and Clarke (2006), the questionnaire responses were first read several times to develop a deeper understanding about the information supplied by the respondents. Notes that highlighted the students’ evaluation, beliefs and behavioural tendencies were taken, and text segments were marked to examine the a priori or pre-existing codes that were related to the codes and themes obtained from the FGI data. For example, a student’s response to Statement Four (“Science
that I study at school is useful for my life, but because of the way that science is being taught I do not know whether school science has any practical use in my life”) was the following:

In school we only depend on teachers’ lectures. During lectures we only listen, so that there is nothing about to see or to understand. As a result, there is a big gap in our learning. Sometimes we are shown two dimensional pictures on blackboard but we never see any three dimensional picture of scientific concept. For example, in chemistry whatever we read about atom, molecule, their size and dimensions, acid and base - we just try to imagine them all. …Therefore science in school is only for achieving A+ [top grades] in exams, this is not for learning any use of science in life.

This response was found associated with two key themes emerging from the FGI data: how science is being taught (following teacher-centred methods or learner-centred methods) and pursuit of good grades in examinations (the text segments highlighted in colours correspond to the themes in the respective colours). Therefore, these themes emerged from the responses through the deductive approach to thematic analysis. In this way the pre-existing nine key themes were examined in the questionnaire data.

At the same time, the inductive approach allowed new themes to emerge from the questionnaire data. New themes were new in the sense that they had not already emerged in the FGI data, but first appeared in the questionnaire data. For example, a student’s response to Statement Four (“Science that I study at school is useful for my life, but because of the way that science is being taught I do not know whether school science has any practical use in my life”) was the following:
Science that we study in school is very essential for getting a good job. We study log in maths, history in social science, etc. but I do not understand whether they are of any use in my life… I think most of the topics in physics, chemistry and biology have uses or applications in our lives. It would be realised when complete knowledge about sciences is learned.

One of the key themes associated with this response was school science is important for a future career (the text segment highlighted in yellow colour corresponds to the respective theme in the same colour). This theme did not emerge from the FGI data but came out of the questionnaire responses through the inductive approach to thematic analysis. Thus the new themes emerged from the questionnaire responses.

In this way, following the hybrid approach to thematic analysis, the maximum number of appropriate themes were extracted from the questionnaire data. On the one hand, by following the deductive approach the themes found in the FGI data were examined in the questionnaire data. On the other hand, by following inductive approach new themes appeared out of the questionnaire data which had not been found in the FGI data (see Chapter 4 for detailed analysis of questionnaire responses and the associated themes).

3.6 Trustworthiness and Ethical Issues

As opposed to quantitative research, trustworthiness in qualitative research is an important consideration. The criteria of credibility such as reliability and validity traditionally used in quantitative research are not applicable in qualitative research (Merriam, 1998). Therefore, the term “trustworthiness” is used instead of “credibility” as a measure of the quality of research. Qualitative research does not usually use standardised instruments or samples selected randomly. Given this, the current study considered the issues relating to the trustworthiness of the data obtained. The purpose of this study was to
capture student voices in explicating in-depth insights into students’ attitudes towards school science. In order to support the trustworthiness of research design and data, a number of principles have been followed:

(1) Establishing initial perspectives of participants in a more relaxed informal setting such as focus groups.

(2) Using the perceptions (or responses) of a relatively smaller group to develop an instrument that speaks in participants’ language.

(3) Establishing the validity of these perceptions (or responses) by presenting possible perceptions to the whole sample (relatively a bigger group) through an open-ended questionnaire.

(4) Revisiting the patterns of the perceptions from the whole group through a reiterative process (comparing and contrasting the responses obtained through the focus groups and the questionnaire) and reporting the similarities and dissimilarities and their reasons.

Despite the self-reporting nature of the data collection process, this operative approach was deliberately designed to ensure the trustworthiness of the data using an interpretive approach where data are checked for agreement through several stages.

Ethical issues that need to be considered as part of this research include ensuring voluntary participation, anonymity, confidentiality, and the analysis of data and reporting of findings (Babbie, 2011). These anticipated ethical issues and the ways they were addressed are outlined below.

To address issues of consent for this research to take place in a Bangladeshi secondary school, I sought approval from the principal of the school from which I invited
students to participate in this study. An explanatory statement was supplied to the principal of the school. This explanatory statement outlined the purpose of this research, what participants were required to do, how anonymity and confidentiality would be upheld, any associated risks and the rights of participants to withdraw themselves from any phase of this study. When this invitation was accepted and approved by the principal, through providing a permission letter (Appendix 2), I made an appointment to meet with the secondary science teachers at the school to explain my research. I sought their support and input in inviting their students to participate in this research. One of the science teachers introduced me to the students who participated in this research. Without disturbing any regular classes, I met with the students at a convenient place within the school such as a common or reading room. Students participating were provided with explanatory letters outlining the purpose of this research, their role as participants, how anonymity and confidentiality would be upheld, risks associated with this research and their rights to withdraw themselves at any point of this research. As the participants were under 18 years, they were required to supply informed consent forms from their parents. They were supplied with the forms to enable this consent to be given.

“Anonymity” and “confidentiality” can assist researchers to safeguard and protect students’ interest and well-being (Babbie, 2011). Therefore, in all recording and reporting of the data, such as focus groups transcripts and in writing my thesis, I have used pseudonyms to ensure the anonymity of the participants and their school. The data have been kept confidential with no data being disclosed, under any circumstances, to anybody outside of this research project including teachers of the school. Data will be stored for five years in a safe place (on a password protected computer and in a locked filing cabinet at Monash University). After five years, all the paper-based data will be destroyed confidentially through the processes prescribed by the Monash University authorities.
3.7 Researcher’s Bias and Reflexivity

While following a constructivist worldview my previous experience as a science student as well as a science teacher in Bangladesh assisted me to construct the meaning of students’ responses. At the same time, in order to be reflexive regarding possible researcher bias and consequently enhance the trustworthiness of the findings, I took a number of measures: (1) member checking (Stake, 2010); (2) peer review (Johnson & Christensen, 2008) and; (3) Investigator triangulation (Johnson & Christensen, 2008).

Member checking was followed in order to ensure the accuracy of the responses provided by the participants. After transcribing the audio-tapes of focus group interviews, participants were provided an opportunity to double-check the transcripts as part of the member checking process. Participants also checked the summary of findings to identify whether their evaluation of school science and their intentions are reflected in the ideas and themes found in their responses. If any discrepancies appeared, I discussed those with them and made changes where necessary according to their suggestions.

Peer review strategy suggests discussing the researcher’s interpretations and conclusions with other people (Johnson & Christensen, 2008). This includes discussion with a peer group who are not directly involved with the research under study. Johnson and Christensen (2008) noted that in practice this peer group are usually sceptical, challenging the researcher to provide solid evidence for many interpretations or conclusions. This process helps the researcher face useful challenges by obtaining the insights of outsiders into the analysis of data. I discussed the summary of the FGI data and shared the questionnaire developed along with the ideas and themes that emerged from the FGI data, with six educators who research on education in Bangladesh. All of them were also research students in the Faculty of Education, Monash University, Australia. They reviewed the questionnaire, and checked and matched the questions and themes by
themselves and provided their feedback. I reviewed and discussed their comments and feedback with them. Discussions carried on until we reached an agreed point about each of the questions in the questionnaire, before finalising it.

*Investigator triangulation* uses multiple investigators in interpreting the data (Johnson & Christensen, 2008). Following this strategy I shared a representative segment of the questionnaire data with my supervisors in order for them to identify the codes and themes. I simultaneously analysed the same segment of data myself. We then discussed the codes and themes that emerged from our individual analyses and checked the consistencies of these among us. Discussion continued until we agreed upon the codes and themes, and finalised them. Codes and themes emerging from the entire data set were finalised after a number of iterations.

Following these three strategies, I as the researcher attempted to be reflexive on possible bias and exerted efforts to enhance the trustworthiness of the results that are presented in the following chapter.

**3.8 Limitations of Research Design**

The research represents the students’ voices about their attitudes towards school science in a particular school. This school belongs to a group of top schools in Bangladesh and consequently there is a limitation in how such findings can be transposed to other school settings in Bangladesh. Nevertheless, the context is important as students are embedded in this context and the research is about their voice. Hence a single school was explored in-depth. Student responses to FGIs were used to develop the questionnaire and confirm that they had understood it and had been able to express their voice to represent their attitudes towards school science. Moreover, the school was big in terms of student numbers and consisted of students with mixed abilities, from different streams (science and non-science), and of both genders, which was considered helpful to obtain a variety of
data. However, the research design may have limited applications when implemented in other settings.

3.9 Summary

This chapter has explained the methodology used for this research to obtain insights into students’ attitudes towards school science through being receptive to student voices. As clarified earlier, evaluation is the central aspect of an attitude, so the research questions were formulated to explore students’ evaluation of various components of school science. The three main research questions are:

1. How do Bangladeshi secondary students justify their evaluation of school science that is Western in nature?
2. a) What are the students’ perceptions of the attributes of an ‘ideal’ science teacher?
   b) How do these teacher attributes support the enjoyment of school science?
3. What reasons do students give about whether to continue to study science?

In order to explore these research questions this research adopted qualitative approaches in all phases of its research design: in developing instruments, collecting data and in analysing the data. Since the research sought to document student voices, all the methods employed aimed at providing students with opportunities to express their voices. Data were collected in two phases. In the first phase five focus group interviews (FGI) were conducted with 32 students in an urban school of Bangladesh. Focus group interviews were conducted in order to allow students to speak in a friendly and supportive environment. Focus group interview data helped develop a questionnaire which was structured based on what students expressed regarding their school science experience. The focus group data were analysed following an inductive approach to thematic analysis in order to identify the key ideas and themes, which in turn were used to develop the open-ended questionnaire. The questionnaire was administered to a larger group of students.
(n=141, returned questionnaires with responses) in order to obtain a general pattern of students’ evaluation of various components of school science. The questionnaire data were analysed following a hybrid approach to thematic analysis, a combination of inductive and deductive approaches to thematic analysis. The steps of analysing data using a hybrid approach to thematic analysis are also described in this chapter. Combination of all the data would provide insights into students’ attitudes towards school science. The following chapter (Chapter 4) reports on the analysis of the questionnaire data gathered.
Chapter 4: Data Presentation

4.1 Introduction

This chapter presents the questionnaire data that were collected in the second phase of this study. In the questionnaire, students were provided with the opportunity for evaluating their school science as well justifying the evaluations with reasons. The questionnaire was given to all the students in the school under study. Out of around 450 students, 141 students returned the questionnaires with responses. As mentioned in Chapter 3, students’ responses were analysed using a hybrid approach to thematic analysis. Since the statements and the questions in the questionnaire were associated with different areas of school science, a number of themes related to different aspects of school science have emerged from the questionnaire responses. The combination of all the responses and the themes provides insights into the collective attitudes of students towards their school science. On several occasions, the differences in attitudes between students from science and non-science streams are also apparent.

4.2 Questionnaire Data

Questionnaire data were analysed using a hybrid approach to thematic analysis (Fereday & Muir-Cochrane, 2006) to provide an overview of student attitudes towards school science. As mentioned earlier in Chapter Three, a hybrid approach is a combination of inductive and deductive approaches to thematic analysis. It has also been mentioned in Chapter Three that the questionnaire was developed from the ideas and themes yielded from the FGIs and the FGI data were analysed according to the steps of inductive thematic analysis suggested by Braun and Clarke (2006). Following the deductive (top-down) approach to thematic analysis, the pre-existing nine key themes and relevant codes obtained from the FGI data were investigated in the questionnaire responses. At the same
time, as part of the hybrid approach to the thematic analysis procedure described in Chapter Three, an inductive approach to thematic analysis was followed in analysing the questionnaire data. The inductive approach allowed new themes to emerge from the questionnaire data. These new themes did not emerge in the FGI data, but from the questionnaire data.

As mentioned earlier, the questionnaire consisted of five statements and four open-ended questions. Each statement consisted of two different issues presented along with four choices to determine participants’ position with regard to the statement. Although four choices (Agree, Disagree, Partially agree and Neutral) adjoined each statement, the frequencies of responses were counted based on the text written by the participants, not only by the ticks they put on the options (agree, partially agree, disagree and neutral). That is, the final responses were counted based on their explanation written in response to the statements. Some of the responses were ambiguous and it was not possible to determine where they exactly fell. In some cases, it was not possible to understand what students intended to express in their response. For example, in response to the first statement (science is interesting, but it is very difficult to study) one of the undetermined responses was: “doing things practically is very important for science subjects. It would be really joyful if everything is experienced by hands-on activities. As a result many difficult topics in textbooks could be understood” (XSCB32) [explanation of the identity used for participants is given in the following paragraph]. In this response, it has not been possible to determine whether the student finds science interesting; or even whether he finds science difficult to study. These responses have been categorised ‘undetermined’. A few students ticked one of the choices but did not explain further in favour of their choices. These responses were counted ‘no response’ since the students did not provide any further explanation to support their position. The responses, that neither ticked any option nor wrote any explanation, have also been categorised ‘no response’.
In the following sections, student responses regarding each statement along with the frequency count are presented. While using students’ quotes, an identification number (for example XSCB32) is presented within brackets after each quote. This ID number has four parts. The first part is the respondent’s Grade. In the given example above (XSCB32), the respondent belongs to Grade 10. If any respondent belongs to Grade 9 then the ID number will begin with “IX”. The following two letters represent the stream (science or non-science) the respondent belongs to. In the given example the respondent belongs to the science stream (SC). If a respondent belongs to the non-science stream, the letters used are “NS”. The following letter represents the respondent’s gender, which is either “B” or “G” (B stands for boy and G stands for girl). In the given example, the respondent is a boy. The final number is a unique number given by the researcher in order to locate the respondent in the data file. This number could be treated as a pseudonym, given so that the participants cannot be identified by others except the researcher.

4.2.1 Statement One: science that we study at school is interesting, but it is very difficult to study. Focus Groups participants had a discussion on whether school science is interesting or boring, which was quite unsettled. At the same time, science was pronounced to be a difficult subject causing disinterests among the students. The responses towards this statement provided the common view of the group, confirming whether school science was seen as interesting or boring and the reasons behind such experiences.

4.2.1.1 First part of Statement One: science that we study at school is interesting. After analysing student responses, the frequencies of participant positions were counted. Table 4.1 below presents the frequencies of participant positions with regard to the first part of Statement One.
Table 4.1

*Frequency of Responses for the First Part of Statement One (n=141)*

<table>
<thead>
<tr>
<th>Agreed</th>
<th>Disagreed</th>
<th>Partially agreed</th>
<th>Undetermined</th>
<th>No response</th>
</tr>
</thead>
<tbody>
<tr>
<td>95</td>
<td>26</td>
<td>6</td>
<td>13</td>
<td>1</td>
</tr>
</tbody>
</table>

In response to the first part of Statement One “science that we study at school is interesting”, most of the students (95 out of 141) found school science interesting, while a relatively small number of students (26 out of 141) disagreed that school science was interesting. Very few students (6) agreed partially; they sometimes found science interesting, while again they sometimes found it boring: “school science is not always interesting and enjoyable; some chapters are interesting and easy while some chapters are monotonous and boring” (XSCB39). Some responses (13) were ambivalent and it was too hard to determine where they fell. For example, in response to Statement One, a student stated: “practicals are essential for science subject. Science is enjoyable when we see everything for our own eyes by having hands-on experience. Much difficult content of science also becomes easier” (XSCB32). From such a response, it was not possible to determine whether he found science interesting or whether he happened to experience science as difficult to study. This type of undetermined response was classified as ‘undetermined’.

Student responses to the first part of Statement One found around four key themes: learning the content of science; how science is being taught; science textbooks; and connection of school science to real life. Table 4.2 below presents the major reasons that students provided under the key themes.
Table 4.2
Major Reasons under Key Themes Emerging from the Responses to the First Part of Statement One

<table>
<thead>
<tr>
<th>Themes</th>
<th>Major reasons for students (frequencies of responses in the parentheses)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning the content of science (30)</td>
<td>agreed: Many unknown things can be learnt by studying science and such knowledge can change student views (22)</td>
</tr>
<tr>
<td>How science is being taught (26)</td>
<td>Science is interesting when teachers teach science well and explain things properly (11)</td>
</tr>
<tr>
<td>Science textbooks (15)</td>
<td>Some chapters in science textbooks are easy and enjoyable (6)</td>
</tr>
</tbody>
</table>

Under the first theme *learning the content of science*, science was interesting for many students (22 out of 95 agreed) because of the content of science; they seemed to believe that they could learn about many unknown things by studying science and this knowledge had the capacity to change their views. However, they did not provide any examples of knowledge learned through the study of science that could change their views.

We learn about so many unknown things/matter by studying science. (IXSCG08)

We learn about new information by studying science, which can change our views.
On the other hand, eight students (less than half compared to their counterparts), who disagreed with ‘school science is interesting’, provided their thoughts around the same theme. According to their explanation around the same theme, they used to find science uninteresting because of having too many theories presented in science compared to the practicals. They also had to memorise many topics in science without understanding or comprehending. A few students also mentioned that they found science difficult and they needed to put extra effort into learning science, which caused disinterest in science.

In science, there are too many theories compared to the practicals. (XSCB47)

We have to memorise many topics in science without understanding or comprehending. (XSCB50)

We need to put in extra effort for science. (IXSCG01)

Nearly the same amount of responses in favour of and against ‘science is interesting’ were provided by the students under the theme how science is being taught. According to the students selecting ‘science is interesting’ (11), school science seemed to be deemed interesting when it was being made understandable or comprehensible to them. That is, if their teachers teach them well, explain things properly and make them understand science topics, science seems to be interesting to them.

Science is interesting when teachers make us understand/comprehend science. (IXSCB04)

In contrast, the common reasons for students disagreeing (15) with the idea “science is interesting” were that they were not being taught by hands-on means,
practically, or science was not being presented in such ways that they found it interesting and enjoyable.

Science is not taught by hands-on/practically… (XNSG50)

Science is not being presented in interesting and enjoyable ways. (XNSB62)

One of the non-science students thought that as they did not attend any practical labs and classes, they did not find science interesting.

Non-science students are not given any opportunity to use science laboratories. (XNSG61)

Under the theme science textbooks, a number of responses (nine) were provided by the students. According to them, they did not find school science interesting because it was “textbook-centred” and the textbooks did not interest them. Also the content of science textbooks was not up-to-date, causing disinterest and dissatisfaction among them.

Science in school is textbook-centred and the textbooks are not appropriate. (XSCG37)

The information given in science textbooks is outdated, which is not useful at present. (XNSB62)

Textbooks seemed to have too much information that was likely to be unrelated to the real world. Also, the language and the presentation of textbook content were not simple enough to create interest in science among students.

The chapters in science textbooks are too informative and uninteresting. (XNSB62)

…language in science textbooks is very hard, nothing is easily understandable.
A few responses (six) saw science textbooks as a reason for accepting science as an interesting subject. The respondents commented that some chapters in science textbooks were easy and enjoyable as they found the science interesting. However, they did not provide any example of chapters that were easy and enjoyable.

Some chapters in science textbooks are easy and so enjoyable; or in other way, some chapters are interesting and enjoyable so that we feel interest in studying those and they become easy. (XSCB39)

Another key theme around the responses is connection of school science to real life, under which most of the responses (eight out of nine responding around this theme) were in favour of the idea that ‘science is interesting’. Students (eight) stating science is interesting seemed to believe that science was closely connected to their real lives; they gained knowledge from science that they saw as essential for their lives.

We get knowledge from science that is useful in real life. For example: light, electricity, soap production, function of lens etc. (IXNSB57)

However, they did not explain how they used this knowledge in their real or everyday life. Of course they used light, electricity, soap and lenses in their daily lives, but they could not provide insights into the way they used the knowledge gained from school science in daily life. The issue of the connection of school science to everyday life was recurrently raised by the students while responding to other statements in the questionnaire as well (e.g., Section 4.2.4).

On the other hand, a non-science student expressed the opposite view to the previous eight students:
We don’t get any practical knowledge of science. For example: cell in electricity chapter, I do not get any opportunity to use or apply the knowledge of this topic in my real life. (XNSB67)

Compared to agreeing and disagreeing students, a very few students (4 out of 141) partially agreed with ‘science is interesting’, because they sometimes found it interesting and sometimes it was boring to them:

School science is not always interesting and enjoyable; some chapters are interesting and easy while some chapters are monotonous and boring. (XSCB39)

In summary, it seems that the content of science and its connection to real life is the reason for students pronouncing science as an interesting subject, although they struggled to provide any specific examples to show the connection between their school science and their daily life. On the other hand, students’ disinterest in school science is mostly rooted in how science is being taught and the science textbooks that they study. The way of presenting science to the students appeared to be comparatively less appealing to them and so less likely to enable them to feel science was interesting.

4.2.1.2 Second part of statement one: school science is very difficult to study.

Table 4.3 below presents the frequencies of participant positions with regard to the second part of Statement One.

Table 4.3

<table>
<thead>
<tr>
<th>Frequency of Responses for the Second Part of Statement One (n=141)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agreed</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>75</td>
</tr>
</tbody>
</table>
In response to the second part of Statement One “science is very difficult to study”, more than half of the students (75 out of 141) experienced school science as difficult to study, while less than half of their counterparts (35) disagreed that school science is difficult. Some students (17) agreeing partially expressed that depending on how their teachers taught they sometimes found science difficult, sometimes easier: “…it depends on how teachers teach us; if teachers follow interesting ways in teaching and give us sufficient examples, science seems to be much interesting and enjoying, otherwise it seems to be so difficult” (IXSCG68). Some responses (13) were ambivalent and it was very hard to determine where they were placed on the scale. Their responses remained ‘undetermined’. For example, I repeat a response to Statement One: “practicals are essential for science subject. Science is enjoyable when we see everything for our own eyes by having hands-on experience. Many difficult content areas of science also become easier” (XSCB32). From this response, I could not determine whether or not he found science difficult to study.

In regard to the second part of Statement One, student responses identified five key themes: learning the content of science; how science is being taught; science textbooks; time and study load; and connection of school science to real life. Four of these themes are identical to the previous themes that emerged from the responses to the first part of Statement One. The newly emerging theme is *time and study load*. Table 4.4 below presents the major reasons that students provided under key themes.
The majority of the responses under the first theme, *Learning the content of science* (20 out of 30), disagreed with ‘science is difficult to study’. The reasoning behind such responses was that if science is studied attentively and/or regularly and understood, science would be easy. According to student responses, as an example, if the laws of motion were studied attentively several times, they would be easy.

…once we understand, it is easy; if it is studied attentively for several times, it is easy - e.g., laws of motion. (XSCG27)
If science is studied regularly, science is not difficult. (XNSG62)

…if the laws in physics and reactions in chemistry are studied following some rules/particular ways, they are easy. (XSCG31)

One interesting response under the same theme expressed that “if science is memorised, it is not difficult” (XNSG53), which seemed to emphasise memorisation as a tool of learning science. Indeed memorisation related issues were found in many responses, thus will be discussed in several forthcoming sections.

In contrast, some opposite reasons were articulated by some students about finding science difficult to study, but the number of responses was significantly fewer (10) compared to those of their counterparts:

…we struggle to understand/comprehend science content; it’s also very hard to keep them in memory. (IXSCB23)

According to student responses, science had too much information, data, laws and postulates to memorise, which made science difficult for them.

There are beyond too much information, data and laws and postulates (which we have to memorise) in science, which make science difficult. (IXSCB16)

Some topics were seen as not well explained and so unable to attract students. As a result, many students had the feeling that science is difficult.

Some topics are too monotonous, which is why we don’t get much interest to study those and thus feel like they are difficult. (XSCB39)

I find so many questions popping out of my mind regarding many science topics, which are neither being resolved in textbooks, nor can our teachers answer them.
All the responses (66) under the theme *how science is being taught* agreed that science was difficult, which implies that students found science difficult because of how science teachers taught them. Common responses included the views that science teachers could not make science easier to them, science was presented to them in a very complicated way, and science teachers did not make them understand/comprehend science.

Teachers cannot make science easier, more interesting and enjoyable for us.

Science is presented and taught in a complex/complicated way… (XSCB40)

If teachers teach well, help us comprehend, then science is easy; otherwise if teachers do not teach well and cannot make us comprehend, it is difficult.

Some responses noted that science teachers just read the textbooks aloud to students and did not think about what would be the way to teach science:

Our teachers just read the textbooks aloud, that’s it, they do not teach us (or explain) the difficult topics. (IXNSG48)

Another common reason was that students had no opportunity to gain hands-on science experience. Lectures were common in science classrooms. Science teachers did not even bother about students’ merit or their capabilities; rather they encouraged students to memorise science. In consequence, many students found science difficult.

Science is a subject to learn practically or by hands-on experience, but we are not given the opportunity to learn/experience science practically. (XSCG37)
…for example, plant physiology, electricity, animal diversity; we do not get any opportunity to learn these chapters by having practical experience. (IXNSG48)

Our teachers do not teach based on our demand or our talent/merit level; they teach how they want to teach… (XNSG58)

A substantial number of responses (24) were received under the theme *science textbooks*, where almost all the responses (23) agreed with the idea that ‘science is very difficult to study’, which implies that many students found science difficult to study because of their science textbooks. Some of the common responses provided the understandings that science textbooks are not easily understandable, the language used in science textbooks is very hard to follow, science topics are presented in a complicated way, and many topics are not well-explained with appropriate and sufficient examples:

The language of science textbooks is very hard/difficult… (IXSCB14)

Many words in science textbooks are very hard to keep in memory… (IXSB23)

In science textbooks, there are so many topics for which sufficient explanation and appropriate examples are not given, for example, transistor. (XSCB40)

Some topics in science textbooks seem to be unreal, we read about them only in our textbooks. (IXNSG48)

On the other hand, only one response under this theme characterised everything in science textbooks as being well explained and not problematic at all:

Everything is well explained in physics and biology books, so I do not face any problem in studying and learning science. (IXSCG07)
Some students found the science syllabus huge, taking up too much of their total study load. Insufficient time was seen as having been allocated for science to teach this huge syllabus, and this was offered by students (7) as another reason for perceiving science as difficult to study. Under the theme *time and study load*, their responses remarked that study of science never finished in the time given and so they did not feel science was easy to study.

…science books have too many chapters compared to other subjects. (XNSG53)

We do not get sufficient time to finish the chapters of science… (IXSCG16)

The questionnaire has a statement on this time and study load related issue and so this matter is elaborated in a later section of data analysis.

A few students (6) mentioned the connection between school science and their everyday life under the theme *connection of school science to real life*. Most of them (4 out of 6) felt science hard to study because they did not find any relation between their everyday life and the science that they studied at school.

We do not find any similarity [relation/connection] of what we study in science with our real lives. (IXSCB14)

Again, some students partially agreeing with the idea claimed that science could be difficult or easy depending on how their teachers taught. Also in textbooks they find some chapters easy and some difficult.

…it depends on how teachers teach us; if teachers follow interesting ways in teaching and give us sufficient examples, science seems to be more interesting and enjoying, otherwise it seems to be so difficult. For example, in the ‘nature of light’
chapter, photometry, illumination and many more topics are not clear to me, because of which I avoid this chapter. (IXSCG68)

In summary, according to the responses of students to Statement One, most of the students appeared to feel that science was interesting. At the same time most of the students evaluated school science as difficult to study. From the responses to Statement One it seems that students found science interesting mainly because the content of science is useful. A few students also found science interesting because of its connection to their everyday life. However, students struggled to provide any specific examples of content or topic showing the connection between school science and their daily lives.

On the other hand, students who showed a disinterest in school science mostly reported science teaching and science textbooks as the reasons for their disinterest (Section 4.2.1.1). Science teaching appeared to be less appealing to them and so left them with a feeling of disinterest.

Similarly, students’ experience of science as a difficult subject was mostly rooted in science teaching and science textbooks. For them science was being taught in a complex or complicated way, and the language used in the textbooks was very difficult. In contrast, many students did not report science as being a difficult subject because they felt that if the content of science was studied attentively several times over and understood it would become easy.

4.2.2 Statement Two: studying science requires me to memorise facts for responding to exam questions, but I want to learn science by doing it practically.

4.2.2.1 First part of Statement Two: Studying science requires me to memorise facts for responding to exam questions. Table 4.5 below presents the frequencies of participant positions with regard to the first part of Statement Two.
Table 4.5
Frequency of Responses for the First Part of Statement Two (n=141)

<table>
<thead>
<tr>
<th>Agreed</th>
<th>Disagreed</th>
<th>Partially agreed</th>
<th>Undetermined</th>
<th>No response</th>
</tr>
</thead>
<tbody>
<tr>
<td>114</td>
<td>4</td>
<td>5</td>
<td>11</td>
<td>7</td>
</tr>
</tbody>
</table>

In response to the first part of Statement Two, “studying science requires me to memorise facts for responding to exam questions”, most of the students (114 out of 141) experienced that studying science required them to memorise scientific facts and information, laws and postulates in order to be prepared for examination, whilst a very insignificant number of students (4 out of 141) disagreed with the idea. Very few students (5 out of 141) agreed partially; they felt that they could acquire some knowledge besides memorising facts: “Studying science is not only about memorising facts and information, laws and postulates; we could at least know something” (XNSG56). Some students’ responses (11) were ambivalent and it was too hard to determine where they fell. For example, in response to Statement Two, a student wrote: “Studying science means researching for new findings. But, our teachers are businessmen; they do not teach properly in classes. Students who go to them [their house] for private tuition get good marks in examinations. This is very unfortunate for us” (XNSB63). From this response, I could not determine whether he found school science only about memorising scientific knowledge to be prepared for exams. This type of undetermined response was classified as ‘undetermined’.

Student responses were found mainly around the theme outcome-focused education. The entire education system focuses on student results in public examinations and the test items often require them to memorise scientific facts, laws, postulates, even equations and mathematical problems, and reiterate the same in exam papers.
Our marks/outcome-centred education system encourages us to memorise science. For example, Bottomley’s experiment, Searle’s method; we just memorise the steps of these experiments and write them down in exam papers. (IXSCG08)

If we memorise and write down exactly the same in exams, we get good marks, otherwise if we write based on what we understood, we do not get good marks. (IXNSB56)

As previously found, science teachers also do not provide opportunities for practical experience of science, rather they encourage students to memorise science.

…our teachers advise us only to memorise, not to comprehend science properly. (IXNSB56)

…for example, we have to memorise chemistry a lot; we can’t see any reaction for our own eyes. (XSCB39)

Students confirm that they have to memorise scientific facts and laws in order to respond to tests in exams and to do well in exams. Memorising science and regurgitating it in exam papers is not pleasant for students. In response to the second part of Statement Two they shared their unpleasant feelings about memorisation and urged that science should be learnt practically. Therefore, the following section now presents the student responses regarding the need for hands-on experience in science.

**4.2.2.2 Second part of statement two: I want to learn science by doing it practically.** Table 4.6 below presents the frequencies of participant positions with regard to the second part of Statement Two.
Table 4.6  
*Frequency of Responses for the Second Part of Statement Two (n=141)*

<table>
<thead>
<tr>
<th>Agreed</th>
<th>Disagreed</th>
<th>Partially agreed</th>
<th>Undetermined</th>
<th>No response</th>
</tr>
</thead>
<tbody>
<tr>
<td>123</td>
<td>1</td>
<td>4</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

In response to the second part of Statement Two, “I want to learn science by doing it practically”, most of the students (123 out of 141) wanted to learn science by having practical experience. In contrast, only one student reported that he was already learning science practically and thus did not need any more practical experience of science: “We can practically experience science during our practicals...” (XSCB34). Very few students (4) agreed partially; they felt the need for practical experience in science, yet they believed that it was quite hard to ensure such opportunities considering the time and facilities provided in school: “Everything in science is not possible to teach practically in our school; we do not have all the necessary equipment in our school. It is even impossible in our country context” (XSCG27). Some students’ responses (6) were ambivalent and it was too hard to determine which category they fell into. For example, in response to Statement Two, I repeat an example: one student wrote: “Studying science means researching for new findings. But, our teachers are businessmen; they give good numbers to those who take private tuition from them and do not teach in class. This is very unfortunate for us” (XNSB63). From this response, I could not determine whether he wants to learn science practically. This type of undetermined response was classified as ‘undetermined’.

Student responses were found to revolve around four key themes: retention of practical knowledge; connection of school science to real life; perceived nature of science learning; disliking memorisation. Table 4.7 below presents the major reasons that students provided under key themes.
Table 4.7
Major Reasons under Key Themes Emerging from the Responses to the Second Part of Statement Two

<table>
<thead>
<tr>
<th>Themes</th>
<th>Major reasons for students (frequencies of responses in the parentheses)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retention of practical knowledge (72)</td>
<td>Hands-on science learning would be retained in memory and useful for a long time; gaining knowledge through experience would ensure that the fundamental knowledge of science is learned (72)</td>
</tr>
<tr>
<td>Connection of school science to real life (53)</td>
<td>Hands-on science learning would enable to apply science knowledge in real life, understand the world around and solve many problems using science knowledge (53)</td>
</tr>
<tr>
<td>Perceived nature of science learning (44)</td>
<td>Hands-on science learning would be enjoyable and thus generate interest among students (44)</td>
</tr>
<tr>
<td>Disliking memorisation (17)</td>
<td>Students did not like memorising science; memorised knowledge do not sustain (17)</td>
</tr>
</tbody>
</table>

In response to the idea “I want to learn science practically”, many students were found to have a perception about how science education should be. Under the theme *perceived nature of science learning*, many students (44) believed that science should be learnt by hands-on activities because these would be enjoyable and be able to generate interest among them.

Science is the subject that is meant to be learnt practically… (XSCG31)
There is no point/value of learning science if it is not learnt practically. (XSCG24)

Hands-on science learning would be enjoyable... (IXSCG12)

We would be more interested in science if we learn science by doing it practically. (XSCG32)

Many students (17) wanted to learn science practically because they did not like memorising science. According to them, memorised knowledge had no benefit; it was not sustained for a long time and it was unclear what had been learnt.

There is no benefit of giving exams by memorising science topics and concepts. This is just waste of time. Memorised knowledge doesn’t last long. (XSCB41)

We do not want to keep science knowledge confined only in book pages. (IXSCG17)

Under the theme *retention of practical knowledge*, many students (72) believed that hands-on science learning would be more sustainable, hands-on learning would be retained in memory and be useful for a long time. They believed that gaining knowledge through experience would be better than memorisation and would ensure that the fundamental knowledge of science would be learned, which would make science learning easier in the upper levels.

If we learn science practically, the knowledge of science will be retained in our memory for a long time. (IXSB01)

Watched or observed things last for longer in our memory than imagining science concepts. (IXSCB09)
If we learn science by hands-on experience, we would acquire complete knowledge of science; our foundation in science would be stronger. (XNSG68)

Another important theme around the data is connection of school science to real life. Many students (53) believed that if they could learn science practically, they would be able to apply science knowledge in real life, understand the world around them and solve many problems using science knowledge.

…in order to use or apply science knowledge in real life. (XSCG34)

…in order to understand the world around us. (IXSCB15)

If we learn science practically, we would acquire/obtain real-life-oriented knowledge about science concepts. (IXSCG13)

…for example, depth of a well can be measured by sound, but we are not taught this practically. (XNSF53)

…so many problems can easily be solved if we learn science practically. (XSCB41)

In summary, it seems that the participating students did not have hands-on activities in science classes; they were not provided experiences of practical science. Although they could achieve good marks by memorising science and writing the same on exam papers, they did not like this process. Students had the urge to learn science practically because they believed this would benefit them more than achieving good grades in exams.

4.2.3 Statement Three: I study science only to get good grades, it has very little/no use in my life.
4.2.3.1 First part of Statement Three: I study science only to get good grades.

Table 4.8 below presents the frequencies of participant positions with regard to the first part of Statement Three.

Table 4.8
Frequency of Responses for the First Part of Statement Three (n=141)

<table>
<thead>
<tr>
<th>Agreed</th>
<th>Disagreed</th>
<th>Partially agreed</th>
<th>Undetermined</th>
<th>No response</th>
</tr>
</thead>
<tbody>
<tr>
<td>68</td>
<td>46</td>
<td>2</td>
<td>22</td>
<td>5</td>
</tr>
</tbody>
</table>

In response to the first part of Statement Three “I study science only to get good grades”, about a half of the students (68 out of 141) agreed that they studied science only to get good grades in their examinations. A little more than one-third of the students (46 out of 141), on the other hand, stated that they did not study science to make good results in their examinations. A large number of responses (22 out of 141) remained undetermined as their responses did not clearly indicate their position. For example, in response to Statement Three (I study science only to get good grades, it has very little/no use in my life) one of the students wrote: “not everyone has any practical use of school science in their lives” (XSCB47). Based on this response, I could not determine his position on whether he studied science for good grades nor whether he had any other reasons for studying science except getting good grades. Only five students did not write anything in response to Statement Three and so they were classified as ‘no response’. Table 4.9 below presents the major reasons that students provided under key themes.
Table 4.9
_Major Reasons under Key Themes Emerging from the Responses to the First Part of Statement Three_

<table>
<thead>
<tr>
<th>Themes</th>
<th>Major reasons for students (frequencies of responses in the parentheses)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>agreed</td>
</tr>
<tr>
<td></td>
<td>disagreed</td>
</tr>
<tr>
<td><em>How science is being taught</em> (28)</td>
<td>The application of science in real life was not being taught by teachers (28)</td>
</tr>
<tr>
<td><em>The context</em> (16)</td>
<td>In Bangladeshi context, grades or results in examinations are given more priority than learning science knowledge and its application (16)</td>
</tr>
<tr>
<td><em>Science knowledge is important</em> (39)</td>
<td>Students believed that science knowledge and its application were more important than achieving good grades in examinations (39)</td>
</tr>
</tbody>
</table>

One of the major themes elicited from the responses was _how science is being taught_: many students (28) responded that they studied science only to get good grades in their exams. The way science was being taught had made them follow such strategies. They found that the application of science in real life was not being taught by their teachers, so they studied science basically to obtain good results in exams.

…since we are not given any practical science education (hands-on experience), our main purpose of studying science is to get good marks in exams. (XNSB72)
Some of the students also mentioned the disinterest among their teachers in teaching science and the salary that the teachers received.

…our teachers are not interested in helping us learn science properly. (IXSCG13)

Another student supported this claim with a reason:

…due to the very low salary paid, our teachers are not willing to put their best efforts in teaching science. (IXSCG03)

Another important theme around the responses is the context: 16 students attributed their agreement with “I study science only to get good grades” to their context. The Bangladeshi education context always demands good grades from its students regardless of what they learn in science. Grades are given more priority than learning and applying science knowledge skilfully.

In Bangladesh, getting good marks or GPA is more important than practical application of science knowledge. We don’t bother about using science knowledge in real life; our only goal is to get good marks or GPA. (IXSCG16)

Society, teachers, parents, everyone demands good grades from them:

At present, because of the education system and our surroundings, our mentality has become such that we study only for good grades. Most of our parents do not focus on what their child(ren) learn in school, the only thing they want to see is whether their child(ren) gets a good mark in exams. Our parents yell at us when we get poor marks in exams, which is why we memorise science without understanding or comprehending. As a result we do not have any application of science knowledge in real lives. (XSCB30)
There is a high demand for doctors or engineers in the society. This is why many students set their goal to become a doctor or engineer. In order to qualify for those professions, students need to have a very high GPA in their exams. As a result, the use or application of science knowledge becomes trivial:

Our goal [combined demand of student, parents, teachers and the society] is to become a doctor or engineer, or some highly demanding professional, for which we need to have a good GPA, not the use or application of science. As a result we are busy after good marks, not after applying science knowledge. (IXSCB08)

One of the key themes was *difference in experience among non-science students*. In many cases, non-science students had different experience about their school science compared to science students. Many students thought that science was not being considered as an important subject for non-science stream (business studies and humanities group):

In business studies group, science is not considered as such an important subject. Usually we study science to get good marks in exams. (IXNSB54)

We, the students of business group, think that we do not have any benefit for studying science, as a result we just study science for marks in exams. (XNSB61)

On the other hand, of students disagreeing with the first part of the statement, three responded mainly around the theme *science knowledge is important*: most of the disagreeing students (39 out of 45) thought that science knowledge and its application were more important than achieving good grades in exams:

I am more interested in acquiring real knowledge of science than obtaining good marks in exams. (IXSCB06)
…getting good grades is not that important, rather acquiring complete knowledge of science and applying it in practical life is more important. (IXSCG02)

A few students still considered their school science useful for their dream of inventing scientific things and knowing about the universe:

I study science to learn about scientific things, to invent various scientific things in future, and to learn about the world and the universe. (IXSCG14)

Only two students (out of 141) disagreed with the assertion because they studied science for both reasons, pursuing their goal of life along with getting good marks in exams, which would also be supportive of their goal:

I definitely study science to good marks in exams. Besides, I want to be an engineer for what I study science. (IXSCG07)

4.2.3.2 Second part of statement three: science that we study at school has very little/no use in my life. Table 4.10 below presents the frequencies of participant positions with regard to the second part of Statement Three.

Table 4.10
Frequency of Responses for the Second Part of Statement Three (n=141)

<table>
<thead>
<tr>
<th>Agreed</th>
<th>Disagreed</th>
<th>Partially agreed</th>
<th>Undetermined</th>
<th>No response</th>
</tr>
</thead>
<tbody>
<tr>
<td>57</td>
<td>58</td>
<td>6</td>
<td>15</td>
<td>5</td>
</tr>
</tbody>
</table>

In response to the second part of Statement Three “science that I study at school has very little or no use in my life”, a little less than half of the students (57 out of 141) agreed that their school science had very little or even no implication for real life. Nearly the same number of students (58 out of 141), on the other hand, disagreed with the
assertion and believed that their school science had applications in real life. Similar to the first part of Statement Three, here I also could not determine many students’ (15 out of 141) positions regarding the second part of the same statement. Here I repeat the example that I gave for the first part of Statement Three (I study science only to get good grades, it has very little/no use in my life): “not everyone has any practical use of school science in their lives” (XSCB47). Based on this response I could not determine the student’s position on whether he saw any use for school science in his real life. As mentioned earlier, five students did not write anything in response to Statement Three and so they were classified as ‘no response’. Table 4.11 below presents the major reasons that students provided under key themes.

Table 4.11  
*Major Reasons under Key Themes Emerging from the Responses to the Second Part of Statement Three*

<table>
<thead>
<tr>
<th>Themes</th>
<th>Major reasons for students (frequencies of responses in the parentheses)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>agreed</strong></td>
<td></td>
</tr>
<tr>
<td>Lectures were the dominant teaching method used in science classrooms; practicals were demonstrated where students had to watch them as inactive observers (24)</td>
<td>agreed</td>
</tr>
<tr>
<td><strong>disagreed</strong></td>
<td></td>
</tr>
<tr>
<td>Students believed that science is all around them; everything is dependent on science (30)</td>
<td>disagreed</td>
</tr>
</tbody>
</table>

The frequently pronounced reason for not having any use for science knowledge in real life was the teaching methods used in science classrooms. A common experience of
the students was that they did not have any hands-on activities in science classes. They learnt science mainly by following the lectures of their science teachers, they were not shown the applications of science topics practically, they were not being told about the application of science knowledge in real life, and they were encouraged to memorise science. Although they had some hands-on practicals, they were not given the opportunity to do the hands-on practicals by themselves. Rather, science teachers just demonstrated the practicals and they watched this as inactive observers in practical labs.

We do not learn science by having hands-on experience by which we could learn to apply science knowledge in our life. (IXSCG18)

We just memorise science, as a result we do not have any use for science in our real life. (XSCB49)

…we can’t even touch any equipment in practical labs, our teachers do all the experiments and we just watch those. As a result we do not know any practical use of science knowledge. (XSCG21)

...in chemistry we learned that CaO+CO₂=CaCO₃, but practically we never added CO₂ (Carbon dioxide) with CaO (Calcium Oxide). So we just memorised that CaO plus CO₂ will produce CaCO₃ (Calcium Carbonate). We never experienced that. (XSCG33)

None of the topics in science seem to have any use in my life. For example, cleaning products; we study the formula of soap production. Are we going to make any soap for which we need to know the production process of soap? We do maths on how many units of electricity we use daily. What is the benefit of doing this math? We get the electricity bill from the providers, if needed they will do the maths. Why should we? Similarly, count of yarns, quantity of cow dung to be used
in a biogas plant etc. we study these only to achieve good grades in exams, otherwise they are of no use in our life. (XNSG53)

One of the reasons given is that the content of science that students learn at the present time is outdated to a great extent.

…the models and information used to explain scientific things are of no use now-a-days. For example, the model of camera used to give the lesson on a camera, would be one of the most outdated models in the history of cameras. This camera is no longer being used. So, we got to read about this only to answer the exam questions. (IXSCB05)

Another important theme is the difference in views among non-science students. Non science students viewed their school science quite differently. Many of them did not think that this school science was useful for their life or their future career:

I am a student from business studies group. I do not have any use of science in my future career. I just study science for getting a good GPA, I do not have any use of this science in my future job life. (XNSG58)

Many non-science students thought that science was only for science group students. Science group students would use this learned science in their life and future career.

Science students can only use the school science that they learn. Those who are going to be an engineer in future will have to develop their skills in physics and chemistry. Those who are going to study medicine will develop their skills in biology. On the other hand, students in business studies and humanities groups
study science only for good marks in exams. They do not have any application of science in their lives. I am not a student of science group. (XNSG66)

Most of the students who disagreed with the contention that school science is not useful in their life wrote their responses around the theme *science is everywhere*. This theme is quite ambiguous. Most of the students pronounced that “science is everywhere”, “everything is dependent on science” but they did not make a clear connection between their school science and their real life. For example:

It would be wrong to say that we do not have any application of science in our life because we are living in a scientific era. Everything is science beginning from brushing our teeth in the morning until turning off the light before bed at night.

(IXSCG15)

One of the students suggested that they had yet to use school science in their life:

We have the application of science knowledge in every single moment of life. Although we cannot use all the knowledge of our science books yet, but someday they will be useful. (IXSCG19)

Some students seemed to be unsure about the difference between school science and the technology that they use in their daily life. Therefore, their responses seem to present the use of technology in real life instead of presenting the application of their school science in the real world.

We have lots of uses of science in our daily life. Every day we use the computer, mobile, television, etc. which are a contribution of science. (IXSCG13)

I collect question papers and solve the tests using the internet. I chat with my friends using Facebook. (XSCG34)
According to student responses, use of science in real life seemed to be about knowing things rather than using them in practical life:

…we have learned about soap production in chemistry, how a camera works in physics, internal structure of a toad and a human in biology etc. On top we know about the uses of medicinal plants and many more that are useful. (XSCG27)

It seems that they memorised knowledge or information about many scientific things and their uses, but they were not being shown any practical use of those things. As a result, they were unsure about the exact use of their knowledge in real life:

We definitely have some application or use of school science in our life, but as we memorise everything we do not see them or cannot realise the uses. (XNSG50)

Very few students (4) mentioned precise examples of real life applications of their school science. Interestingly, half of these (2) were from the non-science stream. One of the non-science students gave the following example of the use of science in real life:

In science, I learned about how to do grafting on a tree, how to set a tree on another tree. Then I did grafting on my own trees, I saw it works, and it benefitted me. So, science that I study at school has some application in my life. (IXNSB53)

Another non-science student gave this example:

I have some application of science in my life. For example, I make paper weight using abandoned pen and bulb, which I learned from our science book. I learned to make wash bottle using abandoned bottles, pen holder using broken glasses; all these things I learned from our science books. (IXNSB54)

A science student gave the following example:
…we learned about various medicinal plants in biology. We learned how neem (Azadivachta indica) tree is good for our health; I learned that if we take neem tablet, our health will remain well, therefore, I prepared neem tablets for us.

(XSCG32)

Another science student wrote:

I fixed the plug of our television the other day. It became possible only because I studied science. (IXSCB24)

Very few students (6 out of 141) partially agreed with the second part of Statement Three and mentioned that, in some cases they found some applications of science in their life but in other cases they could not:

Although I do not find any application of physics and chemistry, but I found the application of biology in my life. I learned about plants and how to take care of them and now I can take very good care of my garden. In addition, I learned about many diseases and I can keep myself safe. (IXSCG07)

In summary, there is social pressure on students to achieve the best results in examinations, especially in public examinations. Student responses confirm that everyone is interested to see the output in terms of the grades they achieve, regardless of what they learn in science. Teachers, for this reason, focus more on preparing students for examinations and do not worry about teaching practical science. Students are not being told about any application of science knowledge in everyday life. In consequence, they do not know about the uses of their science knowledge in their real life. On the other hand, students, who do not study science only for grades, believe that science is everywhere and knowledge is very important but they lament that they are yet to apply science knowledge in their lives.
4.2.4 Statement Four: science that I study at school is useful for my life, but because of the way that science is being taught I do not know whether school science has any practical use in my life.

4.2.4.1 First part of Statement Four: science that I study at school is useful for my life. Table 4.12 below presents the frequencies of participant positions with regard to the first part of Statement Four.

Table 4.12
Frequency of Responses for the First Part of Statement Four (n=141)

<table>
<thead>
<tr>
<th>Agreed</th>
<th>Disagreed</th>
<th>Partially agreed</th>
<th>Undetermined</th>
<th>No response</th>
</tr>
</thead>
<tbody>
<tr>
<td>87</td>
<td>5</td>
<td>2</td>
<td>27</td>
<td>20</td>
</tr>
</tbody>
</table>

In response to the first part of Statement Four “science that I study at school is useful for my life”, more than half of the students (87 out of 141) agreed that their school science was useful for their life. A very small number of students (only five), on the other hand, believed that their school science was not useful in their life. A very few (only two) students agreed partially; they found some of the school science useful. For example one of the partially agreed responses was, “some part of school science seems to be necessary. For example, ‘Variegation of Human Body’, ‘Sound’, ‘Electricity’ etc. are needed for us to learn. But ‘House Building Materials’, ‘Minerals’, ‘Cellular Structure of an Organism’, and many more, what exactly are we going to do with these after learning them?” A good number of responses (27 out of 141) remained undetermined as their responses did not indicate their position clearly. For example, in response to Statement Four (science that I study at school is useful for my life, but because of the way that science is being taught I do not know whether school science has any practical use in my life), one of the students wrote:
We know that in developed world there are many applications of science knowledge. The students who belong there are being benefitted from this. But how we learn science in school is just to let us know about scientific things but not to show us any practical application of them. (IXSCB26)

Based on this response, I could not determine his position on whether he agreed (or disagreed) that school science could be useful for his life. However, it would be worth mentioning that from his response, I was able to determine his position regarding the second part of the statement, that is, he agreed with it. Interestingly, a good number of students (20 out of 141) left this question unanswered and so they were classified as ‘no response’. Table 4.13 below presents the major reasons that students provided under key themes.

Table 4.13
Major Reasons under Key Themes Emerging from the Responses to the First Part of Statement Four

<table>
<thead>
<tr>
<th>Themes</th>
<th>Major reasons for students (frequencies of responses in the parentheses)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>agreed</td>
</tr>
<tr>
<td></td>
<td>disagreed</td>
</tr>
<tr>
<td>Science is everywhere (24)</td>
<td>Students believed that science is everywhere around them; science knowledge is very important and their lives are dependent on science</td>
</tr>
</tbody>
</table>

One of the key themes elicited from student responses is that science is everywhere: quite a good number of students (24) believed that science is very useful for their lives because science is everywhere around them, science knowledge is so important and their lives are so dependent on science. However, from their responses it seems that they were
concerned about the necessity of science generally, that is, the science outside of their school. They felt that without science in their lives, the world would be stagnant, but, they did not clarify how they found their school science useful in their lives; rather, they wrote their perceptions about the usefulness of science generally:

Everything around us is dependent on science. Now-a-days almost nothing is possible without using science. (IXSCG19)

Contribution of science in human life is enormous and we can’t think about giving a step without science. (IXSCG12)

Some of the responses give an idea that for some students, science knowledge is so important to have whether or not it has any practical implication:

…we can acquire lots of knowledge by studying science. Due to studying science we know a lot of things about the world. (IXNSB53)

These students seemed to believe that knowing things is very useful and sufficient rather than using them in practical life. However, one student was able to provide examples of topics and chapters that could be useful. She seemed to believe that the knowledge she gained from school science could be useful in her life by raising her awareness and helping her in decision making.

…we can know about so many things by studying science at school. For example, we can be aware and stay alert by knowing about electricity. Variegation of human body, nutrition etc. chapters make us aware of our health and body. Knowledge about plants and plant cells help us be more conscious about plants and their nutrition. Chapters on population and disaster management help us be greatly aware of our environment. Considering all of these, I feel that science is so important.
Another theme around the responses to Statement Four is *school science is important for future career*. A few students (6 out of 141) found school science useful for their future career thus considering it useful for their lives:

- School science is necessary in order to become a doctor or an engineer. (XSCG27)

- Studying science is necessary for me in order to sit for university entrance exams, as I want to be an engineer. (IXSCG07)

Although a very small number of students disagreed with school science being useful, their views seem to be consistent with many of the common responses made with regard to some previous statements. These responses did not generate any new theme. For example, one of the non-science students reiterated a common view of non-science students regarding their school science:

- As I am a student of humanities group, science is not so important for me. Plus, nobody cares about science for humanities students. (XNSG54)

Non-science students expressed similar views elsewhere a number of times. Such views indicate that non-science students to some extent believed that science is only for science students and not an important subject for them; only science students have the authority to study and utilise science knowledge in their lives and future careers. Therefore, school science did not seem to have any usefulness for the lives of non-science students.

It is worth noting that almost equal numbers of students (57:58) agreed and disagreed with the second part of Statement Three, “science that we study at school has very little/no use in my life”, while in response to Statement Four more than half of the
students (87) agreed that school science is useful for their life. In other words, in response to Statement Three, although 57 students agreed that their school science had very little to no use in their life, 87 students offset this and agreed that their school science was useful for their life.

The first part of Statement Three was about grades or results that students strive for while pursuing study in science and the second part of the statement was about the usefulness of school science. On the other hand, the first part of Statement Four was about the usefulness of school science and the second part was about science teaching that students experienced in school. Comparing the cases, perhaps the other part of the statements influenced the pattern of student responses and the frequencies of responses that appeared.

Although the number of responses varied, students who agreed that school science is useful for their life still hesitated while giving examples of uses of school science in their life. The data in the previous section and in this section suggest that students were not sure about the applications of school science when they were requested to report examples. For example, they mentioned that science is everywhere around them while reporting the uses of school science in real life. On some other occasions, they mentioned technology as an application of school science in their life, yet these may not be real examples of applications of the science that they study in school. Such dilemmas are discussed in detail in Section 5.8 of Discussion Chapter.

4.2.4.2 Second part of statement four: because of the way that science is being taught, I do not know whether school science has any practical use in my life. Table 4.14 below presents the frequencies of participant positions with regard to the second part of Statement Four.
In response to the second part of Statement Four, “because of the way that science is being taught, I do not know whether school science has any practical use in my life”, most of the students (91 out of 141) agreed that because of the way science was being taught they did not know whether their school science had any practical use in their lives. Only one eighth of students (18 out of 141), on the other hand, disagreed with the assertion and felt that the way science was being taught helped them to know about the practical uses of school science in real life. A very few (only 3) students agreed partially; to some extent the way science was being taught helped them to realise the practical use of school science, however, they urged for improvement on many occasions. For example, “on some occasions we can realise the practical use of science topics in our life. However, if the quality of teaching and practicals could be improved, we would learn the use of science better” (IXSCG04).

I could not determine some students’ (9 out of 141) positions regarding the second part of Statement Four; their responses remained undetermined. For example, one of the students wrote: “our teachers do not want to teach us anything in regular classes. Rather, they prefer teaching everything in private or in coaching centres” (XNSB66). Based on this response, I could not determine his position on whether he agreed (or disagreed) that the way science was taught helped him realise the practical uses of school science. Since he mentioned a different issue related to the private tuition culture in Bangladesh and his response was so brief, I was unable to pinpoint his exact position regarding the statement.
As mentioned earlier, for some unknown reason a good number of students (20 out of 141) left this question unanswered and classified as ‘no response’. Table 4.15 below presents the major reasons that students provided under key themes.

Table 4.15
Major Reasons under Key Themes Emerging from the Responses to the Second Part of Statement Four

<table>
<thead>
<tr>
<th>Themes</th>
<th>Major reasons for students (frequencies of responses in the parentheses)</th>
<th>agreed</th>
<th>disagreed</th>
</tr>
</thead>
<tbody>
<tr>
<td>How science is being taught</td>
<td>No opportunity of gaining hands-on experience; teachers mostly followed lecture methods while teaching science (66)</td>
<td></td>
<td>Science teaching was adequate; teachers helped them know the real life uses of school science (7)</td>
</tr>
<tr>
<td>Exam focused education</td>
<td>The main focus is to pass the examinations and achieve the best grades regardless of what is required to be learned; examinations were designed to assess memory therefore encourage rote learning (23)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The reason for not having any practical use of school science for most of the students who agreed with this statement (66 out of 91) is that they had not had hands-on experience of science; teachers mostly followed lecture methods while teaching science and they did not tell them anything about the application of their school science. Typical responses under the theme how science is being taught were as follows:

Our teachers do not give us any hands-on experience while teaching science. So we are deprived of having any real-life-oriented science education. As a result we do
not know any application of science knowledge, and so we can’t do any practical application of science knowledge. (IXSCG10)

…in school we completely depend on the lectures of our teachers. As a result, we just listen but viewing and understanding are absent (XSCG37)

…we are not taught how we can apply science knowledge in real life; our teachers do not tell us how we can use such knowledge in our life. (IXSCG13)

Textbook content is just being lectured. Chalk and white/black board are the commonly used instructional materials:

…just the content of science is being read and lectured; apart from that there is no hands-on activity and nothing is explained to understand… (IXSCG14)

…we are being taught science using the chalk-board. Therefore we do not get proper and complete knowledge of science. (IXSCG02)

As a result students have to use their imagination to conceive of scientific concepts that could be given as practicals:

…for example in chemistry, atom, molecule, or their size and structure, acid, base, we have to imagine these while studying. (XSCG37)

Many of them mentioned that the teaching methods they were exposed to were inappropriate for learning science, so that they could not understand the practical use of their school science:

…the ways that are used to teach us science are wrong so that the uses of science in our life are not clear. (IXSCG12)
One of the reasons for using such inappropriate methods may be related to teachers’ expertise and skills in teaching science:

We have many inexpert teachers in our school who cannot teach us about what is the future of studying this school science, what are the benefits of studying this science. I find their teaching useless. (XSCB41)

In consequence, students found science topics difficult, failed to realise the importance of science knowledge and reported that studying science was meaningless and irrelevant. As a result, their interest in science was dropping gradually.

…for example, chapters like ‘Thermal Machine’, ‘Electronics’ are not taught practically so that we do not realise the importance of these chapters and also find these chapters difficult… (XSCG23)

Because of the ways followed in teaching science, I am losing my interest in science… (XSCG22)

The ‘content-dominated school science’ is another feature (sub-theme), because students did not experience the application of school science. Science teaching was mostly textbook-centred and the textbooks were densely content-dominated. The content mostly represented theories, laws, postulates and facts, and was not linked with their application in reality. As a result students memorised theories and facts without knowing their implications for their real life.

…in our textbooks we usually get the answer of ‘what?’ and ‘how?’, but we do not get any answer of ‘why?’ and ‘where is its application?’; therefore we are not able to say if there is any application of school science in our life. (IXSCG18)
…fundamental principle of Calorimetry is, heat lost by one = heat gained by another. This information is very important. From ‘Galileo’s Law of Fall’ we know that in a vacuum, a light and a heavy material will touch the ground at the same time if they start falling with zero velocity. We never experienced these important theories practically. As a result we never can realise the practical application of these sciences. (XSCG33)

‘Nature of science practicals’ was another important feature (sub-theme) that helped understand why students did not identify any application of science. According to the curriculum document of the National Curriculum and Textbook Board (NCTB, 1996), practical component of each science subject (physics, chemistry and biology) carries 25% of total marks in examinations. By the requirement of the curriculum, they had to attend practical classes and do science experiments in order to learn science process skills and the applications of science knowledge by themselves. But in reality their practical is quite different; their teachers demonstrate the practicals and they just watch them as an inactive audience.

We are just demonstrated some fixed conventional practicals. So we don’t understand the practical uses of science. (IXSCG13)

We are not given any opportunity to do science practicals by ourselves. (IXSCG02)

Another key theme raised by the student responses towards Statement Four was exam focused education. According to responses of the students, everyone (other students, teachers, school authority or parents) focuses on passing the exams and achieving the best grades regardless of what needed to be learned. So, the application of science knowledge was not given importance in the teaching or learning of science.
I study science only to do well in exams, exam related things are important to me.

(XSCG24)

The exams did not assess the skills of science; rather exam skills were quite different and technical, and had to be learned.

We are being taught to achieve good grades in exams, not to use science in real life. In school, I learn what section would be the best to write the answer of which question, what would be the length of an answer, how to write the best answers for the exam questions. If we want to learn any application of science we are told that this is not what we need to learn, we should learn how to do well in exams.

(IXSCB16)

The examinations are high stakes. As previously found, high scores in these examinations are important to get admission to better colleges and universities. There is always a lot of social pressure on students to be prepared for well-accepted professions. National examinations and the exam scores are recognised as the gateways to better professions, so these exams are not set to assess science skills.

I only know that I have to do well in exams by any means. If we ask our teacher anything about science they say that we have to study science only to achieve A+, to get admission into a top class college and eventually to a top class university.

(IXSCB06)

Basically we all view studying science as a way of getting a good job. (IXSCB16)

We are taught in way that is helpful to achieve good grades in exams in order to brighten my future, but we do not learn any real life application of science.
As a result they pass the exams with good grades but at the same time they feel that their learning is limited:

We are taught science in school only to pass the exams that is why our knowledge about the application of science is so limited. (IXSB57)

Another important sub-theme of exam-focused education is ‘memorisation’. The process of learning science with this emphasis was reading books, memorising the content and practising examination type questions. The examinations were designed to assess students’ memory about the content within the textbooks; to be specific most of the test items required students to copy the exact text from textbooks, so that they memorised the content and wrote the exact texts in exam papers. As a result there was little or no relation between school science and everyday life.

The way of learning science is, we read, we memorise, we give exams and then we forget. We really forget what we learn because we do not understand science and we must forget. As a result we do not know where exactly science knowledge can be applied. (IXSCG08)

So the system encouraged students to memorise science and did not require the development of science skills.

We just memorise science. We can’t use any science knowledge in real life. We do not even understand how we can apply our science knowledge. We do not even learn the uses or applications of science. (IXSCG20)

Similar to previous cases, a few non-science students were found to believe that their orientation to science was different, and they did not see any practical use of school
science. They seemed to believe that not having any practical class like those offered to science students was the main reason for not identifying the applications of science in their lives outside of school:

We (non-science students) do not do any practical in science, so we do not know any application of science. (XNSG57)

Students who disagreed mainly responded around the theme how science is being taught. Most of them found science teaching suited them and helped them know the real-life uses of science. However, most of them could not provide an example of where or how they related their school science to the real-life uses of science.

Our teachers teach us science with care and make science interesting for us so that we can learn about applications of science in everyday life. (IXSCG11)

This was the typical of the responses of the students who disagreed. Of them, only two students gave a specific example about knowing scientific knowledge rather than using science knowledge in everyday life. Of the two examples, the first one was from a non-science student.

I acquire lots of knowledge about many things that I use daily. For example, before studying science I did not know how exactly electricity current flows, or the mechanism of sound transmission in air. By studying science now I know a lot more information like these which would not have been possible by any other means. (XNSG66)

We are benefitted by studying science and using it in daily life. For example, what we see in chemistry lab or in biology we learn about identifying plants and animals, so that in reality we can be careful and stay safe by identifying them. (XSCG34)
It seemed dubious that some students are saying they are applying their school science in their life even if they could not provide any specific example of how they did this in everyday life. One student's response might explain one of the underlying reasons behind this apparent mystery:

I do not want to comment on this matter, because this would be a criticism of our teachers and the school authority. (XSCB34)

In summary, students confirmed their beliefs that science was useful for their lives because science was everywhere around them, science knowledge was very important and their lives were so dependent on science. However, their responses seemed to be concerned about the necessity of science generally, the science outside of their school. They felt that without science their lives and overall the world, would be stagnant, but they did not clarify how they found their school science useful in their lives and the world around them; rather, they wrote their perceptions about the usefulness of science generally. Another important reason for science being useful was that science was helpful for future careers. For example, to become a doctor or an engineer they had to study science.

On the other hand, most of the students agreed that because of the way science was taught they were unsure whether their school science had any practical use in their lives. According to their responses, common features of school science pedagogy were: it was content-dominated; textbook content was being lectured; chalk and black board were the commonly used instructional materials; it was exam focused and memorisation based; and practicals were demonstrated with students as an inactive audience. Because of all these factors, students were unsure about the connection between school science and their everyday lives.
4.2.5 Statement Five: the chapters to be studied in science are huge, and we are always racing to finish them.

4.2.5.1 First part of Statement Five: The chapters to be studied in science are huge. Since the focus group participants provided a notion that their science textbooks comprised very big chapters so that they had insufficient time to finish them, this statement was developed in order to reconfirm the claim and understand the problems that students faced due to the size of the chapters. After analysing student responses, the frequencies of participant positions were counted. Table 4.16 below presents the frequencies of participant positions with regard to the first part of Statement Five.

Table 4.16
Frequency of Responses for the First Part of Statement Five (n=141)

<table>
<thead>
<tr>
<th>Agreed</th>
<th>Disagreed</th>
<th>Partially agreed</th>
<th>Undetermined</th>
<th>No response</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>21</td>
<td>14</td>
<td>5</td>
<td>11</td>
</tr>
</tbody>
</table>

In response to the first part of Statement Five, “The chapters to be studied in science are huge”, most of the students (91 out of 141) agreed with this, while a relatively small number of students (21 out of 141) disagreed. Some students (14) agreed partially; they found some chapters over-sized and other still manageable: “all the chapters are not huge. Many big chapters are not clear enough in terms of the explanations on important topics” (XSCB36). A few students’ responses (5) were ambivalent so that it was too hard to determine where they fell. For example, in response to Statement Five, a student wrote simply, “I have to spend plenty of time after studying science” (XNSB69). From this response, I could not determine whether he felt that the chapters in science were huge or he did not get sufficient time to finish them. This type of undetermined response was classified as ‘undetermined’. I found 11 students falling into the ‘no response’ category.
Since most of the students agreed that chapters in science textbooks were huge, many of them gave examples of big chapters in science along with an idea about how big they were.

…in physics each chapter is 20-22 pages on average; in chemistry each chapter consists of 15-20 pages on average; and in biology each chapter is 18-22 pages long on average. (IXSCB20)

Physics chapters are huge. For example, refraction of light chapter is 19 pages, Current electricity chapter is 22 pages which takes 10-12 days to finish. (IXSCB01)

We have 22 chapters in science which are equal to 30-35 chapters in other subjects. Especially the biology chapters are very hard to finish, e.g., Plant Physiology is 35 pages, Variegation of Human Body is 28 pages. (XNSG69)

…for example, in Physics, ‘effect of heat on substance’, ‘motion’, ‘reflection of light’; in Chemistry, ‘properties and uses of metals and non-metals’; and in Biology, ‘structural organisation and acquaintance of animals’, ‘toad’ etc. are huge chapters. (XSCG23)

As a result, they reported that their interest in studying science decreased noticeably.

Out of 21 chapters in science book, the shortest chapter is ‘colouring materials’, which is just three pages long. If we begin to study any of other chapters they never finish off. If I start a chapter with huge spirit, I must end up with being bored to finish that chapter off… (XNSG53)

Because of the big chapters, we lose interest in science. (XSCG23)

I am frightened to see the huge chapters in science. If I start studying any of those, I can’t go much further in one go, then if I start again from where I stopped last I
I forget what I studied previously. Finally in examination time, I mess up with everything. (IXSCB04)

I myself investigated the science textbooks in order to count the chapters and total pages dedicated to content and practicals in each book and found the following:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Total chapters (including practical)</th>
<th>Total pages (including practical)</th>
<th>Pages for content</th>
<th>Pages for practical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics</td>
<td>26</td>
<td>354</td>
<td>330</td>
<td>24</td>
</tr>
<tr>
<td>Chemistry</td>
<td>16</td>
<td>223</td>
<td>199</td>
<td>24</td>
</tr>
<tr>
<td>Biology</td>
<td>17</td>
<td>262</td>
<td>224</td>
<td>18</td>
</tr>
<tr>
<td>General Science</td>
<td>21 (no practical)</td>
<td>256</td>
<td>256</td>
<td>0</td>
</tr>
</tbody>
</table>

It seems that all the textbooks contain many pages and most of the pages are full of content. In comparison, Physics is overcrowded with chapters and pages. A very low percentage of space in books is allocated for practicals. On top of this, according to student responses, practicals are practised as a demonstration of experiments where students are a silent audience. These findings are also supported by Mst Shaila Banu (2011).

Moreover, some students’ responses revealed that the subject matter included in the big chapters was not well explained, rather a large number of topics was crammed in textbooks without explaining them adequately.

…science chapters are enlarged unnecessarily; unnecessary things are included more than necessary things. Although the chapters are broadened, they lack of
necessary information and explanation for which so many things cannot be understood. (IXSCG02)

…there are so many things discussed in each of the chapters. We do not understand a lot of them, so a big chunk of time is being wasted… (XNSG55)

Science chapters are as big as they are unfathomable… (IXSCB10)

Some of the students (19) commented that these huge chapters consumed a lot of time. Students have to study nine subjects in total; in every semester they have to sit for eleven examinations (as mentioned earlier Bengali and English have two parts and examinations are being held separately for both the parts) and they have to sit for three end-of-semester exams in each academic year. Consequently, it is very hard for them to manage time for other subjects in addition to the extensive time they have to dedicate to science subjects. In consequence, according to them, they achieve lower grades in exams.

Since the chapters in science are so big, we have to leave many chapters untouched during exams, as a result we achieve poor grades in exams... (IXSCB23)

We have too many science books. Often we do not get sufficient time to study other subjects due to these books. (XSCG37)

In case of some chapters in physics, when we reach the end we can’t remember what we studied at the beginning. (XSCB31)

Although many of the students reported facing many problems due to the huge chapters in science, a very few students (8), provided a justification for the chapters being broadened.
Chapters in science could be broadened in order to learn science content appropriately and thoroughly. It would also be time consuming to comprehend and practise the subject matter in science. (IXSCG04)

If the content of science is not well-understood with sufficient explanation, we would not be able to utilise them in exams as well as in our life. Since the chapters are being broadened, we could learn science content thoroughly. So, even if it takes a little bit extra time, it is good for us. (XSCB34)

Students (21) who disagreed with the statement seemed to believe that the chapters were not too big to be unattainable. According to their comments, if science chapters were studied attentively and understood well, they would be doable.

…if the big chapters are understood properly, they do not take much time to finish. (XNSG65)

…except two or three chapters, most of the chapters in science are short and if studied attentively, each chapter would take one to two days to finish off. For example, ‘the world of science’ chapter is easy and interesting; it could easily be finished in one day. (IXNSB52)

It is worth mentioning that these comments were made by non-science students who study only one science textbook comprising shorter chapters compared to the science textbooks for science students. This textbook also does not provide in-depth knowledge of science content (NCTB, 1996; Rahman, 2011). These students found there were too many chapters in their science textbook:
Except one or two chapters, most of the chapters in science are not so long. Rather
the number of chapters is huge. As a result we do not get enough time to finish all
the chapters off. (XNSB62)

On the other hand, a very few science students (2), disagreeing with ‘science
chapters were huge’, were more concerned about the science content being unattractive:

I do not think science chapters are huge, rather they are unattractive. (XSCG30)

Some students (13) partially agreed with ‘science chapters are huge’; they found
some chapters long and some chapters short, or some science textbooks extended and some
relatively less extended.

…all the chapters in science are not overextended. Many of them are short and
easy, we could easily finish them off in short time. Some of them seem like they
should have been broadened with better explanation so that we could understand
them better. On the other hand, some chapters are extended for no reason. Still we
do not get enough time to finish some chapters off. (IXSCB202)

…I get enough time to finish off biology and chemistry. But physics syllabus is
huge. It seems like if I study physics all day long I would not be able to finish
physics syllabus… (IXSCG01)

In summary, according to the student responses, science textbooks contained an
unreasonable amount of content of science for which they were required to spend a lot of
their valuable time. Among all the textbooks Physics was seen as heavier than those for
any other subjects. Although the textbooks covered a huge amount of science content,
much of the topics were not well explained or self-explanatory. In consequence, as they
could not spend the time required for science subjects they achieved lower grades in
examinations. As a result, their interest in studying science had faded away. On the other
hand, some of the students still did not think that science chapters were lengthy. However, most of them were non-science students as they had only one science textbook to study. A relatively very small number of students thought that in order to better understand science content the chapters had to be large, extended and elaborate.

4.2.5.2 Second part of Statement Five: we are always racing to finish the huge chapters. Table 4.17 below presents the frequencies of student positions with regard to the second part of Statement Five.

Table 4.17

| Frequency of Responses for the First Part of Statement Five (n=141) |
|---|---|---|---|---|---|
| Agreed | Disagreed | Partially agreed | Undetermined | No response |
| 74 | 22 | 8 | 26 | 11 |

In response to the second part of Statement Five “we are always racing to finish the huge chapters”, more than half of the students (74 out of 141) agreed, while a relatively small number of students (22 out of 141) disagreed. Although the number of students agreeing with the second part of Statement Five was less than the number of students agreeing with the first part of Statement Five (“the chapters to be studied in science are huge”), the numbers of students disagreeing with both parts of the statement were almost equal (21 and 22). A good number of responses to the second part remained ‘undetermined’ (26), as their responses were not clear enough for categorising. In response to Statement Five, many of the students basically provided their explanation about the big chapters being huge (first part) and seemed to implicitly agree that they were in a hurry to finish the huge syllabus of science (second part). But, as some of them did not explicitly mention that they always had to be busy in order to finish the big chapters, I could not categorise them as ‘agreed’; rather they were deemed ‘undetermined’. For example, in
response to Statement Five one of the students responded: “Even though the chapters are huge, if they were filled with appropriate examples and good pictures, they would have been easy for us, as a result we would not have any problem with those big chapters” (XSCB30). From this response I was able to identify that the student agreed that science chapters were huge but I could not determine whether he felt he had to race to finish those huge chapters.

A few students (8) agreed partially; they found some chapters over-sized, and had sometimes, but not often, to remain busy in order to finish them off: “In case of some chapters we do not get enough time; sometimes, but not always we are busy finishing them off” (IXSCG06). Finally, I found 11 students falling into the ‘no response’ category.

The consequences of the size of the chapters are significant. Though there are huge chapters in science, students are given less time to study them all. According to their responses, it seems that they could not finish studying all the chapters in the given time frame.

…the time we are given to study the big chapters is not enough. That is, compared to the volume of science chapters we get insufficient time, as a result often it becomes impossible to finish those chapters off. (IXSCG13)

Every chapter takes a lot of time to understand completely. We can’t remember everything of the big chapters. Therefore, we have to pay more attention and give more time after these chapters and so we remain busy to study these chapters.

(IXSCG07)

Not only were the chapters huge, they were difficult to learn as well (already elicited from the responses to Statement One). So study needed extra time and extra effort,
but students were not given the time needed to complete the chapters with better understanding.

Science is difficult to study; compared to that we get less time. Therefore we can’t complete studying science. (IXSCG20)

As mentioned earlier, these students always experienced exam pressure (they had to sit for three end-of-semester examinations in each academic year) and they had to undertake good preparation for these examinations. But the syllabi for examinations seemed quite unattainable in the time given in each semester. As a result, students felt forced to memorise science rather than comprehending and remaining busy with science.

Each semester we have to study eight chapters of physics, five chapters of chemistry and five chapters of biology. On the one hand, these chapters are so big so that they [the chapters] need extra time and effort to comprehend. On the other hand, we get only two or two and half months in each semester. As a result we memorise most of the chapters without understanding. (IXSCB10)

We have to attend three semester exams in a year and for each semester we have less than three months time. Within this short time it is quite impossible to master all the subjects. As the chapters in science textbooks are so oversized we have to spend our time memorising those chapters rather than comprehending them.

(IXSCG02)

As we are not given sufficient time, we cannot learn the content properly; and very often we sit for exams so that we are supposed to take preparation for exams in a very a short time. In consequence, we can’t take better preparation with having better understanding of the content. Due to lack of time we memorise science for exams and so we do not learn the actual knowledge of science. (IXSCG04)
As the syllabi of science are huge, teachers have no other alternative but accomplish them in time. The school authority seems to put pressure on them and so they have to keep the ball rolling. According to student responses, they leapt over the content regardless of what students learnt. The only goal was to get to the end of the syllabi and push students towards the exams. In consequence, students left many chapters unstudied and sat for exams without having complete knowledge of science, according to their responses.

…as science chapters are huge, each time [before each semester exam] any [at least one chapter] of them remain untouched. Our teachers always rush through the content and try to finish the syllabi by skimming over the content so that the school authority can’t blame them [teachers] for anything. (IXSCG03)

Our teachers try to teach us so many things in a very limited number of classes and so they [lessons on content] are brief. As a result we face so many problems in comprehending science lessons. As we do not comprehend the chapters properly we have to spend more time on it. (IXSCG08)

…we leave many chapters untouched as they are huge; these chapters are really very hard to finish off. (XSCB50)

Moreover, students lag behind in other subjects as they have to study nine subjects at a time and each subject carries the equivalent weight in examinations.

…since we spend much time after science [pay more attention on science], we stay behind in other subjects. (XSCG24)

A few non science students mentioned that they had to pay more attention to their major subjects such as accounting and business entrepreneurship. As science was not their major subject they could not allocate more time for science over other subjects. As found
earlier they were also not interested in spending much time on science as they did not find any use for science in their present and future life.

As student of business studies [non-science group] we have to spend more time on our main subjects like accounting, business introduction, business entrepreneurship. On top, we have Maths and English… (IXNSB54)

Most of the students who disagreed with the statement basically emphasised maintaining a regular routine, having patience and studying science attentively in order to overcome the huge size of the chapters so that they did not need to remain busy with science. According to their responses, students had to be patient and, study science attentively to understand properly, so that they would be able to accomplish science chapters in time. These students seemed to be mature enough to take responsibility for being patient and maintaining a regular routine in their education.

If we maintain a consistent routine and study regularly, we would get enough time to accomplish the study of the chapters; we would not need to remain busy in finishing them [chapters in science] off. (IXSCB24)

Although two or three chapters are extended, they [big chapters] only need patience, attention and concentration, nothing else. If we study them attentively with patience, they could easily be completed; we do not need to be busy with them. (XNSG59)

…once we comprehend the content of science properly, we do not need to be busy with science. (XSCB51)

Based on these points of view it seems that students felt they had to take responsibility for completing the huge chapters of science. The students mature enough to take responsibility and work with pressure would be able to do that in the given time. Still,
it seems that for a number of students full study of the chapters in science was regarded as quite unattainable in the given time frame.

Again a few non-science students provided some different views about their experience of science. As found earlier, they did not appear to place as much importance on science, because science had no use in their then current and future lives. Their responses seemed to suggest that non-science students did not give priority to science in the same way as they did for other subjects. All they needed was to pass the examinations and so they tried to find the shortest way to achieve their goal.

I study science just a few days before exams. I am not busy with science like I am with other subjects. Firstly, I don’t like memorising science; secondly, if I memorise science early in advance I would not be able to remember the content by the time of the exams. So in fact I memorise science content only on the nights before the exams and deliver it very next day in exam papers. My only goal is to pass the exams, nothing else. (XNSG53)

In summary, most of the students agreed that they found science chapters excessively long huge and most of the time they remained busy studying these huge chapters. Despite the huge chapters in science, students were given little time to study them all; as a result they could not finish studying all the chapters with a good understanding of the science content. Not only were the chapters huge, they were difficult to learn as well; as a result students had to allocate extra time and effort for studying the chapters to understand the science topics well. They also experienced exam pressure for which they had prepare well, but the syllabi for examinations seemed quite unattainable in the given time frame. As a result, according to their responses, students felt forced to memorise science rather than comprehend the topics.
As they have to cover a vast syllabus of science, teachers have no other alternative but to complete the topics in the given time frame. According to student responses, they (teachers) bounce over the content while teaching science heedless of what students learn. Their only goal is to finish the syllabus off, and in consequence, students leave many chapters unstudied and sit for examinations without having complete knowledge of science. So it is not surprising that students lag behind in other subjects as they have to study many subjects at a time. According to a few non-science students, they needed to pay more attention to their stream related subjects (e.g., accounting, business entrepreneurship) and for this reason they did not have much time to allocate to science. As found earlier they were also not interested in spending more time on science than on their major subjects as they did not see any use for science in their present and future life.

On the other hand, most of the students who disagreed that we are always racing to finish the huge chapters commonly placed emphasis on maintaining a regular routine, having patience and studying science attentively in order to overcome the stress of the lengthy chapters. However, the number of students holding this view was very low compared to the number of students experiencing the pressure of the vast array of content and the inadequate time in which to study it. Moreover, the majority of those unconcerned about the extensive content were from non-science streams who had relatively less exposure to science.

4.2.6 Open-response question One: question on science textbooks. The first open response question asked students: Do you like your science textbook(s)? Why or why not? Explain with examples. Since the focus group participants presented their views about the science textbooks during the FGI sessions, this question was developed to learn more about students’ evaluations of their science textbooks. In response to this question whether they like their science book(s) or not, almost equal numbers of students liked and disliked
their textbook(s); 61 students (out of 141) answered ‘yes’ and 58 students answered ‘no’. Out of 141, seven students did not provide any response to the question regarding their textbook(s). Besides this, 15 students gave ambivalent answers; they liked some of their science textbooks and they disliked the others; or they liked some of the chapters and they disliked the rest: “I like physics and chemistry, but not biology” (IXSCB11).

Table 4.18 below distributes the responses of students across all the streams, grades and genders.

Table 4.18
Frequency of Responses related to Textbooks across all the Streams, Grades and Genders (n=141)

<table>
<thead>
<tr>
<th>Responses of students</th>
<th>Yes</th>
<th>No</th>
<th>No response</th>
<th>Not all the textbooks (some of them) or not all the chapters (some of them)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>61</td>
<td>58</td>
<td>7</td>
<td>15</td>
</tr>
</tbody>
</table>

Student groupings

<table>
<thead>
<tr>
<th>By Stream</th>
<th>Science</th>
<th>Non-science</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>By Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>By Grade</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>By Grade</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>By Gender</th>
<th>By Stream</th>
<th>By Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science</td>
<td>35</td>
<td>9</td>
</tr>
<tr>
<td>Non-science</td>
<td>26</td>
<td>6</td>
</tr>
<tr>
<td>Boys</td>
<td>29</td>
<td>8</td>
</tr>
<tr>
<td>Girls</td>
<td>32</td>
<td>7</td>
</tr>
<tr>
<td>Grade 9</td>
<td>24</td>
<td>7</td>
</tr>
<tr>
<td>Grade 10</td>
<td>37</td>
<td>8</td>
</tr>
</tbody>
</table>
The difference in responses across the streams seems to be significant. Comparatively more students from the science stream did not like their science textbooks; while 50 science students (out of 97) did not like their science textbooks, only 8 non-science students (out of 44) responded negatively about their science textbook. The following sections will unearth the reasons behind this difference besides analysing the overall responses of the students regarding their science textbook(s). Table 4.19 below presents the major reasons for students liking or disliking science textbooks.

Table 4.19

<table>
<thead>
<tr>
<th>Major Reasons for Students Liking or Disliking Science Textbooks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major reasons for students (frequencies of responses in the parentheses)</td>
</tr>
<tr>
<td>liked</td>
</tr>
<tr>
<td><strong>Curiosity in gaining science knowledge (35):</strong> Science knowledge is important; information can be gathered by studying science textbooks, which would increase knowledge level</td>
</tr>
<tr>
<td><strong>Interesting, enjoyable and full of fun (17):</strong> Many interesting and exciting things can be learnt from science textbooks</td>
</tr>
<tr>
<td><strong>Connection to real life (17):</strong> Knowledge from the science textbooks can be applied in real life</td>
</tr>
</tbody>
</table>
4.2.6.1 Responses of the students who like their science textbooks. Most of the students (35, with 20 from the science group and 15 from non-science groups), who liked their science textbook(s), highlighted their curiosity to gain science knowledge as a reason for liking the science textbook(s). They found that by studying science textbooks they could learn “a lot of stuff”, gain knowledge and gather information, which would benefit them by increasing their knowledge level. Most of them responded in a similar fashion to the following statement:

I have gained a lot of knowledge and information by studying our science textbooks; I have learned about a lot of things from the textbooks which eventually increased/ expanded my knowledge level. (XSCG32)

In order to support this statement only one science student gave an explicit example, while most of the students did not provide any example of what sort of knowledge and information they had gained or what sort of knowledge had increased their knowledge level. This example one gave relies heavily on the importance of knowing science content:

…for example in biology, I could learn about identifying various plants and animals and their detailed description. (XSCG34)

Of the non-science students, two gave the same example of a science topic and placed importance on having science knowledge. This topic is particularly present in the general science textbook designated for non-science students.

…for example, after studying the ‘news communication’ chapter I realized how news is being communicated. (XNSG62)

A few of these students also believed that this knowledge would benefit them in future. Here as well, they could not provide any example or further explanation regarding
how this knowledge would benefit them in future. These students were also from non-
science streams.

In our science textbook, the basic subject matter of science has been discussed
which will benefit us in future. (IXNSB57)

So, these students emphasised the importance of having science knowledge but did
not appear to be confident about the implication of this science knowledge that they
obtained from their science textbooks. Among them, relatively a greater number of non-
science students liked their science textbook as a good source of knowledge.

Under the theme interesting, enjoyable and full of fun, a number of students (17,
with 10 from the science group and 7 from non-science groups) put forward the reason that
they could learn many interesting and exciting things from their science textbooks,
although only one of them provided a specific example of interesting content from their
science textbooks. The common comments in favour of liking science textbooks were as
follows:

We can learn about so many interesting and exciting things from our science
textbooks. (IXSCB14)

…every chapter in science textbook(s) is enjoyable as well as being interesting and
full of fun. (XSCG34)

Our science textbook contains many interesting chapters... (XNSG57)

…for example, toad in biology, reflection of light and lens in physics, and organic
compounds in chemistry. (XSCB43)
A number of students (17, with 10 from the science stream and 7 from non-science streams), in addition, seemed to believe that their science textbooks provided them with knowledge related to their daily lives and enabled them to apply this knowledge in real life.

…we can learn about basic knowledge mostly related to our real lives and relevant processes. (XSCG40)

From our science textbooks, we could learn about what is beneficial for us and what is harmful for us. (IXSCB06)

These comments suggest that students place importance on obtaining science knowledge from science textbooks regardless of any evidence of uses of the knowledge in their everyday lives. Amongst them, a few students (8) seemed to believe that they could apply what they learned from science textbooks in everyday life. However, at the same time, they could not provide any example of the application of science knowledge in everyday life.

What I learn from science textbooks, I do (or can) implement and apply them in my personal life. (XSCG32)

The issue related to the connection of school science to real life has been discussed in detail in previous sections of the analysis regarding statements three and four. In the current section of analysis some students repeated their perceptions about the relation of science knowledge with everyday life. Since, this issue has already been reported, the repetition of interpretation of data has been avoided.

The theme easy and well-explained was yielded exclusively from the responses of some non-science students (10 out of 26 non-science students liking the science textbook). None of the science students provided responses categorised under this theme. These
students shared their experience with the science textbook, characterising it as being well-written, well-explained and easy to follow and understand.

Everything in our science textbook is presented in a precise and simplified way, so that we do not face any problem in studying and learning the topics. Some important subject-matters like the greenhouse effect, human body, usage of electricity, ecosystem, and disaster management and Bangladesh, etc., are presented in an easily understandable way. (XNSG67)

Everything is well-explained in our science textbook; as a result, we do not feel any problem in understanding them. (XNSG65)

…for example, if anyone doesn’t know anything about AIDS, after studying our science textbook [AIDS chapter in science textbook] he/she will be able to know about AIDS and be aware of AIDS. (XNSB67)

Chapters in our science textbook are very easy. (IXNSG49)

As mentioned earlier, these non-science students study a single science textbook and compared to the textbooks dedicated for science students, this textbook covers very basic science content while the textbooks for science students cover advanced content of science (NCTB, 1996; Rahman, 2011). The reduced study-load compared to that of science stream students and the nature of the content of science included in the textbook may have been the reasons for the positive responses of non-science students. As a result it seems that these experiences enabled them to do well in examinations and thus achieve good grades in science.

I could answer all the questions in the science exam and I get good grades in science… (IXNSB53)
In summary, a good number of non-science students liked their science textbook(s) compared to their peers in the science stream. The most common reason for students (from all streams) liking their science textbook(s) was that they could learn a lot of knowledge and information from their textbook(s). This knowledge and information increased their knowledge but they did not seem confident about how they would use this knowledge and information in their daily lives. Some of them seemed to believe that this knowledge would benefit them in future but still they could not articulate how this knowledge would benefit them in future.

A number of them mentioned that they found many interesting and enjoyable chapters in their science textbook(s) from which they could learn many interesting and exciting topics of science. However, still students could not supply an adequate example of science subject matter from their textbooks that would be interesting or exciting.

Some of the students also seemed to believe that their science textbook(s) enabled them to apply science knowledge in everyday life. However, their comments suggest a blurry and ambiguous relationship between science knowledge and everyday life since they were unable to provide any evidence of the relation between the two.

A number of non-science students perceived their science textbooks to be easy and well-explained, which was not reported by the science students. These non-science students’ experiences suggest that their science textbook was well-written, well-explained and easy to follow and understand. This experience was possibly expressed because their textbook covers only very basic content of science and requires a comparatively low study load of science, which proved not to be the case for science students.

4.2.6.2 Responses of the students who did not like their science textbooks. Out of 141 students, 58 answered that they did not like their science textbook(s). Out of these 58
students, 50 students belonged to the science stream and only 8 students belonged to the non-science streams. A relatively greater number of science students than non-science students did not like their science textbooks (physics, chemistry and biology). After their reasons for their dislike were analysed, some key features were found. These features are discussed in the following sections.

Most of the students (30, with 29 from the science group and 1 from non-science groups) who did not like their science textbook(s) appeared to feel that their science textbooks were *not comprehensible*: science textbooks were very difficult to follow; many topics were not clear; many topics were written complexly; science content was presented in a complicated way; too many complex and complicated terms were used; much subject matter was not self-explanatory; many topics were not interesting; and overall the content was not connected to the real world. Some of the responses follow:

…so many unfathomable topics are there in science textbooks. They are not well-explained. (XSCG23)

Science textbooks are far away from the reality… (XSCG33)

Physics textbook is full of meaningless imaginary stories. Not a single chapter is understandable. For example, motion, simple pendulum, heat, calorimetry, light etc. are full of text but we can grasp very little of these concepts. (IXSCG02)

Our science textbooks are too boring… (XSCG31)

The content in science textbooks and their presentation are so boring that they initiate apathy among us rather than making us interested in science. (XSCG37)

Our science textbooks are too difficult to study. (IXSCB05)

…in our science textbooks, science content is presented in a very difficult way.
…for example, structure of atoms, periodic table, oxidation-reduction reactions etc. chapters are very unclear. (IXSCG02)

I don’t like our science textbooks because the terms used in these books are so complex and complicated. No easy example or explanation is given to make science content easily understandable. They [science textbooks] are full of difficult and complicated examples. (IXSCB20)

…for example, I don’t like heat in physics, organic compound in chemistry and toad in biology; they are so twisted and complicated. (XSCG46)

Another commonly reported feature of science textbooks is the incompleteness of the topics and content in textbooks. This feature seems to be responsible for science content being unfathomable for many students. According to a number of students (17, with 15 from science, 2 from non-science), science topics in their textbooks are incomplete, because of which students felt that they were unable to understand the topics to learn the knowledge supplied by the content at a satisfactory level. As a result they did not understand the content of science by studying themselves; rather they often needed someone to help understand their textbooks.

So many topics are incomplete. They do not provide a complete sense of science subject matter. (IXSCG23)

…one of the reasons why I do not like my science textbooks is that there is a lack of explanation and completeness in the information provided. Often we get the answers of ‘what’ and ‘how’, but every so often we do not get any answer of ‘why’. For example, in chapter 15 of physics textbook, the relation between speed of light and refractive index is given; the law used here says: $\eta$ [absolute refractive index] =
speed of light in vacuum / speed of light in the substance. There is absolutely no explanation of where this law was derived from and how it was derived. Again, it is written that rays of light change their direction during refraction, but nothing is written on why it happens [change of direction]; just one simple sentence says that, because of the difference in velocity, rays of light refract; but there is no further explanation of this. (IXSCG18)

…many important topics are often presented in brief, for which we face so many problems in understanding those topics. (XSCG45)

Many topics in Biology are not elaborated; few examples are given; few images are given; even many words are not explained further, which is why we are forced to memorise them as we do not know what they mean. (IXSCB04)

Another feature of science textbooks is the language used in the textbooks, which was seen as very hard to follow. A number of students (20, with 18 from the science group and 2 from non-science groups) felt that the words and sentences used were too complex and complicated so that they were unable to understand their textbooks by themselves. They often needed someone to help them understand their own science textbooks.

Language used in our science textbooks is so hard to understand. (XSCG22)

…words and sentences used in science textbooks are so complicated. (IXSCG02)

Without someone’s help, our science textbooks cannot be understood…

(IXSCG12)

…you can’t fathom the science topics by yourself. (IXSCG13)
Science textbooks are written in language that makes it impossible to learn science by ourselves; rather we have to go for private tuition. (IXSCB04)

I think nobody would understand anything of the ‘calorimetry’ chapter by studying themselves. (IXSCB04)

Another important feature announced by the students (16, with 15 from the science group and 1 from non-science groups) for which they do not like their science textbooks is the *depictions* used in science textbooks. The pictures and images are usually given in textbooks in order to enable students to understand the content and experiments of science. But according to the students, the images given in their textbooks were very unclear, of poor quality and not coloured (black and white); these images confused them rather than helping to make the topics clearer and more understandable to the students.

…pictures in science textbooks are not easily legible. (IXSCB05)

…images are so unclear. For example, heart of toad, animal and plant cells etc.

(IXSCG02)

…quality of the images incorporated in science textbooks is very poor. (IXSCB10)

In biology the images of plants and animals are drawn in a way that you could not learn anything about plants and animals from these images. (XSCG35)

The students also felt that the number of images given was inadequate; many of the topics were not explained with a picture, which would be needed for them to understand the topics. Moreover, the images that were incorporated actually made the content more complicated for them.

We do not have sufficient number of pictures in science textbooks. (IXSCG12)
Since we do not have any multimedia in our classrooms, we must have a good number of pictures in our textbooks. But you could say chemistry book has nearly no images at all. The number of pictures in biology and chemistry is less compared to what we need. On the other hand, whatever we got in these books make science content rather more complex. (XSCG37)

According to the responses of the students (16, with 12 from the science group and 4 from non-science groups), their science textbooks were outdated. These textbooks were first introduced in 1996 (NCTB, 1996) and until 2012 (when I was collecting data) no modification was made to these books. So, for 17 years the same textbooks have prevailed in schools. In the past 17 years science has advanced immensely, but Bangladeshi students have not been introduced to any of the advanced science by their science textbooks or even by the teachers as they always follow the current textbooks and struggle to finish them. It is interesting to note here that when I was in Grade 9, I studied the same science textbooks that the students in the current study were using.

Science textbooks are not up-to-date; lots of things are changing by time but they are not included in our textbooks. We have to study much subject matter of science that is not appropriate or applicable in this modern era. So, many contemporary inventions are missing in these books. (XSCG23)

Our textbooks were written in 1996. After that no change has been brought into these books. (XSCB31)

Our science textbooks are so old. No changes have been made to these books [since they were first published]. Every day we hear about new inventions of science happening around the world but we are being taught the obsolete inventions of science… (XNSG53)
…we are still being taught how a black and white television works. (XSCB39)

Some of the students also mentioned the incorrect information provided in science textbooks; they found that much information and data were incorrect in their science textbooks. Each year the authority has reprinted the textbooks and supplies them to students, but they have paid no attention to the errors.

Our science textbooks have so many errors; each year they [the authority] reprints the books but do not correct the errors. (XSCG31)

Again the issue of size of the textbooks was reiterated by a number of the students (17, with 15 from the science group and 2 from non-science groups); according to them, their science textbooks have been made unnecessarily long with more huge chapters than the students can afford the time to read. This feature of science textbooks also seems to have contributed to the professed decrease in these students’ interest in science.

Science textbooks are made unnecessarily big… (IXSCG03)

Chapters in science textbooks are so big, so that we face difficulty in comprehending all of them... (XSCG22)

I don’t like the physics book at all, because it is unnecessarily big, it has so many chapters (25), and we have to study a lot. (XSCG28)

Chapters 13, 14 and 15 in chemistry are too long; we could neither have a good grasp on them nor could we finish them in time, and as a result we lose interest in studying science. (XSCG43)

As per student responses, some students (12, with 7 from the science group and 5 from non-science groups) like some of their science textbooks but not all of them.
I like physics and chemistry, but not biology. (IXSCB11)

I like physics and biology but not chemistry, because physics and biology books are organised. I feel comfortable and it is convenient studying them, but chemistry is very difficult. (IXSCG17)

I like chemistry and biology, because they are interesting, but I don’t like physics. (IXSCG01)

In the case of non-science students, they liked some parts of their textbook and some they did not. Non-science students responded in the following ways:

Some chapters are easy so that I like them, but some chapters are difficult and so I don’t like them. I enjoy studying the chapters on biology, but they are very hard to memorise. I like some of the chapters on chemistry and some of them I don’t. At the same time, I like some of the chapters on physics but some of them I don’t. (XNSG64)

I like some of the chapters in science, for example minerals, energy, sound, ecosystem, electricity etc…. (XNSB61)

In summary, the proportion of students liking and disliking science textbooks was almost equal. However, compared to the non-science students, science students were more likely to dislike their science textbooks. According to the students’ responses, the common features of their science textbooks responsible for their dislike of them were: textbooks were not conducive to learn science content; many topics were unclear and complexly written; much of the content was incomplete; language used in science textbooks was very
complex, complicated and hard to follow; depictions given in textbooks were unclear, incomprehensible and inadequate; the content and information in science textbooks were outdated, and these textbooks have been used for the last 17 years without any change; much information and data were incorrect; and finally textbooks were unnecessarily big, which is unaffordable. Many of these reasons were responsible for the decrease in students’ interest in science.

4.2.7 Open-response question Two: question on science teacher’s personal qualities. The question asked students: What would be the qualities of your ideal science teacher? How would these qualities help you like/enjoy school science? Since the theme effect of teachers’ personal qualities on students’ science learning and interest in science was generated from the FGI data, this question was asked to elicit more perceptions and evaluations of science teachers’ qualities and attributes, and to reveal how these qualities and attributes affected student interest and enjoyment in science.

The key themes emerging from student responses are: (1) Teaching related qualities; (2) Interactions with students; (3) Understanding the learners; (4) Being an expert of science; (5) Private tuition. The most common qualities and attributes mentioned by the students under these themes are presented in the following sections.

Theme 1: Teaching related qualities

Table 4.20 presents responses under the theme teaching related qualities, which emerged with regard to teachers’ qualities and attributes. Under this theme, students mentioned the teaching related attributes that they believed an ideal science teacher would have. The dot points in the table are the repeatedly mentioned qualities and attributes of an ideal science teacher based on what the theme teaching related qualities generated. Frequencies of typical responses are given in parentheses. Responses on similar ideas or
attributes are presented together therefore the frequencies are not sorted in a descending manner.

Table 4.20
Typical Responses under the Theme ‘Teaching related Qualities’

<table>
<thead>
<tr>
<th>Qualities and attributes of an ideal science teacher mentioned by the students (frequencies of responses in the parentheses)</th>
</tr>
</thead>
<tbody>
<tr>
<td>According to student responses, science teachers must:</td>
</tr>
<tr>
<td>• have capabilities of making science easier [easily understandable/comprehensible] to students [must be able to make science easily understandable for students] (61)</td>
</tr>
<tr>
<td>• be able to make science [lessons and topics] interesting, enjoyable and attractive for students (40)</td>
</tr>
<tr>
<td>• follow interesting and enjoyable methods of teaching science [making teaching methods interesting and enjoyable] (8)</td>
</tr>
<tr>
<td>• give enjoyable examples while teaching science (7)</td>
</tr>
<tr>
<td>• have the ability to attract students’ attention to science lessons (6)</td>
</tr>
<tr>
<td>• create opportunities for hands-on science learning experience (24)</td>
</tr>
<tr>
<td>• show practical applications of science knowledge (14)</td>
</tr>
<tr>
<td>• give us practical knowledge of science (13)</td>
</tr>
<tr>
<td>• not be confined to textbooks while teaching science [science teaching should not be limited by textbooks] (3)</td>
</tr>
</tbody>
</table>

According to students’ responses, science teachers: were unable to make science easily understandable for them; did not teach in interesting and enjoyable ways and so could not make science enjoyable; did not create opportunities for hands-on science learning; and did not show practical use of science knowledge. This seemed to be
 unacceptable to the students, as a result many of them mentioned the ways they expected their science teachers to teach science. They expected their teachers to make science understandable, interesting and enjoyable for them. Students expected their science teachers to be capable of making science easier for them. They believed that an ideal science teacher should: adopt interesting and enjoyable ways of teaching; provide relevant examples while teaching science in order to foster better understanding; create opportunities for hands-on experience of science; and show them the practical applications of school science. Another important experience of students is that their science teachers most often were bound by science textbooks; their teaching was mostly textbook-centred and theory-focused. For this reason, students of this study want their ideal science teachers to change this practice and give them hands-on science lessons.

In response to the second part of the question (how would these qualities help you like/enjoy science?), students expressed their evaluation on how the qualities and attributes under the theme teaching related qualities would help them like and enjoy science. It seems obvious that if science teachers could make science lessons easily understandable, use interesting and enjoyable ways of teaching, and provide students opportunities with hands-on experience, students would enjoy science lessons and start to like the subject Science. Such feelings of students are indicated by the following responses:

If teachers cannot enable us to understand science, if they fail to attract our attention to the lecture or [if they fail to] feed our curiosity, science must turn into a boring subject and it [science] will never be an enjoyable subject for us.

(IXSCG12)
Science teachers should have the quality of making science topics interesting while teaching. If the lessons are not interesting we do not feel any urge to pay attention to them [the lessons]. (XSCG31)

Science teachers should have the quality of making science attractive, interesting and enjoyable for students, so that we would be more attentive in science classes and feel encouraged to study science. (XNSB62)

…if teaching methods are enjoyable, plain and simple, students will be attentive to science lessons and learn science. (XSCG40)

Science teachers should give us the practical knowledge of science. If the practical aspects of science are presented and discussed, science becomes very easy to comprehend. (IXSCG17)

…if our science teachers have the quality of showing practical applications of science, we would easily be able to link science with everyday life and it will help our intelligence be developed and mature. (XNSG63)

Science teachers have to teach science by giving hands-on experience, so that students will enjoy learning science, like science and be interested in science. (XSCG32)

…if science teachers let us have hands-on experience, we would be able to use science knowledge in our life. (XSCG41)

**Theme 2: Interactions with students**

Table 4.21 presents the theme *interactions with students* and the student responses that emerged within this theme with regard to teachers’ qualities and attributes. Under this
theme, students expected their ideal science teacher to be friendly and cooperative, and well-mannered and unbiased. They did not want their science teachers to be ill-tempered and punish them. The dot points in the table are the repeatedly mentioned qualities and attributes of an ideal science teacher reflected in the theme *interactions with students*.

Table 4.21

*Typical Responses under the Theme ‘Interactions with Students’*

| Qualities and attributes of an ideal science teacher mentioned by the students (frequencies of responses in the parentheses) |
| We want our science teacher |
| • to be friendly (42) |
| • to be cooperative (3) |
| • to be cordial or hearty (7) |
| • to be well-mannered (18) |
| • not to be ill-tempered: be one of whom we can always ask questions (11) |
| • not to give us any punishment: be one of whom we won’t be afraid of (10) |
| • to treat all students equally [Unbiased] (6) |

Many of the students advocated the teacher attributes of being *friendly and cooperative*. According to their experience, most of their teachers were apparently not friendly and cooperative; many of their teachers were ill-tempered, and the students were afraid of these authority figures. Many of their teachers punished them for minor reasons. The students also expected their science teachers to be well-mannered and unbiased, and to behave well with them and treat all the students equally.
In response to the second part of the question (how would these qualities help you like/enjoy science?), students expressed their evaluation regarding how the qualities and attributes under the theme *interactions with students* would help them like and enjoy science. They indicated that if science teachers were friendly and cooperative, and if they provided students with opportunities for asking questions and also answered them, students would be able to clarify science concepts, understanding them better; as a result students would enjoy science lessons and feel interested in science. Some of the typical responses supporting these arguments are as follows:

Science teachers have to be friendly. If our teachers were friendly with us then we would be able to tell them all our problems without any hesitation. We would be able to ask questions. As a result, our problems would be resolved. We would be able to learn science. But if they are rude to us, we would not be able to solve our problems regarding science. (XSCG31)

An ideal science teacher has to be cordial… (XSCG37)

…who we can ask questions. (XSCG38)

…who would not be annoyed if we ask questions. If he/she teaches us without getting annoyed or losing temper, we would enjoy learning science. (XNSG64)

…who would not insult if we ask any question. (IXSCB20)

…who we would not be afraid of; who will not give any punishment. Then, we will not be afraid of him/her; we will be able to express our science-related thoughts and queries to him/her; we will be encouraged to ask questions and thus we will learn science with huge enjoyment. (XSCG38)
…sometimes we get panicked because of our fear for our teachers and as a result, we cannot even remember what we memorised. (XSCG43)

He/she has to treat everyone equally. Most of the time we see our teachers taking care of those students who are bright. As a result weaker and less intelligent students are left behind. (XSCG44)

If teachers treat everyone equally, students would be able to count on them and then we will try to comprehend science using our dormant talents. In this way science would be more attractive to us. (XSCG29)

Although these traits of a person are not specifically directly related to science teachers, this data cannot be ignored either, as many of the students identified these features as a problem in their classroom and indicated that their teachers’ unfriendly dealings with students hindered their learning including science learning. These characteristics of teachers seem to be problematic and cannot be separated from students’ science-related experience and thus demand inclusion in this study.

**Theme 3: Understanding the learners**

Table 4.22 presents student responses from the third theme *understanding the learners*. Under this theme, students want their ideal science teachers to understand their limitations, problems, needs, demands, and communicate with them properly. The dot points in the table are the repeatedly mentioned qualities and attributes of an ideal science teacher indicated in responses with the theme *understanding the learners*.
Table 4.22

*Typical Responses under the Theme ‘Understanding the Learners’*

<table>
<thead>
<tr>
<th>Qualities and attributes of an ideal science teacher mentioned by the students</th>
</tr>
</thead>
<tbody>
<tr>
<td>(frequencies of responses in the parentheses)</td>
</tr>
</tbody>
</table>

A science teacher has to:

- understand the needs and demands of students (22)
- understand students’ shortfalls and lacks (7)
- understand students’ problems (7)
- be the person with whom we could share our problems (4)
- have the ability to solve students’ problems (4)
- provide extra care to weaker students (10)
- have patience for listening to what students say or ask (16)
- be the person with whom we could communicate easily (2)
- pay attention to every individual student (2)
- speak clearly and spontaneously (11)
- have the ability to make students interested in science (9)

According to student responses, it seems that their science teachers did not deal with their needs and demands, capabilities, and strengths and weaknesses. They seemed to neither understand students’ problems nor pay any attention to individual problems and needs. It seems that students could not share their educational problems with their teachers. They were not permitted to ask questions of their teachers, who seemed to have limited patience for listening to students’ questions and the difficulties that they come across. Weaker students did not receive any extra care or attention from their science teachers.
Based on student voices, it seems that there was an appreciable gap between teachers and students in terms of communication and understanding.

Our teachers maintain a distance with us… (IXSCG03)

Science teachers must have the capability of understanding their students; they have to understand students’ needs. (XSCG31)

Science teachers have to have the quality for identifying students’ problems regarding science… (XSCG35)

If teachers maintain a distance from students and do not pay attention to students’ needs, science learning would be difficult for students. This could be one of the reasons why students memorised science rather than learning it with a thorough understanding.

Students, therefore, wanted their ideal science teachers to: understand their needs and demands; have patience and pay attention to what students say or ask; understand students’ limitations and difficulties; provide students opportunities to comfortably share their problems with regard to science learning; have the ability to solve their problems; and take extra care of weaker students. Some of the students also seemed to have difficulties with teachers’ speech, which they wanted to be clear and spontaneous in order for lectures and presentations to be communicated properly. A few students also wanted their science teachers to make science attractive for them by creating interest and facilitating students to become more science-minded. Similar to the previous responses to the second part of the question (how would these qualities help you like/enjoy science?), students seemed to believe that if science teachers possessed these qualities and understood their students, students would receive more attention from their science teachers to help them overcome their difficulties, which would help students better understand the science concepts and
enjoy the science lessons. Some of the typical responses supporting these points are as follows:

…he/she has to be patient enough to listen to what we say, our comments and observations. If he/she teaches us with patience, I think we will understand and learn what he teaches. (XSCG45)

…he/she has to speak clearly and spontaneously. If he/she does not speak clearly we would face difficulties in understanding his/her lessons. So, he has to be clearly spoken. (IXSCG02)

Science teachers must have the ability to create interest in science among students so that students will not be uncaring of science. If they can make us interested in science, science would be easier for us and we will study science with joy.

(XNSG54)

Theme 4: Being an expert of science

Table 4.23 presents the student responses generated under the fourth theme being an expert of science. Under this theme, students expected their ideal science teachers to have complete knowledge of science and to be a master of science who would be able to answer the questions asked by students for clarification of science concepts. The dot points in the table are the qualities and attributes that were recurrently mentioned by the students and generated the theme being an expert of science.
Table 4.23

Typical Responses under the Theme ‘Being an Expert of Science’

Qualities and attributes of an ideal science teacher mentioned by the students
(frequencies of responses in the parentheses)

A science teacher should:

- be an expert of science (24)
- have complete knowledge of science (13)
- not have just textbook-centred knowledge (2)
- be capable of answering students’ questions (19)

Students reported that their science teachers did not have enough content knowledge, which is required for quality science teaching. According to student responses, they most often did not receive answers to their questions when they asked for clarification. They also found their science teachers to be mostly dependent on textbooks; they (teachers) did not usually provide any information or explanation outside of their textbooks. They did not relate the knowledge of science with students’ everyday lives. As a result, day-by-day students lost interest in science. So, the students suggested that an ideal science teacher must have complete knowledge of science and be capable of answering students’ questions. They want their science teacher to be an expert of science with deep knowledge in science, which is not textbook-centred; rather the knowledge should be relevant to the real world. The following quotes provide evidence of their thoughts.

…he/she has to be a veteran of science so that he/she will help expand our knowledge. (IXSCB16)
Science teachers must know well about science so that we could get appropriate answers to our questions. As a result, students will better understand science lessons and, science will be more attractive to us. (XSCG34)

An ideal science teacher’s knowledge will be such that he can answer all the questions asked by his students… (XSCG35)

…he/she should have in-depth knowledge about science; this knowledge should not be textbook-centred, rather has to be reality-centred. (XSCG37)

Finally, students reported, in response to the second part of the question, if science teachers did so students would find science easier and more interesting, and learn science lessons appropriately, so that their knowledge would be enhanced.

An ideal science teacher must be full of science subject knowledge. If he/she does not have complete knowledge of science subject he would not be able to teach us science properly. (IXSCG02)

…and if he/she does have complete knowledge of science subject, he/she would be able to present the science subject appropriately to us and so we would be able to obtain a better understanding of science concepts and learn science accurately. (XSCB40)

**Theme 5: Private tuition**

Table 4.24 presents the responses from students categorised under the fifth theme private tuition. As students reported, many teachers taught students privately at their home in addition to teaching in school. Under this theme, students mainly wanted their ideal science teachers to avoid this tendency and teach science comprehensively in classrooms. The dot points in the table are the repeatedly articulated qualities and attributes related to the theme private tuition.
Table 4.24

*Typical Responses under the Theme 'Private Tuition'*

Qualities and attributes of an ideal science teacher mentioned by the students (frequencies of responses in the parentheses)

<table>
<thead>
<tr>
<th>An ideal science teacher:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• has to teach in class, not in private (5)</td>
</tr>
<tr>
<td>• must be ethical and honest: must not have any greed (10)</td>
</tr>
</tbody>
</table>

According to students’ responses, some of their science teachers have a tendency to tutor students privately at their home rather than teaching comprehensively in classroom. For this reason, students mentioned about *ethics* and *honesty* as requirements for an ideal science teacher. Some of the students signalled their teachers should not be greedy and should not choose private tuition as an alternative to classroom teaching.

Most of our science teachers have a tendency to teach very well when they teach privately at their home, and without having a proper discussion and explanation on much of science content in [regular] classes [that make up] exams; they make questions from the undiscussed and unexplained topics. As a result, students who go for private tuition get the full benefit of it [as they are being taught those undiscussed and unexplained topics at the teacher’s home]. (IXSCB11)

The goal of an ideal teacher has to be educating his/her students. If someone wants to do business, he/she should choose to teach. He/she has to leave teaching-in-private and teach science in school properly. (IXSCB04)

…he/she has to be ethical and honest. (XSCG34)

…he/she should not have any greed. (IXNSG48)
Students’ responses to the second part of the question (how would these qualities help you like/enjoy science?) did not explicitly report how this quality or attribute would help them like or enjoy science. However, as students mentioned, if their science teachers paid full attention to the science classes at school, they would receive more constructive lessons on science topics and enjoy the full benefits of science lessons. This would likely help them enjoy and like school science.

In summary, as students stated, science teachers seemed to be unable to assist students understand science; science lessons were not interesting, enjoyable and attractive for students; science teachers did not teach science by hands-on activities; they did not show practical applications of science knowledge; they did not have the capacity to attract students’ attention; they also did not have capabilities of making science easier for students. So, students wanted their science teachers to: make science interesting, enjoyable, attractive and easier for them; use interesting and enjoyable methods for teaching science; introduce hands-on activities; and show practical applications of science knowledge.

Science teachers also seemed not to have a strong base of content knowledge; their knowledge appeared to be textbook-centred. So, the students expected their science teachers to: be experts in science; have complete knowledge of science; be capable of answering students’ questions; and have the ability to facilitate students’ interest in science.

As reported, their teachers were not friendly and cooperative. Some teachers were found to be ill-tempered and to punish students; they did not give students opportunities to ask them questions and did not treat students equally. Therefore, students wanted their teachers to be friendly, cooperative, cordial and well-mannered; not to be ill-tempered; not to give any punishment; and to treat all students equally.
Students also wanted their teachers to: understand their needs and demands; pay attention to every individual student; understand students’ problems; give students the opportunity to share their problems and have the ability to solve the problems related to science learning; understand students’ shortfalls; have patience for listening to what students might say or ask; and provide extra care to weaker students.

4.2.8 Open-response question Three: reasons for choosing and not choosing the science stream. Since a discussion on why students in the science group chose science to study and why non-science (business studies or humanities) students chose not to study in science occurred during the focus groups sessions. Students were asked, in the questionnaire phase, to respond to the question: “why did you choose to study science? (for science stream students) OR why did you choose to study business studies/humanities rather than science? (for non-science stream students)”. The purpose of this question was to find out the reasons behind their decision to study science or not to study science at the secondary level of education. In order to understand students’ attitudes towards school science, it is important to know the common reasons for students’ decisions, because students who choose science for this level of education can continue with science in higher secondary level and beyond; but students who do not choose to study science (although they have a general science subject at this secondary level) would not be able to study science subject at the next levels of education and are thus likely to discontinue with science related careers.

Students’ responses revealed six main reasons for their decisions to study in science or non-science groups. They are: 1) future career; 2) interest in science subject matter; 3) parents’ desire and people’s (in society) views about science related careers and science students; 4) academic results of the Junior Secondary Certificate (JSC) examination, especially the grades in science and mathematics; 5) importance of science knowledge; 6)
perceived difficulty of school science. Many of the students provided more than one reason so that the frequencies of responses per reason were counted instead of the number of students providing the reasons. Table 4.25 below presents the six main reasons and the frequency of responses per reason.

Table 4.25
*Frequencies of Reasons provided by Students for Choosing or not Choosing Science to Study*

<table>
<thead>
<tr>
<th>Reasons for students</th>
<th>Frequency of responses of science students</th>
<th>Frequency of responses of non-science students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Future career</td>
<td>48</td>
<td>7</td>
</tr>
<tr>
<td>Interest in science subject matter</td>
<td>39</td>
<td>4</td>
</tr>
<tr>
<td>Parents’ desire and people’s (in society) views about science related careers and science students</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Academic results of the Junior Secondary Certificate (JSC) examination</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Importance of science knowledge</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>Perceived difficulty of school science</td>
<td>0</td>
<td>13</td>
</tr>
</tbody>
</table>

**Future career**

The top-most reason given by the students in terms of the frequency of responses is *future career*. A large number of responses (48) was received from students of the science group who chose science to study to have a better career in future. Nearly a half (22) of these responses were associated with the desire to have a very specific science profession in their life, which included becoming a doctor or an engineer:
…because I want to be a doctor or an engineer. (XSCG27)

A very few (3) responses mentioned some other science-related careers such as scientist (2) or aeroplane pilot (1).

My aim in life is to become a scientist. (XSCG26)

The rest of the responses (23) of science students were not specific about any particular profession. Rather, these responses put forward a strategy that studying in science stream keeps open all the pathways of career choices.

…anyone can move to any profession from science; in future, any subject can be chosen for higher studies [if anyone studies science]. But no one will be able to move back to science from non-science streams in future. (XSCG23)

On the other hand, a small number of responses (7) were provided by non-science students who chose non-science streams in order to have a profession of their choice.

I want to be a chartered accountant in future. (XNSB65)

I want to be a lawyer in future, which is why I chose humanities group. (XNSG54)

**Interest in science subject matter**

The second most frequent reason is *interest in science subject matter*. A large number of responses (39) was received from science students who chose science to study because of their intrinsic interest or enjoyment in science, whereas a very few (4) responses provided by non-science students reported that they chose the non-science stream because of their interest or enjoyment in non-science subject matter. Some of the responses given by science students are as follows:
Science has been my favourite subject since my childhood. I have huge interest in science… (XSCG30)

I very much enjoy studying science subject matter. (IXSCB11)

In contrast, only very few non-science students responded in a similar way:

I have huge interest in subjects related to business studies. (IXNSB52)

**Parents’ desire and people’s views about science related careers and science students**

A good number of responses (21, with 20 from the science group and 1 from non-science groups) mentioned the reason *parents’ desire and people’s (in society) views about science related careers and science students.* Most of the responses around this reason indicated that students, especially science students, chose science because their parents wanted them to study science.

My parents wanted me to take science… (XSCG23)

My parents and other family members want me to become a doctor. (IXSCG12)

In contrast, only one non-science student expressed that she chose the business studies group because of her family members’ preferences.

Family members wanted me to study in the business studies group. (IXNSG49)

One additional point was made by some of the science students: people, including parents, held positive views about science related careers and science students. According to their responses, people in Bangladeshi society admired science related careers, especially doctors and engineers. Many parents wanted their child to become a doctor or an engineer. People also seemed to think that the brightest and most talented students studied science and students who did not take science were not talented.
…my parents planted a dream in me since my childhood that if I become an engineer or a doctor in future, everyone in the society will respect me and give me honour. (IXSCG12)

…in Bangladeshi context, almost all the parents want their children to become a doctor or an engineer. (XSCG37)

…almost everyone in our society thinks that students who study in science are brilliant [brightest] and all other students are of poor quality. (IXSCG13)

Such reasons pose a question: if most of the non-science students do not report an intrinsic interest and enjoyment in non-science subjects, if most of the non-science students have not chosen non-science streams because of their future career preferences, if their parents have not pushed them to choose any of the non-science streams, and if society has a very positive view about science students, then what are the reasons for them having chosen non-science streams to study? The following responses may provide an explanation.

**Academic results of the Junior Secondary Certificate (JSC) examination**

A substantial number of responses (23, with 15 from non-science groups and 8 from the science group) reported that the reason for their study choice was based on academic results of the Junior Secondary Certificate (JSC) examination, especially the grades in science and mathematics. Based on their academic results in the JSC examination held at the completion of Grade 8, students were chosen for the streams, regardless of what their choices were. According to their responses, if anyone achieved an A+ grade in science and mathematics, plus a minimum CGPA (Cumulative Grade Point Average) of 4.29 (out of 5), were chosen for science stream. All other students who could not achieve the benchmark of requirements were chosen for the non-science streams.
I got A+ in science and mathematics in JSC examination, for which I was given science stream to study. (XSCG33)

Students who had a CGPA more than 4.29 were sent to science stream. I achieved less than this point which is why I have been put in business studies group. (IXNSB53)

I got A+ in mathematics but A- in science. As a result, the school authority gave me the business studies group. (XNSB62)

These non-science students seemed to have had an interest in taking science but as their interest, desire and preference were not considered against the threshold of grades and their performance in the CGPA, they could not continue their study with science. The following responses represent some of these views:

I so wanted to study in science group, but because of the results in JSC exam I am now in a non-science group. (XNSG62)

Science is my favourite. Since my childhood I so wanted to study in science. But, I could not achieve the required numbers in JSC exam; as a result the school authority did not give me a chance to study in science. I was so disappointed. I really had a strong desire to study in science. (XNSG60)

**Importance of science knowledge**

Another reason for study choice provided exclusively by some of the science students (17) was that they believed that *Science knowledge is important*. According to their responses, if anyone studies science, he or she would be able to learn new knowledge and inventions of science. According to some of the responses, new knowledge and information help in various aspects of life.
If science subject is studied, a lot of stuff can be learned and we can get introduced to new inventions of science. (IXSCB14)

We learn about new inventions of science through the study of science. (IXSCG05)

Copious information and a lot of knowledge could be learned through science study, which would help us in various aspects of life. (XSCG41)

However, similar to the responses in Section 4.2.1.1, students here did not provide any example of how science knowledge would be helpful in various aspects of their life. It is therefore apparent that students placed emphasis on learning science knowledge, and believed that science knowledge is important and useful, however they seemed not to have understood how this knowledge could be useful.

**Perceived difficulty of school science**

Another reason suggested exclusively by non-science students (13) is that *science is difficult*. A good number of non-science students chose non-science streams because of the perceived difficulty of science for them. They found it difficult to understand science concepts, because of which they did not choose the science group for further study. A few of the responses also mentioned another reason for not understanding science: how science was being taught in lower grades. As a consequence they had decided not to take science at secondary level.

Science seems difficult to me… (XNSG55)

I do not understand science much… (XNSG58)

…while studying in Grades Seven to Eight, I could not understand science properly. Even in school I was not made to understand science properly. I was supposed to memorise science concepts to sit for exams as it was the practice in
school. For this reason, I gradually started to lose my interest in science although I liked science very much. But there was so much stuff in science that I could not understand. Finally, I chose the humanities group to study as I did not get any support from anyone. (XNSB72)

In summary, a difference in responses between science and non-science students is apparent. Science students mostly chose science because of their future career preference, their intrinsic interest in science subject matter, their parents’ and social demands, and their belief in the importance of science knowledge. On the other hand, non-science students chose non-science streams mainly because of their failure to achieve the required results in the JSC examinations set by the school authority and their experience of science as a difficult subject.

4.2.9 General comments of students. The last open question asked students whether they had any other comments related to their school science: “If you have any other comments related to the science that you study in your school, please write them”. Most of their responses were in the form of recommendations. For example, 24 students commented in response to the last question that “science learning should be more hands-on based”. Most of the data were related to the themes that had previously emerged, so that new themes did not arise from these data. For example, the above-mentioned response belongs to the theme how science is being taught (see Section 4.2.1.2). Table 4.26 below presents the frequently given comments in response to the final question in the questionnaire.
Table 4.26
*Frequencies of Recommendation-type Comments related to How Science is being Taught*

<table>
<thead>
<tr>
<th>Typical text segments</th>
<th>Frequency of similar text segments reported by students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching methods should be improved and more interesting methods should be used in science lessons</td>
<td>15</td>
</tr>
<tr>
<td>Science teaching should be more hands-on based</td>
<td>20</td>
</tr>
<tr>
<td>We should be taught the practical applications of science that we study at school</td>
<td>11</td>
</tr>
<tr>
<td>Practical knowledge should be more emphasised</td>
<td>5</td>
</tr>
<tr>
<td>Science teaching should include more practicals</td>
<td>2</td>
</tr>
<tr>
<td>Non-science students should be taught hands-on science</td>
<td>2</td>
</tr>
<tr>
<td>Practicals should be included in science curriculum for non-science students</td>
<td></td>
</tr>
</tbody>
</table>

In summary, comments included a focus on improvement in the way science is being taught (teaching methods), and the notion that the teaching and learning of science should be more hands-on based so that practical uses of science knowledge would be learned. Varieties of teaching-learning activities that activate student interest in learning science were also recommended.

Some students made comments related to the theme *science textbooks*. Table 4.27 below presents the frequently given comments on their science textbooks.
Table 4.27

*Frequencies of Recommendation-type Comments related to Science Textbooks*

<table>
<thead>
<tr>
<th>Typical text segments</th>
<th>Frequency of similar text segments reported by students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textbooks should be updated with latest information and inventions of science</td>
<td>9</td>
</tr>
<tr>
<td>Science textbooks should be written in easy language</td>
<td>5</td>
</tr>
<tr>
<td>Scientific explanations in textbooks should be clearer</td>
<td>2</td>
</tr>
<tr>
<td>Science textbooks should be attractive</td>
<td>2</td>
</tr>
</tbody>
</table>

In summary, recommendations included that easy and age-appropriate language should be used in science textbooks so that students could understand, and that texts should explain scientific concepts and ideas more clearly. Moreover, students recommended an upgrade of science textbooks; they should include updated information and the latest innovations.

A few students made comments related to the attributes of a science teacher. Table 4.28 below presents the frequently given comments on what attributes a science teacher should have.
### Table 4.28

*Frequencies of Recommendation-type Comments related to the Attributes of a Science Teacher*

<table>
<thead>
<tr>
<th>Typical text segments</th>
<th>Frequency of similar text segments reported by students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our science teachers should teach science with more care and effort. They should be cordial and sincere</td>
<td>6</td>
</tr>
<tr>
<td>Science teachers should present science in an easier way</td>
<td>3</td>
</tr>
<tr>
<td>Teachers should develop friendly relationship with students</td>
<td>1</td>
</tr>
</tbody>
</table>

In summary, students’ comments recommended a change in teacher attributes, including science teachers teaching science with more care and effort. They should be friendly, cordial and sincere. They should be able to present science in an easier way.

The analysis of the questionnaire responses has been presented above, illustrating patterns of students’ evaluation of different components of school science. The following section summarises of this chapter.

### 4.3 Summary

This chapter has reported students’ responses to the open-ended questionnaire that was developed based on students’ voices. Students’ responses provided their evaluations of school science, and their beliefs and behavioural tendencies related to school science based on their experience of school science. Students’ responses also provided the reasons for their evaluations, beliefs and behavioural tendencies regarding school science. Analysis of the data has revealed a number of themes that are associated with different components of
school science such as science teaching, science curriculum, science textbooks and content, science teachers’ attributes that affect student learning, students’ motivations for participating in science. A combination of all the responses on evaluations of school science and the justifications for the evaluations has provided insights into the pattern of students’ collective attitudes towards school science. The next chapter discusses these insights into students’ attitudes under several themes associated with the findings of this chapter.
Chapter 5: Discussion

5.1 Introduction

This chapter discusses, in light of the research literature, the results presented in Chapter Four. Based on the data analysis in the previous chapter, this chapter first looks into how the questionnaire data apply to the conceptual understanding of attitude used for this study (in Section 2.2.4). When students were asked to respond to questions about school science, students reported their experience, evaluation, beliefs and attitudes regarding different aspects of school science such as: the nature of school science (is it interesting? is it difficult to study?); the content of school science; the nature of science teaching in school; the nature of the curriculum; assessment practices; and parental demands and social pressure that were related to and impacted on their choices of science courses and future science careers. Therefore, the following sections apply students’ evaluation, beliefs and attitudes related to the different aspects of school science under several themes to the conceptual understanding of attitude. The key themes around school science are highly interconnected, so one theme is very likely to overlap with another theme in discussion. For example, it is not possible to discuss students’ experience of school science as a difficult subject in Section 5.4, without also mentioning Subsection 5.4.2 regarding the impact science textbooks have as a reason for science being difficult. Again, Section 5.6 is completely dedicated to the discussion of science textbooks, where students’ evaluation of science textbooks is reported and this in turn is linked to the de-facto curriculum in Bangladesh.
5.2 How the Questionnaire Data Apply to the Conceptual Understanding of Attitude

This study set out to obtain insights into students’ attitudes towards school science. According to my understanding, students’ attitudes are already formed based on their experience with school science. When students were asked about different components of school science, they responded based on their formed attitudes. Analysis of their responses provided insights into their attitudes towards school science. For convenience the conceptual understanding of attitude has been presented again below in Figure 5.1.

Figure 5.1. Conceptual understanding of attitude
According to the conceptual understanding of attitude (Figure 5.1), evaluation was considered as the central aspect of an attitude. This research received student responses, most of which were evaluative responses regarding different components of school science. For example, students evaluated school science as a difficult subject to study based on their cognitive and affective experiences related to school science (see Figure 5.2); this provides an insight into their attitudes towards school science. Some of the responses are used in the figure below (Figure 5.2) as examples in order to understand how students’ responses provided insights into their attitudes towards school science.

Belief is another component of attitude towards any object (in this study school science), which forms based on evaluation (Figure 5.1). Some of the evaluative responses provided understanding of students’ beliefs related to school science (Figure 5.2). Some of the responses expressing students’ beliefs were, for example, “if we learn science by hands-on experience, we would acquire complete knowledge of science”, or, “hands-on science learning would be enjoyable”. Such beliefs are rooted in students’ previous experiences and their evaluation based on the experiences. These beliefs also provided insights into students’ attitudes towards school science.

According to the conceptual understanding of attitude (Figure 5.1), behavioural tendency is another component of attitude which, similar to the belief component, forms based on evaluation. In other words, some of the evaluative responses provided an understanding of students’ behavioural tendencies in terms of school science (Figure 5.2). For example, a student response expressing a behavioural tendency was: “I would want to learn science by doing it practically in order to understand the world around us”. This and similar behavioural tendencies have formed based on students’ evaluations and/or beliefs related to school science. These behavioural tendencies also provided insights into students’ attitudes towards school science (see Figure 5.2).
Figure 5.2. How student responses provide insights into students’ attitudes towards school science

Students provided responses based on their cognitive and affective experiences

Cognitive experience:
Example of typical responses:
- In science, there are too many theories compared to the practicals
- We need to put in extra effort for science
- We do not learn science by having hands-on experience
- Science is taught in a complex/complicated way
- Our teachers just read out the textbooks aloud; they do not teach us (or explain) the difficult topics
- In science textbooks, there are so many topics for which sufficient explanation and appropriate examples are not given

Affective experience:
Example of typical responses:
- We struggle to understand/comprehend science
- Some topics are too monotonous
- Teachers cannot make science easier, more interesting and enjoyable for us
- Science is being taught following uninteresting methods
- The chapters in science textbooks are uninteresting

Evaluation: Based on cognitive and affective experiences, students provided their evaluative responses
Example response: School science is very difficult to study

Beliefs: Some evaluative responses provided understanding about their beliefs
Example of typical responses:
- Science is a subject to learn practically or by hands-on experience
- Hands-on science learning would be enjoyable
- If we learn science by hands-on experience, we would acquire complete knowledge of science
- Science will be learned properly if we learn science practically

Behavioural tendencies: Some evaluative responses provided understanding about their behavioural tendencies
Example of typical responses:
- I want to learn science by doing it practically in order to use/apply science knowledge in real life
- I would want to learn science by doing it practically in order to understand the world around us
- We would be more interested in science if we could learn science practically

Some beliefs directly contributed to attitudes

Provided insights into a formed attitude towards school science
School science is difficult to study; it will become easy if science is learned through hands-on experience
5.3 Attitudes Towards Science as a Subject: Is School Science Really Interesting?

Most of the participants (72%, see Section 4.2.1) of this study reported that school science was interesting. This is consistent with findings from international studies, such as the ROSE project (Schreiner & Sjøberg, 2004), PISA 2006 (Bybee & McCrae, 2011) and TIMSS 2007 (Martin et al., 2008), and a local study (Mojumder & Jahanara, 2009). Interestingly, this contrasts with the reports of students from developed countries such as Australia (Lyons, 2006b), Sweden (Lindahl, 2003), and the UK (Barmby et al., 2008; Osborne & Collins, 2001). Closer examination of the research reveals that students from developed and technologically advanced first world countries do not show a similar interest in science to those from less developed and less industrialised countries (Awan, Sarwar, Naz, & Noreen, 2011; Bybee & McCrae, 2011; Martin et al., 2008; Schreiner & Sjøberg, 2004). Students from developed countries have identified science as a boring subject (Barmby et al., 2008; Lindahl, 2003; Lyons, 2006b; Osborne & Collins, 2001). These studies did not explore why such students’ responses differed from those of the children of less industrialised developing countries.

Sjøberg and Schreiner (2010) attempted an explanation about such interest among the students from developing countries like Bangladesh. As part of the ROSE project, they presented a list of 106 possible topics of school science and asked students whether they were interested in learning about those topics. Sjøberg and Schreiner found that students from developing countries like Uganda, Bangladesh, Zimbabwe showed a great deal of interest in learning most of the topics presented, while students from developed countries were more selective in choosing topics of interest. Based on this and similar findings from the ROSE study, the researchers speculated that in developing countries going to school at age of 15 is considered a “luxury” or “privilege” (Sjøberg & Schreiner, 2010, p. 16). Hence, students in developing countries may be happy to learn about nearly everything that
a school can offer, whereas children in developed countries may consider going to school as an obligation rather than as a privilege. However, such claims are beyond the scope of this study as students did not broach any issue of luxury or privilege or similar ones regarding educational opportunities, therefore the claims could not be supported by the responses of students of the current study.

As the current study asked students why they found science interesting, most students were found to struggle to explain why it was interesting for them. The most frequent response (18 out of 55 responses1) was that they could gain new knowledge by studying science: “we learn about so many unknown things/matter by studying science” (IXSCG08). Such responses suggest that school science is interesting not because of its intrinsic interest, but rather for some extrinsic motivational reasons for being interested in school science. This motivation for learning new science knowledge may be related to the value that is associated to knowledgeable students by the large community in Bangladesh. In an examination-driven education system, where it appears that test items are aimed at evaluating the first cognitive domain of Bloom’s taxonomy (Bloom, 1956) (i.e., knowledge), students are encouraged to learn science by memorising facts and information (Tapan, 2010). Grades obtained in examinations are then an indicator of the quality of a student. Students achieving the best grades are widely regarded as the brightest, most talented and knowledgeable. The common practice is that these top students mostly choose the science stream in all levels of their academic career, and students who cannot take

1 Frequency of responses is different from the number of students agreeing or disagreeing with any statement. One respondent could provide his or her response under several themes while he/she has been counted only once for his agreement (agreed/disagreed) with each statement.
science are considered as less knowledgeable and valued less by society. This is evident in the following comment by a focus group participant, which is supported by some participants responding to the questionnaire:

Cassy: Everyone says that best students take science. If someone studies in the business group, people would say, “Ooh! You study business!” It means you are not the best student; you are just an average student. They always underestimate the non-science students.

...everyone [in the society] believes that those who study science are the most brilliant [brightest] students. Next are the students who study in the business studies stream; they are the second best, and then those who study humanities are the worst. As a result, since my childhood I thought about nothing else but taking science. (XSCG37)

Therefore, it seems that there is an extrinsic motivation driving students’ interest in school science as it earns value and respect in the society. Evidently, there are some other motivations for being interested in school science. They are revealed as the discussion continues.

5.4 Experience of Science as a Difficult Subject

Almost two thirds of students (65%, see Section 4.2.1.2) reported science as a difficult subject to study, while 10% of students were uncertain about this (see Table 4.2). Students in the current study reported science as difficult to study under the themes learning the content of science, how science is being taught, science connected to daily life, time and study load, and science textbooks. Most of the responses were received under two of these themes: how science is being taught and science textbooks. This shows some consistency and some differences with results reported from Woolnough (1996) and
Lyons’s (2006a) comparative review of three studies (Lindahl, 2003; Lyons, 2003; Osborne & Collins, 2000). Woolnough found that many students (ranging from 37% to 56% from Years 7 to 11) expressed their view that school science was difficult because they found their teachers made things too boring by talking too much. Teaching was more lecture-based and students were supposed to do what the teachers told them to do. As a result, many of them reported that they couldn’t understand science. This is comparable to the theme, how science is being taught, which emerged in this study. On the other hand, Woolnough (1996) revealed that many of the students portrayed science as a subject for highly advanced and clever people who can spend all their time after study in science and science related work, and therefore they considered a career in science as not exciting; however these perceptions were not shared by the students of the present study.

Lyons (2006a), in his review of three studies, reported passive learning, memorisation, irrelevance of science content, and unfamiliar terms, words and concepts in science as the roots of the perception of difficulty among students. Several of these can be characterised as the way science is being taught, while irrelevance can be compared to the theme science connected to daily life mentioned by some students in the current study.

As most of the responses were received under two themes; how science is being taught and science textbooks, students’ attitudes in these main themes will now be discussed.

5.4.1 How science is being taught. Nearly 54% of the responses (66 out of 123 responses agreeing that science is difficult to study) reported that science was difficult because of how it was being taught. They found that the way science was being presented to them was very hard to follow and understand. Science teaching is such that science never becomes easy for them: “Teachers cannot make science easier, more interesting and enjoyable for us” (IXSCG04). They reported that the textbook content is being lectured to
them, with chalk and talk at the black board the most commonly used instructional method. Although in the science curriculum, there was a practical component requiring students to reconfirm their learned knowledge by doing experiments in laboratories, teachers demonstrated the practicals where the students had to watch on as an inactive observer: “… we can’t even touch any equipment in practical labs, our teachers do all the experiments and we just watch those” (XSCG21).

Students’ views of the transmissive style of teaching agree with Tapan (2010) who reported the frustrating scenario of one-way practice in science teaching in Bangladesh. Tapan found that science teachers teach the same things in the same way they were taught when they had been students. There are teacher’s guides in Bangladesh that have introduced many innovative teaching methods and are designed to help teachers improve their teaching of science. However, Tapan suggested that science teachers are very reluctant to use such innovative methods due to lack of interest, motivation, and proper in-service training and rather continue to teach the students to rote learn (Tapan, 2010).

Further it was reported by students that due to rote learning of science concepts there was little to no application of scientific knowledge to everyday life. School science, as a result, must seem to them to have no relation to their life. Rather, it was about memorising facts, laws, information and postulates, and practising and sitting exams to achieve good grades: “studying science at school means memorising information and a number of facts and laws for responding to the exam questions. Since we are not taught science practically, we do not understand many of scientific events” (IXSCG13).

Several qualitative studies (Lindahl, 2003; Lyons, 2003; Osborne & Collins, 2001) have described similar practices of transmissive teaching methods in science classes. In recent time, Goodrum et al. (2012) also reported teachers using the traditional transmission model in Year 11 and 12 science classrooms in Australia. Lyons (2006a) declared that
frequent use of transmissive modes of teaching left participants with the impression that science is a body of knowledge to be memorised. As a consequence, participants in the three studies (Lindahl, 2003; Lyons, 2003; Osborne & Collins, 2000) were overwhelmingly critical of the use of transmissive modes as the default option for teaching science.

Lyons (2006a) further suggests a teacher-centred transmissive approach has a number of consequences for students’ engagement with school science. As confirmed in the current study, Lyons (2006a) asserted that many students do not perceive the teacher-centred transmissive teaching approach as conducive to understanding science concepts. Failure to understand science concepts frustrates students even if the content itself is interesting. Lyons found such frustration contributes to the perception that science is a difficult subject to learn by affecting students’ self-efficacy. The voices of Bangladeshi students in this study resonated with what Lyons reported (see Chapter 4), and emphasised that this style of teaching leaves little opportunity for in-depth discussion among students. Lack of communication as part of the learning process was also described as impacting negatively on the students’ learning in this study: “We are required to memorise the content of science textbooks without having any scientific reasoning. Moreover, if we ask about any application of science topics we do not get any convincing answer” (IXSCB05).

Finally, this study concedes that students’ evaluation of science teaching and their perceived difficulties with science impact negatively on their science learning. As a result, this study proposes rethinking how science is taught, where it integrates hands-on, student-centred methods instead of transmissive modes of teaching.

5.4.2 Science textbooks. Almost 19% of the responses (23 out of 123 responses agreeing that science is difficult to study) reported that students find science difficult because of their science textbook(s). According to the participants, the text in science
textbook(s) is not easily understood: “the text in the textbooks is not easily understandable” (IXSCB14). The language used in science textbooks is not age appropriate for them, because of the highly scientific terms and sophisticated scientific language: “the language of science textbooks is very hard/difficult” (IXSCB14). Science topics are not well explained, lack sufficient examples, and are presented in a complicated way: “in science textbooks, science topics are presented in a very complex way” (XSCB33). This finding agrees with teacher participants of Sarkar’s (2012) study, who stated that the language of junior secondary (Grades 6 to 8) science textbooks is highly complex when compared to the language ability of students. Sarkar (2012) argued that this complexity of language is an important issue for science education in Bangladesh as it augments students’ difficulties in understanding the science content. Since the teaching-learning activities in Bangladesh rely heavily on the government sanctioned textbooks, teachers have little flexibility to teach content in any other way but that proposed in textbooks (Sarkar, 2012). Therefore, the language of science textbook(s) requires a careful revision to bring the language in line with the age and ability of the students in order to make the content more easily understood. Further discussion on issues associated with textbooks appears in Section 5.6.

5.4.3 Implications of the experience of science as difficult to study. According to Lyons (2006a), the experience of school science as difficult to study could have a number of implications in science learning and attitudes of students. Lindahl (2003) intimated that such perceived difficulties and the subsequent frustration associated with non-understanding of science concepts can affect student’s self-efficacy. As a result, Lyons (2006a) contends, students begin to memorise science without trying to understand the concepts. This was also reported by students in this study, for example this quote, “we have to memorise many topics in science without understanding or comprehending” (XSCB50). Osborne and Collins (2001) suggested that perceived difficulties associated
with non-understanding of science concepts can lead to students adopting a sustained disinterest in science learning. Some students in this study reported that they began to feel antipathy in science learning (see Chapter 4). Lyons (2006a), also argued that such experience of difficulty and disinterest in science learning could be carried through to their adulthood and could affect their long term career choices. Similarly, students in Woolnough’s (1996) study perceived that scientific careers would seem beyond them due to the difficult nature of studying science. However, something different is influencing students in the current study; even though they experience science as difficult to study, they still show interest in doing school science and wish to pursue science related careers in the future (see Chapter 4). Further discussion on this interest in engaging with science is followed up in Section 5.10 on students’ motivation for choosing science.

5.5 Overloaded Science Curricula

In the Bangladeshi context it is difficult to separate the impact of textbooks from that of the curriculum. For most teachers the government published textbooks represent their only contact with the curriculum, while the curriculum document itself sits in the office of an administrator (see discussion in Chapter 1, Section 1.3). According to most of the students (74%) the science textbooks seemed dominated by large amounts of content that needed to be covered in a very short period of time. Most students found there were extensive science concepts to study, with only 15% of students disagreeing with the notion that textbooks contained too much content. A majority of students (58%) commented that they were always under pressure to learn more and needed to be rushing to complete the chapters in science textbook(s) in line with the teacher’s work pace. This is not confined to Bangladesh; the notion of an overloaded curriculum that is rushed by the teacher has been reported in studies in many countries across the world (e.g., Danaia et al., 2013; Goodrum et al., 2012; Jenkins, 2006; Osborne & Collins, 2001; Ranade, 2008). According to Jenkins
(2006), such complaints about the science curriculum being overloaded seem to have been commonly and uncritically accepted as fact.

According to students in this study, the overloaded curriculum creates pressure on them and contributes to lack of comprehension of science concepts among them (see Chapter 4). Ranade (2008) indicated that the overloaded science curriculum was a “burden” for Indian students and “tied [it] to incomprehension” (p. 102). Osborne and Collins (2001) suggested that with a rushed science curriculum, students are being “frog-marched across the scientific landscape, from one feature to another, with no time to stand and stare, or absorb what it was that they had just learnt” (p. 450). Ranade (2008) further explained that curriculum makers in India are faced with the issue of an explosive growth in the information as part of science that they need to include in the curriculum. They responded by adding more topics and by pushing other concepts down to lower levels. This may also be true for Bangladesh as it shares a similar educational culture and follows the same Western-science-influenced curriculum. Following Western science in a non-Western country seems to be a real challenge. Some of the challenges of following Western science are discussed in Section 5.6.2.

Students in Bangladesh constantly feel an urgency to complete and understand the must-learn content of science as they are required to undertake three end-of-semester examinations in each academic year as preparation for the national examination (S.S.C.) held after completing Grade 10. These examinations determine their further studies at higher secondary and university level, and ultimately their careers. The examinations are held at a set time, regardless of whether the students have completed the curriculum or not, and/or whether students have learnt it (see Chapter 4). This is consistent with the findings of Koul and Fisher (2002) who attributed the overloaded curriculum in India directly to the examination regime.
Teachers and students both have to endure the consequences of an overloaded curriculum in their teaching and learning. Students in this study agreed and understood that with so much content to cover, teachers needed to cover the content quickly which led to transmissive modes of teaching. Mst Shaila Banu (2011), and Osborne and Collins (2000) suggested that due to an overloaded curriculum, teachers feel pressure to choose teaching methods that cover more content in a shorter period of time, and thus revert to transmissive modes of teaching. Sarkar (2012) further identified that an overloaded curriculum limits the scope of teaching options and the discussion of science concepts. Similarly, Kemper (2000), and Mst Shaila Banu (2011) intimated that the overloaded curriculum does not allow science teachers the time to do any activities associated with learning science. As a consequence, students are rushing through content but lack understanding of the scientific concepts and revert to cramming as the best way to study the content and complete the curriculum in time (see Chapter 4).

The overloaded curriculum can also result in lower grades in examinations and less interest in science (see Chapter 4). Students commented that because of the overloaded science curriculum they had to focus more on science subjects and less on other subjects, which caused lower grades in other subjects. Conversely, if they focussed on other subjects and less on science subjects, they would get lower grades in science subjects

…we have to study so many things in other subjects. If we spend more time on science subjects then we will get poor grades in other subjects, inversely, if we focus on other subjects then we will have poor grades in sciences. (XSCB39)

As the exam items demand lower levels of thinking on a Bloom scale (Bloom, 1956), students’ rote learning and then crammed knowledge approaches allowed them to answer examination questions (discussed in the previous section). Those who could not
memorise and recall the text as it was presented in the textbooks during an examination were likely to get poor grades and subsequently lose interest in studying science.

Research on science education in Bangladesh (Mst Shaila Banu, 2011; Rahman, 2011; Sarkar, 2012) has reported this characteristic of science curriculum as problematic from the perspectives of teachers who are used to rushing with the content of such an overloaded curriculum to prepare students well for exams. Students in this study reported that their overloaded science curriculum was problematic for them. Therefore, a careful revision of the science curriculum is necessary in order to make it attainable for students.

5.6 Science Textbooks: The De-facto Curricula

The proportion of students reporting their liking or disliking of the science textbooks is almost equal. However, compared to the non-science participants, science students were more likely to dislike their science textbooks. One reason for this is the difference in the nature of science textbooks. According to non-science students, the general science textbook is well written, well explained and easy to follow. An explanation for this is perhaps the emphasis on applied content in the general science curriculum, while the textbooks for science students is focused mostly on pure, descriptive and highly academic, factual content. Siddique’s (2007) analysis of secondary science curricula revealed that the general science curriculum had a strong emphasis on domestic applications and applications in contexts, especially those of the environment, health and natural resources. The content of this science curriculum had relevance to the learners’ personal and social contexts, which is a characteristic of a science curriculum aimed at preparing scientifically literate citizens.

On the other hand, most of the science students disliked their science textbooks because of the: content, language and illustrations in science textbooks. The following sections discuss these elements of science textbooks. Throughout the discussion, science
textbooks and curriculum will be used synonymously as in Bangladesh textbooks are the de-facto curricula; textbooks are considered as the updated version of curricula in Bangladesh by everyone (Sarkar, 2012).

5.6.1 Content of science textbooks. Participants mentioned four themes related to concerns they had with the features of the content in science textbooks: outdated, pure content with too few applications of science knowledge, incompleteness, and unclear and complex content. Student responses under these themes, presented in Chapter 4, will now be discussed in the following sections.

5.6.1.1 Outdated content. Participants revealed that the content and information in science textbooks was outdated, and as such was of little use to them. Many contemporary inventions were not included in their textbooks; rather students had to study scientific concepts that were outdated in society or obsolete in their current contexts. For example, one student responded that they did not understand why the textbooks used examples such as black and white televisions in their explanation: “...we are still being taught how a black and white television works” (XSCB39). The textbooks that they followed in 2012 (in which year their responses were being received) had been published in 1996 and since then there had been no changes to them (science textbooks) in terms of updating the content to make it more contemporary with students’ lives. Since textbooks are followed in all aspects of teaching, learning and assessment, this outdated feature of science textbooks causes disinterest and dissatisfaction among students. In line with this, Rahman (2011) argued that the textbooks content cannot be described as inspiring, while the teachers in Sarkar’s (2012) study reported the content in the junior secondary science textbook as outdated and a great deal of the content was unrelated to current issues in the world. Since education practice in Bangladesh does not allow any flexibility to teachers but to follow
the textbooks, science teachers of Sarkar’s (2012) study even failed to teach IT related contemporary content to students.

The outdated nature of science textbooks was also reported by Australian parents in Tytler and Symington’s (2006) study, who pointed out that the textbooks the students currently use look much the same as those they themselves had used in the 1960s. They also commented that the view of science contained in textbooks at the time of their study did not reflect what they understood as the current practice of science. Tytler (2007), at the same time, recognised that the broad shape of science education worldwide including in developed countries has remained relatively unchanged, at least in its official guise, for the last half century at least. What has changed, according to him, is mainly the practice of scientific research and technological development, the nature of public engagement with science, the range of expansion of knowledge in science, the nature of schooling, and the nature of youth. Therefore, the voices of the participants regarding the issue of outdated content in science textbooks need to be recognised with importance, and the obsolete nature of science textbooks has to be replaced by contemporary content and pedagogy, as science textbooks have the ability to influence how students perceive the science enterprise (Chiappetta, Sethna, & Fillman, 1991).

5.6.1.2 Textbooks present science content as only factual knowledge. Science textbooks are perceived by students as mostly containing pure content representing theories, laws, postulates, principles and facts, without showing any connection to students’ real world: “…for example, motion, simple pendulum, heat, calorimetry, light etc. are full of texts only” (IXSCG02). This and similar expressions of students concur with the analysis of science curricula by Siddique (2007), who found the science concepts included in existing secondary science curricula for science students to be mostly pure content with little connection to learners’ personal and social lives (see Appendix 7 for
content typically presented in a science textbook). Application of science concepts in context has been neglected compared to the pure content in secondary science curricula of Bangladesh. Finally, Siddique (2007) argued that this feature is a common characteristic of a traditional science curriculum that usually focuses on preparing future scientists. Later on, Sarkar’s (2012) analysis of junior secondary science textbooks in Bangladesh revealed that the textbooks emphasised mostly pure academic content and were not connected to students’ everyday lives.

Such characteristics of science curriculum does not exist only in Bangladesh. A similar trend was found in Australian Year 11 and 12 science curricula by Goodrum et al. (2012), which is often viewed as preparing students for university studies that produce future scientists. In the UK, participants of Osborne and Collins’s (2001) study also expressed their evaluation of school science as consisting of facts to be learned where they have to learn straight facts of science and repeat them in exams.

Due to over-emphasis on theoretical and abstract content of science, students in this study felt forced to memorise the text in their textbooks without knowing the connections to their everyday lives (see Chapter 4). This made science difficult to learn: “There is too much information, data, laws and postulates (which we have to memorise) in science, which make science difficult” (IXSCB08), and at the same time students failed to realise the applications of science knowledge. Similarly, Goodrum et al. (2012) showed that the content-laden Australian science curriculum emphasising abstract theoretical ideas resulted in the perception of science as conceptually difficult. On the other hand, students in the UK (Osborne & Collins, 2001) expressed that there are always right answers in science and the right answers must be learned [by rote memorisation] to respond to the exams, which is not consistent with the actual purpose of science education.
Textbooks’ emphasis on factual knowledge could also have a negative effect on students’ interest in science: “Our science textbooks are too boring” (XSCG31). The remarks of students in this study agree with the students in the UK of Osborne and Collins’s (2001) study, who reported their lack of interest in learning science that overemphasised facts and knowledge to learn. Given that affective outcomes (e.g., interest) are much more enduring than cognitive outcomes (e.g., knowledge) (Petty & Cacioppo, 1986), Osborne and Collins (2001) suggested that if one of the primary outcomes of a good science education is to be an enduring interest and engagement with science then school science needs to focus more on its affective aims.

Therefore, in order to ensure more affective legacies (e.g., interests) of school science and comply with student demands, this study recommends emphasising less on abstract theoretical content and more on the content that has connections with learners’ personal and social lives in order to engage them more with their school science and uphold their interest in school science. This study also suggests to carefully revise the science textbooks with emphasis on developing inquiry skills, as students wanted to learn not only about the applications of science knowledge but also the ways in which science processes can assist in developing specific and generic competencies. This would help students extend the school science beyond their school, rather than to be forced to memorise the abstract and pure content to score highly on examinations.

5.6.1.3 Incomplete content. Students reported incompleteness of content as another problematic characteristic of science textbooks. In order to explain incompleteness, students further commented that most of the topics in science textbooks lack sufficient information, complementary examples and adequate explanations and many of those the textbooks did include could not be understood. They found many scientific words and terms that were not further explained, though students felt that they needed further
explanation to be understood. For this reason, students laboriously memorised the scientific words and terms as they did not know what they meant, and as a result, they felt that science was difficult.

Students’ commented about the lack of sufficient information and explanation that coincided with the experience of secondary science teachers in Bangladesh studied by Rahman (2011). Teachers in his study reported that the science textbooks often lacked adequate examples and explanations on science topics. Because of this, they (teachers) sometimes failed to develop a clear understanding about the topics. As a result, they faced difficulties in explaining the topics clearly to students.

Devetak and Vogrinc (2013) suggested that a quality science textbook is supposed to provide students with a clear insight into the basic content, structure and systematic nature of the science subject. They argued that students’ conceptions about the scientific content can only poorly develop due to a poorly prepared textbook and inaccurate reading of textbook materials. The most important criterion for a good science textbook is probably that it should take into account the level of development of students, their level of understanding and experience with science concepts at previous schooling levels. A list of important concepts with explanations should be written at the end of each chapter and/or at the end of the textbook. Comparing students’ voices with these guidelines for a quality science textbook, the science textbooks of Grades 9 and 10 in Bangladesh cannot be claimed to be of good quality in terms of promoting understanding of science concepts among students.

5.6.1.4 Unclear and complex content. Many topics in science textbooks were reported as unclear and complexly written, and were not perceived as self-explanatory. Students further explained that examples that could communicate the ideas or easy-to-comprehend explanations were rarely given. Albeit a few examples are given in textbooks
on some occasions, they were perceived as unclear and complex as well. Many students’ questions were not answered in textbooks. Students, as a consequence, perceived most of the topics in textbooks as monotonous, complicated and difficult to follow. Such features of textbooks also influenced their interest in science (see Chapter 4).

Students’ perceptions about the unclear and complex nature of science textbooks agreed somewhat with the perceptions of science teacher participants in Rahman’s (2011) study. Those science teachers were heavily dependent on science textbooks for content knowledge in the science that they needed to teach. They were having difficulty with finding clear content knowledge from the supplied science textbooks. They also reported the paucity of clear and concrete examples needed to understand science topics. As a result, they did not have clear understandings about science concepts and found it difficult to explain the concepts to students.

In a textbook-reliant education system, as in Bangladesh (Siddique, 2008; Tapan, 2010), if textbooks are not clearly written and explained, it causes lack of understanding and alternative conceptions to develop in students (Devetak & Vogrinc, 2013). This makes science a difficult and uninteresting subject. Therefore, in agreement with Rahman (2011) this study suggests that the National Curriculum and Textbook Board (NCTB), the only authority for preparing textbooks in Bangladesh, improve the textbooks in order to overcome the perceived ambiguities in science textbooks so that students’ perceived difficulty could be reduced and interest in science improved.

5.6.2 Language expressions in science textbooks. Language in science textbooks was perceived as very complex so that the content was not easily understandable. Words, terms and sentences used were reported as complex and inappropriate compared to the ability of students. Students, as a result, became unable to understand their science textbooks by themselves (see Appendix 7 for typical language used in a science textbook).
Jenkins (2006) confirmed students’ difficulties with understanding science concepts and suggested that the use of language to explore scientific ideas is a key element of the constructivist approach to science learning. If the language ability of students is not compatible with the language used in science, students must have difficulty understanding science concepts.

Lack of understandings could result in lack of interest in science learning and feelings that the science subject is difficult (see Section 5.4.3). This may be attributed to the Western nature of school science in Bangladesh (Sarkar, 2012). In support of this, Tapan (2010) stated that secondary science textbooks were developed in line with the standards and style of textbooks at O-level/GCSE level (the British system).

Yager (1983) reported that Western school science textbooks overemphasise learning scientific words and definitions, which is one of the major contributing factors to the difficulties of learning science with textbooks. Yager’s (1983) analysis of K-12 science textbooks revealed that terms were a central feature in most science textbooks which required a disproportionate percentage of time for vocabulary mastery. Bryce (2011) more recently confirmed similar features in science textbooks, identifying these as often using difficult technical vocabulary and uninteresting language, which promotes incomprehension of science concepts while reading.

Such characteristics of science textbooks not only pose challenges for students, they also challenge science teachers in Bangladesh. Tapan (2010) acknowledged that science teachers, especially in rural Bangladesh, are still facing difficulties while teaching science subjects as they are not oriented with the content and pedagogy of modern Western school science.
According to Aikenhead (2001), Western science has its own language attributed to its own culture, the Euro-American culture. Considering the inevitable existence of Western science in Bangladeshi science textbooks, the textbook authority may need to think how local language can be used comprehensively in science textbooks in order for students to better understand scientific concepts and terms while learning Western science in a non-Western setting. At the same time, teachers may need to be educated in and become familiar with the use of the language of Western science in their native language in order to act as a “culture broker” (Aikenhead, 2001, p. 340) while teaching Western science to non-Western Bangladeshi children.

5.6.3 Pictorial representations in science textbooks. Pictorial representations given in science textbooks were perceived as unclear, incomprehensible, inadequate, not colourful (black and white), and of poor quality. Rather, the pictorial representations made the content more complicated for students, even though the purpose of representations was to make the topics clearer and more understandable to students. Students also reported that they found very few illustrations in their science textbooks though many topics demanded explanations with illustrations. This finding concurs with the findings from a curriculum evaluation study by Stern and Roseman (2004). Their evaluation on middle-school science curriculum materials revealed that science textbooks lack representations to clarify abstract scientific ideas. Representations that are included in science textbooks are often incomprehensible, and the illustrations of complex processes, like photosynthesis are insufficiently explained; many diagrams are filled with technical terms that have not been previously introduced, and many of the representations are likely to mislead students.

Since, representations can help make abstract scientific ideas understandable to students (Devetak & Vogrinc, 2013; Stern & Roseman, 2004), more attention must be focused on understanding the impact of visual images on students and their science
learning (Cook, 2008). When visuals are incorporated into science textbooks, it has to be kept in consideration that middle and high school students tend to see visuals as an actual copy of the reality and not as conceptual representations (Grosslight, Unger, & Jay, 1991). Therefore, in line with the guidelines provided by Devetak and Vogrinc (2013) and student demands, this study suggests that pictorial representations have to be clear enough to serve their purpose – to illustrate the textual content; colours should be used on illustrations and the colours must be carefully selected, since many students interpret differently the colours representing different features in the picture; pictorial materials must include adequate information, so that the information can foster comprehension of concepts presented in textual and pictorial materials. While incorporating images, textbooks should use realistic images that present reality according to the human optical perception. This would also involve students in considering which aspects of a real thing are being represented by the illustrations and which are not (Thagard, 1992).

5.6.4 Summary of the student evaluation of science textbooks. In order to summarise participants’ responses regarding science textbooks, all the issues reported by the students in this study are reproduced in Figure 5.3. Participants mainly voiced their concerns on three aspects of science textbooks: content, language expressions and pictorial representations. Content was reported as outdated, presenting science as only factual knowledge, incomplete, unclear and complex. According to student responses, the being outdated and presenting science as factual knowledge features of science content seem to have had a negative consequence on their interest in science, and presenting science as factual knowledge, incomplete, unclear and complex nature of content, pictorial representations and language expressions used in science textbooks were likely to contribute to their lack of understanding in science. Lack of understanding lead students to have a declining interest in science, to rely on memorising scientific facts, to feel its
difficulty, and to lack realisation of the applications of science knowledge (see Figure: 5.3).

Figure 5.3. A summary of student voices regarding science textbooks

Finally, this study suggests the textbook authority pay careful attention to students’ voices and critically revise science textbooks to overcome the issues pointed out by students (Figure 5.3). As non-science students liked their science textbook due to the well written, well explained and easy to follow nature of their textbook, science textbooks for science students need to focus on such features.

Science content needs to be up-to-date in order to make textbooks compatible with students’ out-of-school experience. More emphasis on applied content is needed, rather than the focus on pure and descriptive factual academic content. The content needs to have
relevance to learners’ personal and social contexts for preparing scientifically literate citizen. Language expressions need to be well matched with students’ level of comprehension so that reading comprehension is not too difficult. Pictorial representations need significant attention and improvement as well.

5.7 Assessment Practices in School Science

According to the students, the current assessment system requires them to memorise the abstract content in science textbooks and recall exactly the same in exam papers: “Our marks/outcome-centred education system encourages us to memorise science. For example, Bottomley’s experiment, Searle’s method; we just memorise the steps of these experiments and write down in exam papers” (IXSCG08). Exam items do not encourage students to answer based on their understanding of science, rather cramming science knowledge from science textbooks and copying the same in exams appears to give better results: “If we memorise and write down exactly the same in exams, we get good marks, otherwise if we write based on what we understood, we do not get good marks” (IXNSB56). Such assessment procedures do not require students to develop the higher order skills of Bloom’s taxonomy (Bloom, 1956), that is, application, analysis, evaluation or synthesis. In agreement with this finding, Holbrook (2005) reported that in Bangladesh student learning is examination-driven, and examinations mostly demand cramming and recalling the content from textbooks while test items are taken from the textbooks.

Coll and Taylor (2012) argued that education in developing countries is still dominated by high-stakes, external and summative examinations that largely focus on lower-level cognitive skills such as recall. Such examinations are inconsistent with a learner-centred education approach, because the examinations consist of tests of memory recall, which encourage rote memorisation of scientific facts (p. 773). They noted, however, that this is not unique to developing countries.
Rote memorisation of scientific facts as a requirement of assessment was also reported in Australia by Lyons (2006b) and Goodrum et al. (2012), in China by Zhang et al. (2003), in Sweden by Lindahl (2003), and in the UK by Osborne and Collins (2001). Osborne and Collins’s (2001) study suggested that in such an assessment practice, which emphasises low-level skills and recall of factual information, teachers respond with a transmissive teaching style which traditionally has been perceived to maximise pupil achievement.

Responding with a transmissive style of teaching due to the assessment practice has also been reported by Tapan (2010), and Sarkar and Corrigan (2012) in Bangladesh. Tapan suggested that because of the traditional assessment system teachers find no alternatives but to reinforce students’ rote learning. Additionally, teacher participants of Sarkar and Corrigan’s study reported such traditional assessment practice as a challenge for promoting scientific literacy in classrooms. Moreover, Osborne and Collins’s (2001) study suggested that such pragmatic responses with a transmissive style of teaching resulted in a negative outcome regarding students’ enjoyment of science.

Students of the current study also commented that they did not enjoy such a teaching style and that the assessment procedure encourages solely memorisation. Alternatively, they wanted to learn hands-on science, believing hands-on science would be more enjoyable: “Hands-on science learning would be enjoyable...” (IXSCG12), and sustainable: “If we learn science practically, the knowledge of science will be retained in our memory for a long time” (IXSB01). Lindahl’s (2003) participants also responded in a similar way and wanted more control over their science learning. Lyons (2006a), additionally, argued that such practice of memorisation or rote learning does not provide any opportunity for in-depth discussion. This leads students to be unable to actively engage with science.
5.7.1 Socio-economic implications of current assessment practice. Students commented on the social pressure on them to do the best in national exams, particularly the SSC examinations which is the gateway to the Higher Secondary level of education in Bangladesh. The entire market is competitive. The only way to prove oneself is to achieve high academic results in the national exams. Students who do the best in SSC exam will get the opportunity for admission into the best colleges. But the best colleges are very few compared to the number of students passing SSC. The best colleges are expected to prepare students for the best universities. Again, places are very limited in the best universities compared to the number of students passing the Higher Secondary Certificate (HSC) exam. In addition, most of the parents want their children to choose the best professions like becoming a doctor, engineer, scientist, etc.: “Our goal [combined demand of student, parents, teachers and the society] is to become a doctor or an engineer, or some highly demanding professional, for which we need to have a good GPA” (IXSCB08). These professions are attractive and give pride to their family. So, good grades in an examination act as a ladder to improve one’s social standing in the community and ensure a good career and healthy future. With this comes a better social status in society, since status in society is very important in Bangladeshi culture.

This situation is very similar to the situation in India reported by Ranade (2008), who connected the Indian examination-dominated education system with an economic cause. She commented that education in India is still driven largely by the desire of children and their parents to obtain a qualification (or certification) rather than for any intrinsic learning or development of thinking. Entry into higher education requires high scores at earlier levels; higher degrees with high scores are prerequisite to the best jobs and high income. Science subjects are studied solely for the purpose of succeeding in the examinations. Any material outside the scope of examination is considered irrelevant and ignored by both teachers and students.
This situation is also quite similar to the findings of Osborne and Collins’s (2000) study in the UK. Student participants of their study repeatedly mentioned the instrumental value of school science rather than its intrinsic value; participants valued science education for career aspirations rather than as a subject of intrinsic interest.

Finally, the findings of this study suggest that the assessment practices are interconnected with the teaching and learning. Without reform of the current assessment system, better teaching and better learning cannot be expected. If the regime of examinations assessing students’ memorisation capabilities does not stop, changes in teaching will not occur. As a result, mere memorisation of scientific facts will continue. In order to improve the scenario, a student-centred assessment system needs to be introduced with a focus on higher order skills of Bloom’s taxonomy (Bloom, 1956) such as application, analysis, synthesis and evaluation. This may then positively impact on the teaching and student learning in science.

5.8 Relevance of School Science

Most of the students were found to believe that school science was useful for their lives. However, at the same time they agreed that because of the way science was being taught they could not discern how school science might be relevant to their lives. Science teaching in school is likely to be failing to make the connections between school science, students’ personal needs, and the issues in real life and society. This finding confirms the findings of Cleaves (2005) who qualitatively analysed students’ considerations while choosing post-compulsory science courses. Her students reported a lack of relevance in the way that science was taught in school along with their disenchantment with the school science curriculum.

Science teaching is mostly reported by the students in this study as lecture dominated with few hands-on opportunities, exam focused and encouraging memorisation.
To support their beliefs about the usefulness of school science, students expressed their views about the general values of science in society such as science is everywhere, science knowledge is very important, or the contribution of science to human life is enormous. While presenting such views on the utility of science in general rather than the utility of their school science, they failed to provide a single example that supported their views. Similar to the views of student participants of Osborne and Collins’s (2001) study, students in the current study seemed to have a modernist faith in science as a source of solutions. Students in Osborne and Collins’s study were found to perceive scientific knowledge as being an important component of their education, but they emphasised only the general value of science in society often with examples of its instrumental value.

Similarly, Goodrum et al. (2012) found science students in Year 11 and 12 in Australia had a very positive view about the importance of science in broader society, even though science was being taught in traditional ways using the transmission model. Osborne and Collins (2001) argued that in such views the controversial nature of scientific research is less prominent and the scope for engaging critically with contemporary scientific issues is less recognised.

Such views about the importance and utility of science were found by Sjøberg (2002) to be connected with a country’s culture and developmental status. Sjøberg’s study found that children in all countries, including developed and developing, consider science to be useful for everyday life and for society more generally. However, children in developing countries were found to be far more positive than those in developed countries. Children in developing countries were found to have a heroic image of scientists; they are brave and intelligent; they help the poor and underprivileged people; they cure the sick; and overall they work for improving the standards of life for everybody. Sjøberg (2002) suggested that students from developing countries are to a greater extent concerned about
raising the material standards and effecting a general improvement in their living conditions, so that they view science as a vehicle for social mobility and economic development. In contrast, children in developed countries, who are extremely dependent on science and technology, were not found considering these aspects of science and scientists; they were skeptical and less positive in their attitudes and perceptions regarding science and technology. Sjøberg then argued that the image students from developing countries have of science and scientists has an influence on the motivation and willingness to engage with science, which appears to be applicable for Bangladeshi students (see Section 5.10).

Students’ evaluation confirming school science as irrelevant to their lives is also consistent with a number of studies worldwide (Barmby et al., 2008; Ebenezer & Zoller, 1993; Goodrum et al., 2001; Lyons, 2006b) and probably a persistent problem for school science education (Hofstein, Eilks, & Bybee, 2011). Students in studies by Lyons (2006b) and Barmby et al. (2008) expressed their attitudes about school science as personally irrelevant and boring. Similar to the students in the current study, students in their studies reported that due to the way science is being taught they did not realise the relevance of school science.

Although science students in Year 11 and 12 of the study by Goodrum et al. (2012) reported a mostly transmissive model of teaching in their science classrooms, most of them commented that science is relevant (often to almost always) to their future and often helpful in occasions to their health and useful in everyday life. Students in their study were asked to indicate how relevant science was to various issues in their lives and general society. In contrast, most of the non-science students in Goodrum et al.’s study, who did not chose science for Year 11 and 12, expressed their evaluation on science studied in earlier years as not particularly useful or relevant to them personally. While non-science students’ views in Goodrum et al. agreed with the views of students in the current study,
science students’ views contrasted. This may be due to the fact that after junior secondary level of education in Australia only a small percentage of students choose science for further study in Years 11 and 12 and they have already set their mind to pursuing higher studies in science at university level. The students’ experience in Bangladesh of irrelevant school science is not unexpected since Tapan (2010) found that ‘new’ curriculum and textbooks, prepared in 1995 and introduced in the following years, shied away from hands-on practice to a more theory-laden and text-dominated focus. According to Tapan, this was a blundering phase of science education in Bangladesh.

Such a picture of school science as irrelevant to students’ lives is contradictory to the ideal picture of school science stated by Goodrum et al. (2012). According to the ideal picture, school science should be relevant to the needs, concerns and personal experiences of students, and the teaching and learning of science has to be centred on inquiry; students investigate, construct and test ideas and explanations about the natural world.

Considering the mismatch between students’ evaluation and the ideal picture of school science, it may be reasonable to conclude that school science education in the case of Bangladesh is way behind World standards as well as students’ expectations with regard to its relevance. It would be worth mentioning that the school selected for this study is in the top ten percent of schools in Bangladesh in terms of their academic outputs and achievements, teacher qualifications and teaching, administration, resources and facilities, and so forth (Anonymous, 2015; Observation on March 1, 2012; Personal communication with Rubina (pseudonym) on April 4, 2012). Therefore, this study begs the question: If the students from a well-ranked school present this picture of school science, what would be the evaluation of others?

Finally, in order to achieve the standards of school science in terms of its relevance this study, in line with the ideal picture of school science (Goodrum et al., 2012), suggests
that for learning to be made more meaningful, science concepts should be taught in a context that is relevant and based on the experiences of the students. Every effort should be made to link the science taught in school with experiences and understanding outside the classroom and common in the everyday life of the students. If a student learns science concepts in a context that is meaningful then that learning is intrinsically useful no matter what career pathway a student undertakes. Just because a student decides to seek a science related career, it does not mean the science he or she is taught needs to be boring, irrelevant or lacking a sense of engagement. The science concepts that students learn can be challenging but they should be achievable. They should also enhance personal and social decision-making. (Goodrum et al., 2012, p. 49)

5.9 Science Teachers’ Qualities and their Importance for Student Learning in Science

5.9.1 Emotional attributes of an ideal teacher. As reported by the students in this study, they wanted their teachers to be friendly, cooperative, cordial and well mannered; to treat all students equally; not to be ill-tempered; and not to punish them. Students also wanted their teachers to understand their needs; to pay attention to every individual student; to understand students’ problems; to provide students opportunities to share their problems, and to have the ability to solve the problems; to understand students’ shortfalls and limitations; to have patience and be attentive to what students say or ask; and to provide extra care to weaker students. These attributes of a science teacher are similar to those characterised as the emotional attributes of a good teacher by Raved and Assaraf (2011). In their study, 10th-grade Biology students (n=61), in their interviews, identified interpersonal teacher–student interactions and teachers’ consideration of students’ needs as the central characteristics of a good teacher. Students in Raved and Assaraf’s study also stressed the importance of a teacher who knows his/her students, is attentive to their needs and questions in class and beyond, is patient with weaker students, promotes a non-
punishing pleasant atmosphere in classrooms and uses humour. Raved and Assaraf (2011) argued that teachers’ emotional attributes and teacher-student relationships are very important for good teaching.

At the same time, Raved and Assaraf (2011) assumed that the need for such emotional attributes is due to the ever increasing number of students per classroom and teachers’ responsibility to teach simultaneously in many classes, which results in a superficial acquaintance with students. Although a similar scenario appears in Bangladeshi classrooms, further discussion of the growing demands in classrooms is beyond the scope of this study as students were asked to express their points of views about how they wanted their science teachers to be.

Students’ evaluation of attributes of their science teachers suggests that their science teachers comply with the authoritarian (Baumrind, 1991; Ertesvåg, 2011) nature of some teachers, who want to have high control and little relationship with their students. Such an authoritarian nature of teachers was found among teachers at the pre-primary level of Bangladesh (Mahmuda Shaila Banu, 2012). Mahmuda Shaila Banu’s observation of pre-primary classes in Bangladesh revealed that most of the teachers tended to scold children for their mistakes and poor learning achievements. Teachers in her study were also observed to have high expectations of all children with little account of students’ levels of strengths and competencies. Weaker children were observed to be neglected and verbally abused. Malak, Sharma and Deppeler’s (2015) research has also confirmed the authoritarian nature in teachers at the primary level in Bangladesh. One-on-one interviews with teachers revealed that they still used corporal punishment while believing that this was conducive to student learning and helpful for delivering an uninterrupted lecture. These teachers still believed that students’ disruptive behaviours were a threat to their authority and power. As a result, they use corporal punishment for controlling students in
order to maintain their power and confidence, and keep them undying or undecayable. Simultaneously, primary students in Habib’s (2015) study have confirmed the existence of corporal punishment and expressed that corporal punishment and teachers’ authoritarian behaviours are a barrier to the feeling of school belongingness. When students in Habib’s study could not do the homework or classwork given by teachers, they were beaten and scolded. Malak et al. (2015) finally argued that this practice of using punitive approaches has been a part of the education system in Bangladesh for many years and teachers still believe that this is appropriate; as a result it seems to be continued in future although it is banned by a state law.

Finally, students of the current study suggested that the lack of helpful emotional attributes of their science teachers had a negative impact on their science learning and was a barrier to concept understanding. Therefore, emotional attributes of teachers and the practice of an authoritarian style of teaching needed attention and improvement to facilitate better science learning and conceptual understanding among students.

5.9.2 Professional attributes of an ideal teacher. As stated by the students, science teachers seemed to be challenged to make science easily understandable for them; science lessons were not interesting, enjoyable and attractive; teachers did not create opportunity for a hands-on science learning experience; they did not attract students’ attention. As a result, students wanted their science teachers to make science interesting, enjoyable, attractive and easier for them; use interesting and enjoyable methods of teaching and create opportunities for hands-on science learning experience.

As reported, science teachers also seemed not to have a strong base of content knowledge; their knowledge was mostly textbook-centred. Nevertheless, the participants wanted their science teachers to be experts in science; to have complete knowledge of science; and to be capable of answering all students’ questions.
Such capabilities for teaching science are characterised as the professional attributes of a good teacher by Raved and Assaraf (2011). According to them, professional attributes show a teacher’s level of pedagogical and content expertise. Students of their study contended that a good teacher should have familiarity with the pedagogy of science as well as the learning content. She/he should also be able to provide students with appropriate answers and understand students’ learning levels to attend students’ difficulties with learning science content (Raved & Assaraf, 2011).

5.9.3 Importance of both attributes for students’ science learning.
Undoubtedly, both the emotional and professional attributes are important for students’ science learning and interest in science. Students in Raved and Assaraf’s (2011) study presented the ideal teacher as one who can combine professional and emotional attributes together. A good teacher, according to them, must be an expert pedagogue with adequate content knowledge, and at the same time be highly emotionally intelligent.

Students in the current study were found to expect their science teachers to have a blend of emotional and professional attributes in order for better science learning and enjoyment of science. According to them, if science teachers possessed the emotional attributes (reported in Section 5.9.1) as well the professional attributes (reported in Section 5.9.2) including adequate content knowledge of science, they would surely find science easier and interesting; they would enjoy science lessons, and understand and learn science content appropriately. In consequence, their knowledge would be enhanced and so they would begin to like science subjects. Therefore, this study suggests that teachers need to improve their emotional interactions with students and enhance professional qualities especially content and pedagogical knowledge of science, in order to create child-friendly science classrooms that promote better science learning and enjoyment.
5.10 Reasons for Choosing or Not Choosing Science

This study sought to understand student motivation for choosing or not choosing the science stream to study. A difference in responses was thought likely to appear between science and non-science students. Science students mostly chose science (1) for a better future career, (2) because of their parents’ and social demands, (3) because of their own interest in science subject matter, and (4) due to their belief in the importance of science knowledge. On the other hand, non-science students chose non-science streams mainly because of (1) their failure to achieve the required results in JSC examination set by the school authority and (2) their experience of science as a difficult subject.

Science students seem to have both extrinsic (better future career and parents’ and social demand) and intrinsic (their own interest in science subject matters and their belief in the importance of science knowledge) motivations for choosing science. Similar motivations for choosing science at Year 13 have been reported by the participants of Hipkins, Roberts, Bolstad and Ferral’s (2006) study in New Zealand. The most common reasons manifested by the focus group participants (n=45) for selecting science to study included: a science-related career interest; a strong personal interest in science; and taking science for strategic reasons. Similar to Bangladeshi students, students in New Zealand were also keen to have a traditional science profession like being a doctor, veterinary surgeon or engineer. Such interest among the students in New Zealand was substantially influenced by their families. Strong socio-economic pressure seems to play a role in motivating students to choose science and relevant science careers. Occupations such as medicine or engineering are well-paid, which is a way to alleviate low socio-economic status. Additionally, doctors and engineers are highly respected in society and so parents and families want such opportunities for their children. Such aspirations to become a doctor or an engineer may develop from childhood and drive them to choose and study
science, and show an interest in doing science. As a result, students’ responses may have represented perceptions regarding aspirations towards some specific careers in science, rather than just evaluations of school science.

Parental influence on decisions about science courses and science career choices was also reported by the students in Lyons’s (2006b) study. Lyons’s (2006b) survey of 196 high achieving Year 10 (15-16 years) students in Australia revealed that their parents, and particularly their mothers, had the greatest capacity to influence their enrolment decisions in science courses. Additional interviews with a small cohort of these students (14) referred to a parent’s regret for lost career opportunities, as a reason for being keen to see their children in a position that they couldn’t achieve. Lack of useful qualifications, interruptions to their education or careers because of family reasons, and dissatisfaction with employment prospects were suggested as reasons for lost career opportunities. Similar regrets for interruptions to education and career opportunities are reasonably likely to be more acute in third-world developing countries like Bangladesh. In such countries education and career opportunities are still very limited for the greater population. Parents in such developing countries are much more likely to expect their children to achieve a high level of education and career, which they failed to achieve for themselves and which offers better prospects and higher social status. Students’ parents in this current study may have had an expectation of their children to have the best career pathways that would ensure better social and economic status, compared to the previous generation which happened to lose their opportunities due to the poor economy and infrastructure of this underdeveloped third world country, Bangladesh. However, this study would suggest an in-depth investigation into the reasons why the parents in Bangladeshi society want their children to study science while there is a steady decline in participation in science worldwide and science careers.
While Bangladeshi students did not provide any specific reason for their intrinsic interest in science, many students in New Zealand associated their passion for science with wanting to understand “how the world works” (Hipkins et al., 2006, p. 31). The interesting feature of the responses of Bangladeshi students is that, even though most of the students have less positive attitudes towards science teaching and science textbooks they have shown substantial interest in science and a strong motivation for pursuing a science career.

Similar to the students in New Zealand (Hipkins et al., 2006), some students in this study also had strategic reasons for choosing science: “…anyone can move to any profession from science; in future, any subject can be chosen for higher studies [if anyone studies science]. But no one will be able to move back to science from non-science streams in future” (XSCG23).

On the other hand, one of the main reasons for non-science students not taking science was the requirement of grades to be achieved in national examination (JSC) held after completing Grade 8. These requirements were set by the school authority and students’ aspirations for studying science were of no value to the school authority. The noticeable finding is that most of the non-science students expressed their positive attitudes towards science, and their interest and motivation for taking science courses. But because they could not achieve the benchmark of grades, especially in science and mathematics, they were not selected for the science stream. Such findings can explain the claim by Mojumder (2009), who argued that in Bangladesh students’ participation in science after passing Grade 8 is gradually declining. The current study suggests that such a decline seems to be unintentional and not due to a disinterest among students. Unfortunately the requirements of grades to be achieved did not allow them to study in the science stream. However, as this is a finding from one school, more investigation into more schools could better explain the claim made by Mojumder (2009).
Such requirement of grades to be achieved and streaming at a very early age is likely to have had a very negative impact on some of these young students: first, they had to leave science at a very early age just because they could not achieve the required results in science and mathematics, and they would never get another opportunity to show their potential for science in their future life. At the same time, they have been labelled as ‘less bright’ and ‘poorly talented’ by the society, which is likely to have a negative effect on their psychology and self-efficacy. Indeed, the fact that the students are positioned as able or not able when they are so young (8th Grade and before) means that the system is not allowing for maturity as a factor in learning and in motivation. Thus, those who mature later as learners and thinkers or in becoming clear about what they want to study are forever disadvantaged by streaming early in their adolescence.

From the school’s point of view, the school has to continue the non-science subjects as well as the science subjects. If everyone wants to study science then the school might face a shortage of students in their non-science classes for which they recruited teachers. Therefore, other options could be considered which would benefit both the students and the schools. For example, in Bangladesh a uni-track curriculum was proposed to be enacted from 2006, in which a general science subject combining the content of physics, chemistry and biology was proposed to be compulsory for all students in Grades 9 and 10. According to the proposed curriculum, students at the same time were required to study non-science subjects such as business studies (Hossain, 2007). As a result, according to the proposed structure, streaming students was meant to happen at Grade 11 instead of Grade 9. However, while this curriculum was developed it was never implemented.

Siddique (2007) argued that “there is no justification for a specialised science curriculum at the secondary level in Bangladesh where only 32.2% of secondary science students study science [science stream] at higher secondary level and two percent of the
population has the opportunity to get a “professional job” (p. 119). Therefore, in line with Siddique, an appropriate uni-track curriculum for all students should again be proposed to be enacted in Bangladesh in order to match current trends around the world, and to enhance equality of educational opportunity for all students. Further such a change offers benefits for the society by fully utilising skills and talents of all students, rather than disregarding science interests among many students at a very early age and labelling them as less bright and less talented.

According to some non-science students, their preference for non-science streams was built on their perceived difficulty in the science subject. This finding is in agreement with Fouad et al. (2010) who identified subject difficulty as one of the key barriers for math and science choices. The perceived difficulty in science and its effects on students has already been discussed in Section 5.4.

5.11 Summary

In this chapter, a discussion on the main focus of this study, students’ attitudes towards school science in Bangladesh, has been offered. Students’ experience of school science, their evaluation on different aspects of school science, such as science teaching, science textbooks and content, assessment practices, relevance of school science and the motivational factors behind student decisions about science courses and future careers in science have been discussed in terms of the relevant research literature. Students’ attitudes towards different components and issues of school science have been compared with the research worldwide to understand the status of the current scenario of school science in students’ views in one Bangladeshi school. Based on the discussion in this chapter, the following chapter draws some conclusions about the status of secondary school science in Bangladesh based on this study in a single school, along with an account of the contribution that this study may make for science education practice and research.
Chapter 6: Conclusion

6.1 Introduction

This chapter brings together the results and discussion to draw conclusions on insights into students’ attitudes towards school science in Bangladesh. In doing so, this chapter firstly presents an overview of this research. The following sections revisit the findings with regard to each research question and provide insights into Bangladeshi students’ attitudes towards school science. Next the chapter addresses the aims in terms of possible recommendations for the future of science education in Bangladesh and for similar research based in developing countries. The chapter also indicates some possible areas of future research, and finally the chapter, as well as the thesis, concludes with an account of the contribution of this PhD in the field of science education. It is worth noting that this research has studied the attitudes of students in-depth in one school context in Bangladesh. The findings may not be generalised, however be important as an introduction to the understanding of the trends of the practices of teaching and learning Western school science in a non-Western context; and this has been remembered as well while making the recommendations.

6.2 Overview of the Research

This study set out to obtain insights into secondary students’ attitudes towards school science, which is Western in nature, in Bangladesh. In this research, an evaluation of school science and its components was considered as the central aspect of an attitude formed towards school science. So the main objective of this research was to collect data on students’ evaluative responses related to school science, analyse and interpret these responses to obtain and present insights into their attitudes towards school science. In order
to collect in-depth data on student attitudes this study focused on a single school and has drawn results based on the responses of representative students of the school.

To achieve this, first focus group interviews were conducted with five groups of students who were a representative sample of the secondary students in the selected school. The focus group interview data provided key ideas and themes that were used to generate an open-ended questionnaire. The questionnaire was used on all the students in Grades 9 and 10 of the school (about 450) and finally 141 questionnaires were received with responses. Findings from the students’ responses to the questionnaire provided the understanding of the insights into students’ attitudes towards school science.

The process of elucidating insights into students’ attitudes was as follows:

\[\text{Figure 6.1. Tapping the insights into students’ attitudes towards school science}\]

Chapter Four has presented the data gathered for this research and Chapter Five has discussed the major findings of this research under several themes and issues identified in students’ responses. Unlike other studies this research has explored the reasons underpinning student attitudes, rather than assuming them. On several occasions, students also indicated how to resolve these issues in order to meet their expectations from school.
science. This is the strength of having student voices. Now it is time to revisit the research questions of this study.

6.3 Research Question 1: How do Bangladeshi Secondary Students Justify their Evaluation of School Science which is Western in Nature?

Students have justified their evaluations with various reasons and explanations. A common pattern was found in most of the students’ evaluations and explanations. In response to the first research question, the findings suggest that:

- Most of the secondary students evaluated school science as difficult to study. Typical justifications were:
  - Science teaching is mostly of transmissive style;
  - School science is mostly about memorising facts, laws, information and postulates, and practising them for examinations to achieve good grades;
  - Science curriculum is overloaded with content to be covered in a very limited time;
  - Content in science textbooks is not well-explained, lacking sufficient information and the latest inventions of science;
  - Language in science textbooks is very abstract and complex so that it makes science hard to understand;
  - Pictorial representations in science textbooks are unclear, inadequate and incomprehensible.

- Most of the secondary students evaluated school science as irrelevant to personal needs and issues in their society. Typical justifications were:
  - Science teaching in school is failing to make the connections between school science and students’ personal needs;
  - Science teaching is mostly lecture dominated with little hands-on practical activities; it is exam focused and encourages memorisation;
Science textbooks are not conducive to learning science, presenting pure content as factual knowledge with very little applied components;

Science textbooks often present outdated content which is irrelevant to students’ current needs;

Assessment in science requires students to develop memorisation skills, not application skills in science.

Findings of the study also revealed that:

- Most of the secondary students reported that school science is interesting. However, most of those, who agreed school science was interesting, struggled to provide their justifications for this evaluation. A justification from some of the students was:
  - New knowledge can be gained through the study of science.

These findings based on student responses to the questionnaire have provided an insight into their evaluation of school science which is Western in nature. Western style school science has long been practised in Bangladeshi schools; however, responses of students from a well-ranked school suggest that school science still appears not to be engaging and accessible for students and therefore promotes their negative attitudes towards it. It appears that Western school science seems to be difficult and irrelevant due to a number of reasons: transmissive style teaching, overloaded curriculum, traditional textbooks being full of text, less emphasis on hands-on practical learning, and an assessment system assessing skill in memorisation rather than inquiry skills. All these aspects underlying their negative or less positive attitudes towards school science have made Western school science inaccessible in the local context. Western school science is yet to be appropriately tailored for these students. They study school science as part of their study program but the elements which could ensure that the science subject is learned with enjoyment are still lacking. These insights into student attitudes along with the
insights obtained from the findings related to two other research questions have been elaborated in Section 6.6.

6.4 Research Question 2: What are the Students’ Perceptions of the Attributes of an ‘Ideal’ Science Teacher? How do these Teacher Attributes Support the Enjoyment of School Science?

Typical responses presenting students’ perceptions of the attributes of an ‘ideal’ science teacher are summarised as follows:

- **Emotional attributes of a perceived ideal science teacher**
  - Teacher’s positive interactions with students (such as friendly and cooperative relationship with students);
  - Understanding different learners’ needs – empathy to the students’ situations (such as understanding students’ needs and demands, strength and weaknesses).

- **Professional attributes of a perceived ideal science teacher**
  - Ability to make science understandable for students (such as making science easier for students);
  - Expert knowledge of science content (such as having complete knowledge of science, or being able to answer student inquiries).

Student responses confirm that when science teachers possess these attributes, students believe they would enjoy learning science because:

- Science lessons would become interesting and easy;
- Knowledge of science would be enhanced.

These findings based on student responses on the questionnaire have provided an insight into their evaluation of science teachers and into their beliefs about the attributes of an ideal science teacher, which they expect their science teachers to develop and exhibit in...
order to facilitate their enjoyment in studying science. This is significant with regard to student attitudes due to the fact that science teachers have the responsibility to make science accessible and enjoyable for students, which in turn could result in positive attitudes in students towards their school science. It is apparent that science teachers in the school under study were seen as not friendly, not cooperative, lacking understanding of learners’ needs, and overall lacking knowledge of science content and pedagogy. The negative experiences with teacher attributes had a negative impact on students’ attitudes towards school science. For example, students’ comments suggest that when teachers are friendly and cooperative towards them, they feel free to ask questions to clarify their science concepts, which could lead them enjoy science learning. These along with similar insights regarding student evaluation of science teachers combined with the insights related to other research questions are discussed in detail in Section 6.6 in order to understand students’ overall attitudes towards school science.

6.5 Research Question 3: What Reasons do Students Give about Whether to Continue to Study Science?

Science and non-science students had different reasons about whether to continue to study science. Typical responses presenting students’ reasons are summarised as follows:

- Science students mostly had four reasons for studying in science:
  - Better future career;
  - Parents’ desire and societal demand;
  - Intrinsic interest or enjoyment in science subject matters;
  - Importance of science knowledge in the society.

- Non-science students mainly reported two reasons:
- Academic results of JSC (Junior School Certificate) examinations, especially grades in science and mathematics subjects;
- Science was difficult in lower Grades.

Understanding students’ motivations for studying science is important to obtain insights into students’ attitudes towards school science. Based on these findings, it can be concluded that after having a number of negative experiences most science students reported their belief that studying science still had clear benefits for them. Contrasting the fact that science seemed difficult and irrelevant to their personal needs and issues in society, and the textbooks were problematic for many, they still reported that science is interesting and better career opportunities are waiting out there in future.

Combination of all the insights presented in the aforementioned sections (Sections 6.3, 6.4 and 6.5) provide a nearly complete picture of school science from student perspectives. The next section therefore combines all these insights and discusses the overall pattern of insights into Bangladeshi students’ attitudes towards school science.

### 6.6 Insights into Students’ Attitudes towards School Science

Based on Bangladeshi students’ perspectives in this context, it is reasonable to claim that the content of Western school science is there but it is not well contextualised to fit with learners’ experiences. The overall picture of students’ attitudes to school science is that it is difficult, lacks relevance, and is not engaging. For this, students criticised the transmissive style of teaching and lack of hands-on practical work that might have given them opportunities to apply scientific concepts in the real world. Although in the science curriculum, which was designed for science stream students, there is a practical component for doing experiments in science laboratories, students reported that they could only observe the experiments passively when their teachers demonstrated them. Non-science students at the same time objected to having no practical component in their compulsory
science course. Overwhelmingly the large majority of students believed that a lack of hands-on practical work negatively impacted their understanding of the applications of ideas and concepts of science, as well as their interest in science topics and content.

The students raised the issue of science teaching that encourages only rote memorisation of scientific facts. They stated that, given the transmissive instruction with few hands-on activities and an overloaded curriculum, their only option was to rote learn the scientific facts. The government sanctioned textbooks represented the pseudo curriculum for science students, who found these textbooks frequently presented pure theoretical content with little applied component, dated examples, and content unrelated to their lives. Added to this were high stakes examinations that require memorised responses to be regurgitated from the text. There was thus little encouragement for students to learn school science. Science teachers also appeared to be neither personally cooperative nor helpful in overcoming the drawbacks of the curriculum and assessment practices; therefore their unfavourable dealings with students appear to have reinforced these attitudes towards school science. To sum up, students had strong negative attitudes to the way their learning was guided by the pressures on them from the teaching and curriculum.

This practice of teaching and implementing the curriculum would possibly result in reduced student enrolments in Western countries where science curriculum is designed to engage and encourage greater student participation. However, in Bangladesh participation is not a problem. Students are highly motivated to take science subjects. A unique finding of this research is students’ interest in being engaged with school science although their evaluation and justifications present an overall less positive picture of school science. Behind this lies a strong cultural belief that studying science is a pathway to respect in the community and better long term employment opportunities. Science knowledge is viewed as very important for the society, science professions are viewed as attractive and able to
earn better money, social respect, and pride for the family. There is enormous social pressure on students to study science, as it is viewed as the pinnacle of subjects by parents and the society. Parents feel proud to share with others that their child is studying science. Children in Bangladesh are motivated by pleasing their parents. Science is viewed by students, parents and the society as the pathway to a better life. Studying science in secondary school leads to higher scores for college and university entrance. High scores guarantee the entrance to the best colleges and best courses in the best universities, and as such the highest paid careers. In a developing country such as Bangladesh, the opportunity to improve one’s place in society and social standing in the community is highly important.

Quite a good number of non-science students, who had not been given the opportunity to study in the science stream and who did not have any pathway open to study science in future, are still positive about science. Many of them commented that they would have studied science if they had been given the opportunity when promoted to Grade 9. They had to leave science only because they could not achieve the required grades in science and mathematics examinations, which assess students’ memory rather than science process skills, practices or aptitude.

In the culture of a developing country, a career in science and technology is also seen as closely related to the country’s economic development. Major challenges in such cultures are related to the betterment of material standards, economic growth and the improvement of the health and welfare system; science and technology are seen by people as a fundamental driving force in dealing with these challenges (Sjøberg & Schreiner, 2005). Therefore, a job in science and technology is perceived as important for society and so meaningful for the individual.

While a core purpose of science education is to develop intrinsic interest among students, Bangladeshi students appeared to be inclined more to the extrinsic benefits of
pursuing science education. So though students do not enjoy studying science and find it difficult and irrelevant, they also view it as a valued commodity. Science study can be the passport to a better education and future career. As Bangladeshi students are highly motivated to engage with science, the country must make the most of this favourable situation which is in strong contrast to reports of students’ attitudes towards science in developed countries that are highly science and technology oriented.

Bangladeshi students are willing to engage with science does not necessarily mean that school science has to be difficult and irrelevant and all the unengaging features of school science have to remain there. It is time to deal with all the relevant issues identified by the students in order to make school science easier, more relevant and useful for students in non-Western contexts that follow Western school science. Although the findings of this research may not be generalised, the pattern of student perspectives seems to harmonize with findings from other research in the same context. Therefore, paying attention to the pattern of student attitudes obtained through this research can be considered an important beginning to providing students school science education that is fit for purpose in Bangladesh.

Although the students in this research represented a single school context, this school has to follow the rules and regulations set by the government, so do the centralised curriculum and textbooks prepared by the curriculum authority. Therefore, the issues raised by the students need to be resolved mostly by the central authority. There are important aspects to focus on for improvement of learning in school science. These include ways to utilise student interest in science; and working out how to respond to students’ negative or less positive attitudes towards school science. School science in Bangladesh is Western and the existence of Western school science is inevitable. Students’ negative experience while learning school science frequently occurs, possibly because the local
context and Western pedagogy are not appropriately coupled with Western science. As a result students, even teachers, do not see the relation of science that they study at school to their lives and society. Based on the findings of this study, recommendations for overcoming the issues identified by the students are provided in the following Key Recommendations section.

6.6 Key Recommendations

The research findings of this study led to a number of recommendations that may lead to improving students’ experience in science classrooms, and possibly be helpful in improving their attitudes towards school science. Science teachers, curriculum developers, the textbook authority and writers, educators and other relevant stakeholders should consider these recommendations based on the insights from the school context under study when implementing science education into the future. On some occasions, the recommendations would also need to be tailored according to the contexts where they are to be used.

6.6.1 Revision of the curriculum. Due to the fact that most students evaluated school science as difficult to study and irrelevant to their personal needs and social issues, attention needs to be paid to a number of areas of the school science curriculum in Bangladesh. Careful attention and appropriate modification of the curriculum could facilitate the improvement of students’ experience of school science and make it more relevant to students’ lives and issues in the society.

*Hands-on Learning*

Students suggested to include more student-centred hands-on approaches in their lessons as a way to substantial and sustainable science learning. They need opportunities where they can engage in learning that makes them more active and less passive in the
learning process. Therefore, they need to perform hands-on activities to facilitate and strengthen their understanding rather than only watching their teachers perform such tasks. As delivery of lectures by teachers has been reported as one of the key reasons for science being difficult, scope for hands-on and student-centred discovery learning can be increased. In order to facilitate this, science curriculum in Bangladesh needs to be redesigned with an effort on creating more space for hands-on teaching and student-centred discovery learning. Additional issues as indicated by Rahman (2011) in Bangladeshi classrooms such as class size, teacher training and class hours may impact the introduction of student-centred discovery learning. However there does appear to be a need to teach science, which is Western in nature, with Western pedagogy.

**Recommendation 1: Reduce the practice of transmissive style teaching and increase the scope for student-centred learning with considerable focus on discovery learning approaches.**

**The Overloaded Curriculum**

Since the overloaded curriculum limits the scope for hands-on science teaching and learning (Sarkar, 2012), reducing curriculum content will free up time within the classroom for the integration of more hands-on science (Osborne & Collins, 2000). From the students’ perspectives the science curriculum in Bangladesh needs to be reviewed and fine-tuned to reduce the amount of content in order to ensure greater science understanding and applications of this understanding beyond science classrooms. Less is more here, and students with stronger understanding of key features of the domains of Physics, Chemistry and Biology will be better placed to relate these to their world and to study these subjects at higher levels. A reasonable rather than excessive amount of content should, therefore, be included in the science curriculum to make it consistent with the time frame, so that the pathway to learning hands-on science would be created and memorising science without
understanding would be minimal. As an example, the recently reformed Australian science curriculum (National Curriculum Board, 2009b) could be reviewed. The current school science curriculum of Australia has focused on three interrelated strands: science understanding, science inquiry skills, and science as a human endeavour. Science understanding emphasises selecting and integrating appropriate science knowledge in ways that explain and predict phenomena. Science inquiry skills are concerned with developing the skills of posing questions, planning, conducting and critiquing investigations, collecting, analysing and interpreting evidence, communicating findings, evaluating claims, and making valid conclusions. Science as a human endeavour highlights the applications of science knowledge beyond classroom. This strand deals with the need for informed and evidence-based decision making about current and future applications of science (National Curriculum Board, 2009b, p. 6). A critical appraisal of some of these skills and the underpinning pedagogy would contribute to a more fruitful curriculum that develops students’ scientific thinking.

**Recommendation 2: Review the overloaded curriculum; reduce it to key content and concepts; break it up into time spent on science understanding, time spent on learning inquiry skills and time spent on applications of science knowledge in the real world.**

*Review the way high stakes assessments encourage rote learning*

As students reported that studying science seemed to focus more on memorising facts, laws and information to undergo high stakes assessments to achieve good grades, the practices of rote learning and high stakes assessment have to be reviewed. Although a new assessment system, namely Creative Questioning, has recently been introduced (Hossain, 2009) to assess higher order skills of Bloom’s Taxonomy (Bloom, 1956) in students, student responses reflect that their assessment system is still bound by memorisation skills.
If assessment items are designed in ways so that students are not encouraged to memorise, teachers would also avoid encouraging students to rote learn science. In the science curriculum for science stream students, there is a practical component for science subjects requiring students to revisit their learned knowledge by doing experiments in laboratories. However, students commented that the practicals were conducted in a transmissive mode where teachers demonstrated the practicals and students passively observed. So the practical component of science curriculum is limited in its success in developing application skills and inquiry skills in students.

Research (Madaus & Clarke, 2001) found that high stakes tests do not have positive effects on teaching and learning in the science classroom; rather, high stakes tests increase school dropout rates, and cannot motivate the unmotivated students. Therefore, for the sake of students’ science learning, thoughtful attention is needed regarding high stakes assessment practices: a reduction in the number of national examinations would possibly ease the pressure on students. Currently students have to attend three national examinations over the entire secondary education level: Junior Secondary Certificate (JSC) at the end of Grade 8, Secondary School Certificate (SSC) at the end of Grade 10, and Higher Secondary Certificate (HSC) at the end of Grade 12. The results of these examinations are used to eliminate students from particular pathways in the selection process. For example, JSC results are being used to discount some students from science. Similarly, SSC results are being used to select students for colleges and HSC results are being used to select them for universities. The results achieved in national examinations decide which college a student will be admitted to and which course at tertiary level they can study, rather than such decisions taking account of their aspirations or aptitude. These national examinations place pressure on students and force them to constantly run a survival race, given the mechanisms of career choices discussed earlier. Any of the examination results could adversely affect their social life and future career. In each phase a number of students drop
out of the survival race and are deprived of equal educational opportunities. Therefore, this study recommends the use of examination results carefully, not as the exclusive means of selecting students for a course of study; their aptitude also needs to be considered.

**Recommendation 3: Reduce the number of high stakes assessments and modify the current assessment strategies so that they would not support rote learning and so promote inquiry skills in students.**

6.6.2 **Revision of science textbooks.** The content in science textbooks is not well explained in student terms and language, and presents factual knowledge with very little applied components. As a result students may continue to find science difficult and fail to make the connection between school science and their lives. The current science textbooks were last published in 1996, and are therefore outdated; the content in science textbooks is not consistent with students’ current interests. Now it is time to think about giving students a fresh set of science textbooks with updated content and representation of recent inventions of science, as students have suggested. The textbooks will also have to be well explained and include content that is relevant for students.

Research (Siddique, 2007) suggests that the secondary science curriculum and textbooks in Bangladesh are “suitable neither for preparing future scientists nor for scientifically literate citizenry” (p. 119). Therefore, in order to make science textbooks accessible and bring them closer to students’ lives, science textbooks need to focus more on applications of science knowledge as recommended in the previous section. According to Marks, Stuckey, Belova, and Eilks (2014), the content in science textbooks has to be relevant to students’ present and future life as a means of raising their capacity for self-determination, participation in society and solidarity with others. This will then create a scientifically literate citizenry. Keeping this in mind, textbook writers could therefore
focus on developing content that is relevant to students’ present and future lives and has the potential to develop scientific literacy among students.

Corrigan (2006) noted that context is very important for school science to be relevant. Therefore, contextualisation of science content has to be emphasised while developing science curriculum and textbooks particularly in a non-Western context like Bangladesh. Science education in Bangladesh follows the Western science curriculum including the Western contexts; therefore as discussed in Section 5.6.1.2, more emphasis is needed on content that connects with students’ personal and social contexts in order to engage them more with their school science, and to help them be scientifically literate citizens. Every effort should be made to link the science content with experiences and understanding outside the classroom and common in the everyday lives of the students. For example, as Bangladesh is prone to natural disasters, natural disasters brought on by earthquakes, tsunamis and hurricanes can be used to make the connection with the basic ideas of fluid dynamics and thermodynamics (Post & Sadler, 2010). Teachers can also use these events to highlight the relevance of school science.

As the language used in science textbooks is not compatible with the language ability of students, language in science textbooks, therefore, needs to be age-appropriate and compatible with students’ capacity. Scientific terms need to be well explained as many of them are Western and not familiar in the Bangladeshi context. Sophisticated language needs to be replaced by context-appropriate language so that students understand science, possibly in their own language. Teachers also have a role in supporting students for understanding the language of science (McComas, 2014), therefore teacher support is highly recommended.

As per students’ requirements, pictorial representations in science textbooks need to be clear, adequate, comprehensible and communicable. As suggested in Section 5.6.3,
the textbook authority needs to keep in mind that high school students often consider pictorial representations as an actual copy of reality rather than as a conceptual representation. Therefore in order to make pictorial representations purposeful, they need to be clear and use colours appropriately. If possible they should be kept close to reality and the illustrations should be self-explanatory.

As discussed in Section 5.6.1.3, in order to prepare quality science textbooks for students a clear insight into the basic content, structure and systematic nature of the science subject needs to be provided. The level of development of students and their level of understanding and experience with science concepts at previous schooling levels should be taken into account. A list of important concepts with explanations can be provided at the end of each chapter and/or at the end of the textbook. Recent innovations or events can also be introduced to present the basic principles of science. Textbooks writers are recommended to develop science textbooks based on research (Khine, 2013) that addresses the criteria of a quality science textbook.

**Recommendation 4: Revise the science textbooks to make the content well explained and age-appropriate language; focus on applications of the content and emphasise contextualization of the content more in order to make it more relevant to students’ lives outside school; include recent inventions and events; and replace the pictorial representations with clear, colourful and comprehensible illustrations, that are adequate in number as well.**

**6.6.3 Improving teacher attributes.**

*Improve interactions with students*

As students suggested their science teachers need to develop the attributes that they believe necessary for an ideal science teacher; science teachers should consider these
demands and should focus on developing the attributes. Research (Umameh, 2011) recognises the need for teachers to develop positive relations with students in order to ensure fruitful and satisfying learning outcomes. Therefore, science teachers need to redesign their ways of interacting with students. They need to build a friendly and cooperative relationship with students, so that students can ask questions, share their views, learn science in a friendly and positive environment and so facilitate their improved academic performance.

Science teachers are also required to understand students’ needs and demands. Research (Pianta, Belsky, Vandergrift, Houts, & Morrison, 2008) has demonstrated that the emotional support of a teacher, recognition of children’s needs and limitations, strengths and weaknesses, and responding to them has a potential influence on students’ academic achievement. Knowing students’ needs and limitations, strengths and weaknesses related to science learning, and dealing with them appropriately would then ensure better science learning among students. Teacher training on developing such skills could also change students’ experiences of interaction with their teachers.

Recommendation 5: Science teachers need to build a friendly and cooperative relationship with students. They are required to understand students’ needs and demands, strengths and weaknesses related to science learning.

Improve content and pedagogical knowledge

Students also demanded that science teachers have complete knowledge of their science subjects if they are to make science easier for them. Science teachers in Bangladesh, therefore, should have to demonstrate expertise in both content and pedagogical knowledge in relation to school science. Research evidence (Rahman, 2011) showed that Bangladeshi science teachers faced difficulties with explaining science
content, providing real life examples, linking the principles of science with real life events and providing current ideas regarding science content. These difficulties were mainly due to insufficient knowledge and understanding of science subject matter, affecting pedagogical choices. Rahman (2011) suggested that any difficulty in understanding science content may make it difficult to organise and structure the content appropriately, which would impact the ability to design an effective lesson on the topic of study. This would then lead teachers to transmit knowledge for memorisation, which was reported by the students of this study.

Since teachers’ content and pedagogical knowledge was not a primary concern of this study, a detailed recommendation for improving teachers’ content and pedagogical knowledge has not been suggested here. However, Rahman’s (2011) recommendations based on his investigation may be helpful for teachers to improve their content and pedagogical knowledge: collaborative or collective learning through professional communities of science teachers could be adopted as this approach enables teachers to overcome their fear of and possible disrespect of their colleagues, and to share their knowledge, skills and resources among themselves.

The curriculum of science programs at tertiary levels (such as Bachelor of Science in Physics or Bachelor of Science in Chemistry) is an important aspect of building capacity for qualified science teachers and therefore needs to be carefully scrutinised and possibly revised so that science teachers recruited for school science would have adequate content knowledge of science to teach in high schools. In addition, teacher education and professional development programs need to focus on developing necessary and sufficient pedagogical knowledge and skills among science teachers so that they can develop pedagogically appropriate science lessons for students. Therefore, appropriate teacher education and professional development programs for teachers need to be developed in
order to improve the skills that are needed to become an expert teacher, as outlined by teacher education experts (e.g., Loughran, 2010).

**Recommendation 6: Science teachers are expected to acquire appropriate content knowledge of science as well as pedagogical knowledge of science.**

6.6.4 Pathways to science. Many non-science students expressed their interest in doing school science at secondary level. The requirements of academic grades in science and mathematics often mean these students could not choose science to study. This study recommends withdrawing such criteria of exclusion at an early age. Specialisation at this stage seems to have some negative impacts on students’ mental health, self-esteem and self-efficacy. This study recommends enacting the uni-track curriculum that was proposed by the National Curriculum and Textbook Board (NCTB) of Bangladesh (Siddique, 2007). This curriculum proposed a single science subject for all the secondary students to avoid any specialisation and/or exclusion, so that everyone would be able to study science until Grade 10. Moreover, Fensham (2004) noted that in order to prepare scientifically literate citizens, school science is necessary for every student, not just for the group who will study specialised science at tertiary level or choose science related careers. Therefore, the recommendation for a uni-track curriculum could create and support a pathway to broaden the spectrum of scientifically literate citizen in the country.

**Recommendation 7: A uni-track curriculum is proposed for the secondary level of education in Bangladesh.**

6.7 Areas for Further Research

This study has explored the trends of the pattern of student attitudes towards school science in one school context in Bangladesh. Such trends provide opportunities for further research to be initiated in order to establish if these trends are represented across the
Bangladeshi school system. Similarly, the insights obtained through this research suggest that research in similar contexts may help better understand the accessibility of Western school science in non-Western schools. This study therefore suggests six areas for further research. They are noted below in Sections 6.7.1 to 6.7.6.

### 6.7.1 More qualitative research on student attitudes

This study recommends more qualitative research on student attitudes. While most of the previous studies on attitudes have been quantitative, providing a superficial notion of student attitudes, this PhD project studied students’ attitudes qualitatively and has provided in-depth insights into student attitudes in a specific school, unfolding a number of issues related to school science from the students’ points of view. The nature of the findings has demonstrated the difference between quantitative and qualitative studies on student attitudes. As mentioned in the beginning of this research, if we really want to improve students’ experience in science classrooms we need to listen and understand student voices. This qualitative study revealed the reasons for students’ attitudes towards school science in their specific context and their suggestions to improve the school science to enable them to enjoy a fit-for-purpose science education. On the other hand, quantitative studies have lacked explanations of the reasons for students’ attitudes, showing only linear relationship among factors of school science (e.g., Barmby et al., 2008; Caleon & Subramaniam, 2008); however, the relationships among factors of school science are not always straightforward and the factors are not limited to a few variables. Finally, as the study of attitudes towards school science has been recognised as a central focus in improving the teaching and learning of science (Tytler & Osborne, 2012), using qualitative methods of inquiry to study student attitudes towards school science is therefore necessary to improve the quality of science education.
6.7.2 Large-scale research on how students would wish to be taught. Jenkins (2006), in his extensive review on students’ views, perceptions and attitudes related to science education, reported that there appear to be no large-scale rigorous science-specific studies that have explored school students’ views about how they would wish to be taught. This research created a pathway to study students’ attitudes about how they would wish to be taught, and therefore recommends that further large scale research be conducted nationally and internationally in the area so that the findings can map the ways students would like to be taught in their science classes and help identify a pedagogy of students’ choices.

6.7.3 Large-scale research on students’ views about assessment practices. Students' views about assessment practices have received much less attention than other aspects of school science (Jenkins, 2006). This research gathered students’ views about assessment practices in school science and explored, to a limited extent, how assessment practices controlled and directed science teaching and students’ learning in science. Students’ views can provide a different picture of science assessment practices as they are one of the most important but less recognised beneficiaries of such assessment practices. Therefore, this research recommends more studies on student views about assessment practices, which can support research on student learning and best assessment practice for school science.

6.7.4 Comparison research across western and non-western countries. Attitude research is dominated by research in Western contexts. Similar to some international studies, this study found that non-Western students’ perceptions differ from the perceptions of students in Western countries. It is time to identify precisely and more broadly the differences between the two contexts and exchange the lessons. Comparison research across Western and non-Western countries would contribute new knowledge to the
literature. Non-Western contexts and knowledge also have the potential to be a point of reference for Western researchers and to lead to further improvement (Roshid, Siddique, Sarkar, Mojumder, & Begum, 2015; Singh, 2015).

6.7.5 Research on cultural beliefs related to science and science careers in non-Western developing countries. This study found that despite reporting a number of poor experiences with school science, Bangladeshi students still showed an interest in doing school science and pursuing science related careers in future although only two percent of the population has the opportunity to take up a science related profession (Siddique, 2007). If we want to achieve the goal of Science for All (Fensham, 2004), this interest among students will be very helpful for achieving the goal. At the same time we need to know the source of such interest and how to deal with this interest. Although along with this study, a few other studies (Sjøberg, 2002) have attempted explanations of the reasons for such interest and tendencies for pursuing careers in science, more research is still necessary in order to identify the cultural beliefs related to science embedded in society. This would be a further area of investigation which has the potential to create new knowledge about non-Western peoples and cultures who follow and use Western science every day.

6.7.6 Research on implications for the education system in Bangladesh. This research did not focus on how the education system in Bangladesh works and what would be the implications of the student voice for the system. This study also did not cover issues related to system constraints, professional development of teachers and financial constraints, which may have implications for students’ experiences in science classes. Students did not mention these issues. Based on this research capturing student voices, further research could build on these findings and look into the implications for the educational system. Findings on student demands such as teachers’ characteristics could influence future research on professional development opportunities for teachers.
Additionally, the implications of the findings of this study can be explored in relation to future policy directions for teacher professional development.

6.7.7 **Strengthening the outcomes of this study.** This study recommends Bangladeshi researchers and educators to research more on student attitudes, covering more schools across the country, since this study involved students from only one school. More data from more schools and students would enhance the strength and importance of the findings of this study. This study has developed an open-ended questionnaire based on students’ focus group discussions; future research could improve the methodology and the questionnaire to understand students’ attitudes towards school science. As a result, a holistic and real picture of the school science education in Bangladesh could be articulated based on students’ experience and perceptions. The evidence could help government and other stakeholders rethink science education programs and redesign a science education program that could meet the demands of 21st century society.

6.8 **Limitations of the Study**

Although the questionnaire was developed based on student voice gathered in FGIs, the design of the questionnaire may not be ideal. The statements in the questionnaire placing two issues together asked students to respond to both parts of the statements at a time, however the analysis chapter (Chapter 4) presented the data on each part of a statement separately rather than presenting the data on two parts of the statement together. It could thus be questioned, why student responses to a single statement were analysed separately in two sections. In this study, students’ responses were presented separately for convenience and to make the data more communicable and understandable. During the questionnaire development stage, it seemed from the focus group discussions that the parts of the statements were linked for the students and thus were provided in this form so as to enable students to take a position. On balance, this may need further consideration. On
reflection, it is now apparent that it would have been more appropriate to pose the statements as separate questions rather than two parts in a single statement. To sum up, the questionnaire design may not be ideal and may need modification in similar studies.

Capturing the voices of both science and non-science stream students may need to be attended to separately in future – so that the voices of both populations can be reasonably represented. Such a perspective became apparent after the data had been collected and analysed. Nevertheless their different voices have been represented separately when required.

While this study focused on capturing student voices only, it is now apparent that the silence of the teacher voice is missing from the holistic picture and this therefore is a limitation. Teachers may not be provided with professional development opportunities to deal with the issues raised by the students of this study. If teachers’ voices were present, a number of issues could have been cross-tabulated and as a result a more interesting picture of school science would have been possible. Inclusion of teachers’ voices in further study is suggested.

6.9 Concluding Remarks

This PhD study creates a base for identifying the problems of teaching and learning Western science in schools in developing countries. The findings may inform non-Western countries and enable them to realise how the students are experiencing Western school science. This, with support of further research, could assist science educators in taking action to improve students’ experience in science classrooms.

This study makes the claim that while Western science is dominating many non-Western schools, Western pedagogy may have not been adopted. Due to financial constraints, developing countries like Bangladesh still cannot afford Western pedagogies,
for example, hands-on or inquiry methods of teaching with necessary equipment, materials and disposable chemicals to assist in understanding the theory, which students have demanded. Either Western science curriculum and pedagogy needs to be appropriately modified for developing country classrooms or the developing countries have to overcome financial constraints and introduce appropriate Western pedagogy with the necessary equipment and materials.

While a few qualitative studies have focused on perceptions of school science in developed countries, this study is a unique contribution for less developed or developing countries. The literature on attitudes related to science and school science is dominated by Western contexts with little exploration of how non-Western students deal with Western science. This qualitative study qualitatively how students in a non-Western developing country experience Western school science. On the one hand, this study contributes new knowledge to the world literature with a particular focus on non-Western contexts. On the other hand, perceptions of school science from students’ points of view may guide educators to improve the quality of science education and change students’ experience in science classrooms, whereby the current common practice does not appear to allow students to participate in bringing a change to their own classroom experience.

This study contributes to the methodology of attitude research by showing the application of an innovative method of inquiry and capturing student voices. The study was predominantly dependent on student voices and sought to understand their attitudes towards school science based on their voices. Instruments were developed based on their voices as well. Such a methodology would help in providing a new direction towards studying attitudes qualitatively, at a time when most of the attitudes studies are quantitative and ask students the questions that researchers feel are important to know about.
This study has also prepared the ground to show the differences in attitudes of students in developed and developing countries. Of course, there are differences in attitudes among and between students in developed and developing countries. Some significant differences with regard to students’ evaluation on school science have emerged from this study. This study will therefore act as a point of reference for further research on the differences in attitudes of students in developed and developing countries. Both the developed and developing countries could educate themselves by learning from each other and attempt to bridge the gap between these countries. This would further create the ground for new research and advancement of knowledge.
Reference


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Appendices

Appendix 1: Human Ethics Certificate of Approval

MONASH University
Monash University Human Research Ethics Committee (MUHREC) Research Office

Human Ethics Certificate of Approval

Date: 7 May 2012
Project Number: CF12/0549 - 2012000220
Project Title: Bangladeshi secondary students’ attitudes towards school science
Chief Investigator: Assoc Prof Debbie Corrigan
Approved: From: 7 May 2012 to 7 May 2017

Terms of approval
1. The Chief investigator is responsible for ensuring that permission letters are obtained, if relevant, and a copy forwarded to MUHREC before any data collection can occur at the specified organization. Failure to provide permission letters to MUHREC before data collection commences is in breach of the National Statement on Ethical Conduct in Human Research and the Australian Code for the Responsible Conduct of Research.
2. Approval is only valid whilst you hold a position at Monash University.
3. It is the responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as approved by MUHREC.
4. You should notify MUHREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
5. The Explanatory Statement must be on Monash University letterhead and the Monash University complaints clause must contain your project number.
6. Amendments to the approved project (including changes in personnel): Requires the submission of a Request for Amendment form to MUHREC and must not begin without written approval from MUHREC. Substantial variations may require a new application.
7. Future correspondence: Please quote the project number and project title above in any further correspondence.
8. Annual reports: Continued approval of this project is dependent on the submission of an Annual Report. This is determined by the date of your letter of approval.
9. Final report: A final report should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected date of completion.
10. Monitoring: Projects may be subject to an audit or any other form of monitoring by MUHREC at any time.
11. Retention and storage of data: The Chief Investigator is responsible for the storage and retention of original data pertaining to a project for a minimum period of five years.

Professor Ben Canny
Chair, MUHREC

cc: Dr Angela Fitzgerald; Mr Foez Mujumder
Appendix 2: Permission Letter from the Case School under Study

BAF SHAHEEN COLLEGE DHAKA
Tejgaon, Dhaka-1206
web: www.bafsd.com.bd

Ref: SD/30/Trg/Vol-07/48A          Date: 16 March 2012

PERMISSION LETTER FOR COLLECTING DATA ON “BANGLADESHI SECONDARY STUDENTS’ ATTITUDES TOWARDS SCHOOL SCIENCE”

Ref: Your application submitted on 1st March 2012.

Foez Ahmed Mojumder
Room G16, Building 6
Faculty of Education
MONASH UNIVERSITY VIC 3800

Dear Mr Foez Ahmed Mojumder

Thank you for your request to recruit participants from BAF SHAHEEN COLLEGE for the above-named research.

In reference with your application I have read and understood the Explanatory Statement regarding the research <project number: 2012000220> and hereby give permission for this research to be conducted.

Khadeja Khatun
Acting Principal
BAF Shaheen College, Dhaka
Appendix 3: Permission Letter from the Pilot School under Questionnaire Piloting

Permission Letter for piloting questionnaire related to “Bangladeshi secondary students’ attitudes towards school science”

July 30, 2012

Foaz Ahmed Mojumder
Room G16, Building 6
Faculty of Education
MONASH UNIVERSITY VIC 3800

Dear Foaz Ahmed Mojumder,

Thank you for your request to recruit participants from Agargaon Taltala Govt. Colony High School and Mohila College for the above-named research.

I have read and understood the Explanatory Statement regarding the research (CF12/0549-2012/009229) and hereby give permission for this research to be conducted.

Yours Sincerely,

[Signature]

Principal
Agargaon Taltala Govt. Colony High School and Mohila College
Dhaka, Bangladesh.
Appendix 4: Questions for Focus Group Interview

1. When you think about science that you study in school, what kind of image or experience come to your mind?

   Supplementary questions:

   1.1 When you think about what you learn in science classes, what kind of image or experience come to your mind? And/or, how do you feel when you think about what you learn in science classes?

   1.2 When you think about your science lessons and/or activities involving science learning, what kind of image or experience come to your mind? And/or, how do you feel when you think about your science lessons and/or activities involving science learning?

   1.3 When you think about your science teacher what kind of image or experience come to your mind? And/or, how do you feel when you think about your science teachers?

2. Can you please describe a science lesson/class that you liked most? Please explain why you liked it most.

3. Can you please describe a science lesson/class that you disliked most? Please explain why you disliked most.

4. What is your overall evaluation of school science?
Appendix 5: Open-ended Questionnaire

Questionnaire for Secondary Students

Research title: Insights into secondary students’ attitudes towards school science in Bangladesh

Thank you for your consent to participate in this research. This questionnaire is to obtain insights into secondary (Grade IX and X; science and non-science) students’ attitudes towards school science. You have already been given the explanatory statement for this project to inform you of the purpose and activities of this research. In the previous months, I conducted five focus group discussions with 32 of your classmates and they provided me with valuable insights about the school science that they have been experiencing in your school. Based on their insights and impressions, I have developed this questionnaire in order to learn more about your specific attitudes towards school science. In this questionnaire, you will find some statements and questions related to your experiences of school science, which have come directly or indirectly from your classmates’ voices. So I would like to request that you read the statements and questions carefully and provide your valuable thoughts related to the school science that you experience in your school.

Demographic information

Your roll number: ___________ Age: _______________ years

Grade/Class (put a tick): □ IX □ X

Group/Stream (put a tick): □ Science □ Business studies □ Humanities
Questions

1. Below are five statements related to the science that you study in your school. Each statement has two parts. You need to state your position regarding each statement (agree, partially agree, disagree, or neutral) and explain your own thoughts/reasons to support your position. Tick agree if you agree with both parts of the statement separated by a coma. Tick partially agree if you agree with one part of the statement and disagree with the other. Tick disagree if you disagree with both parts of the statement. Tick neutral if you neither agree nor disagree with the statement, or if you do not want to make any comment or write any argument in terms of the statement.

a) “Science is interesting, but it is very difficult to study” [Statement One]
   
   Your position: □ Agree □ Partially Agree □ Disagree □ Neutral
   
   Explain your reasons in support of your position:

b) “Studying science requires me to memorize scientific laws, facts and information for responding to exam questions, but I want to learn science by doing it practically” [Statement Two]
   
   Your position: □ Agree □ Partially Agree □ Disagree □ Neutral
   
   Explain your reasons in support of your position:

c) “I study science only to get good grades, it has very little/no use in my life” [Statement Three]
   
   Your position: □ Agree □ Partially Agree □ Disagree □ Neutral
   
   Explain your reasons in support of your position:

d) “Science that I study is useful for my life, but because of the way that science is being taught I do not know whether school science has any practical use in my life” [Statement Four]
   
   Your position: □ Agree □ Partially Agree □ Disagree □ Neutral
   
   Explain your reasons in support of your position:
e) “The chapters to be studied in science are huge, and we are always racing to finish them” [Statement Five]

Your position:  □ Agree  □ Partially Agree  □ Disagree  □ Neutral

Explain your reasons in support of your position:

2. Do you like your science textbook(s)? Why or why not? Explain with examples. [Open-response question One]

3. (a) What would be the qualities of your ideal science teacher?

(b) How would these qualities help you like/enjoy science? [Open-response question Two]

4. (a) For science stream students:

Why did you choose to study science?

(b) For non-science stream students:

Why did you choose to study business studies/humanities rather than science? [Open-response question Three]

5. If you have any other comments related to the science that you study in your school, please write them here [General comments]
Appendix 6: Sample Response to the Open-ended Questionnaire

Questions

1. Below are five statements related to the science that you study in your school. You need to state your position regarding each statement (agree, partially agree, disagree, or neutral) and explain your own thoughts/reasons to support your position. Tick Agree if you agree with both parts of the statement. Tick partially agree if you agree with one part of the statement and disagree with the other. Tick disagree if you disagree with both parts of the statement. Tick neutral if you do not want to make any comment or write any argument in terms of the statement.

   a) “Science is interesting, but it is very difficult to study”

   Your position: □ Agree □ Partially Agree □ Disagree □ Neutral

   Explanation: Agree

   Science that we study in school is interesting and enjoyable. But science is not written in easy language in our textbooks. As a result we do not learn science so easily. Even in India, our neighbouring country, science contents are written in very easy and comprehensible language. Many figures are also attached to the contents. As a result students learn science with ease. They then find it interesting. They enjoy studying science.

   Actually science is a very interesting subject. All the content of science is interesting and enjoyable. But because of the way the books are written, medium and low level students do not comprehend science contents clearly.

   Moreover, I must say that nothing is presented in a simpler way in our textbooks. Everything is presented in a complex way. As a result we do not understand lots of things by ourselves, even after trying a hundred times.

   b) “Studying science requires me to memorize facts for responding to exam questions, but I want to learn science by doing it practically”

   Your position: □ Agree □ Partially Agree □ Disagree □ Neutral

   Explanation: Agree

   Everything in science cannot be learnt by hands on experience. For example, observing plant cells. This cannot be comprehended or learnt by pen and paper. Here we need a microscope. But we studied this in Grade 6. At that time we just memorised. At that time we were not taught by hands-on experience. As a result we were bound to memorise.

   There are many topics that we studied in Grade 6 but we do not study them in Grade 9. We do not remember those after our exam is over. But if we had learnt those by hands-on experience we would get a clear and long-term idea about the basic things of science.

   In addition, we have many teachers in our school who do teach properly in classes. As a result we do not get a clear idea about the complex concepts in classes. These teachers force students to go for private tuition to their house. They prepare some difficult items/questions in school exams and give those items/questions to those private students
and teach them those questions/items. As a result those who do not go for private tuition to them cannot answer those questions in exams.

c) “I study science only to get good grades; it has very little/no use in my life”

Your position: □ Agree □ Partially Agree □ Disagree □ Neutral

Explanation: Partially agree

Yes, this is right. Actually a good GPA means GPA 5 [out of 5]. I want to achieve this. Because if I do not get GPA 5, everywhere in my society I will have to keep my head down, even if I study hard.

Actually, there is not much application of science knowledge in my life. For example, Log1=0; I learn this, I write this and I memorise this, but this doesn’t have any implication in my life, what do you think?

Or, in the history of science, Henry G. I. Moseley invented atomic numbers. But to prepare a periodic table now we need electron numbers. Therefore, Henry’s invention is voided/invalid. Is there any application of this knowledge in my life?

Nonetheless, these things are given in admission tests, board exams, BCS exams, etc.

d) “Science that I study is useful for my life, but I do not know whether science that I study at school has any practical use in my life”

Your position: □ Agree □ Partially Agree □ Disagree □ Neutral

Explanation: Partially agree

Science that we study in school is essential for getting a big/good job.

We study log in maths, history in social science, etc. but I do not understand whether there is any application of these in my life.

The POLASHI Battle happened in 1757. It was finished/done in 1757. Studying the history of this battle has no implication in my life.

But I think most of the things in physics, chemistry and biology have a use or application in our lives. It would be realised then when complete knowledge about these sciences is obtained/acquired/gained/attained.

e) “The chapters to be studied in science are huge, and we are always racing to finish them”

Your position: □ Agree □ Partially Agree □ Disagree □ Neutral

Explanation: Agree
Chapters in science are much too big. Contents/topics of science are not well presented and well organised. It even takes too much time to realise or comprehend the small topics; on top of that if the chapters are too big then imagine what would happen. Therefore, we memorise the topics without comprehending. Eventually after a few days we forget what we have memorised.

In consequence, we have to be very busy in studying and finishing the complex and difficult chapters of science.

But if these contents or topics were presented in a simpler and easier language and studying science were made more attractive and enjoyable, we would not need so much time to learn such small topics. Then our talents would be manifested and bloom.

2. Do you like your science textbook(s)? Why or why not? Explain with examples.

No. I do not like the science textbooks.

I already mentioned about our textbooks. These are written very complexly. Textbooks are written in 20th century styles at this twenty first century time. Consequently, I feel less interest in studying science textbooks.

Almost nothing is well-presented in science textbooks. This is why I don’t enjoy studying the books. Still these are important for our lives. Many of these are not well-presented which is why I don’t like the books. After all I love science. I would start liking these books if the writing styles of these books were easier and more comprehensible.

3. (a) What would be the qualities of your ideal science teacher?

(b) How would these qualities help you like/enjoy science?

I think an ideal teacher should possess the following qualities:

- Presenting the difficult contents of science in a simpler way
- Treating students like his/her own child
- Not being too greedy for money (In greed is sin, in sin is death)
- Being willing to explain difficult words
- Teaching every single line of the books
- Conducting oral tests once in a week, taking care of weak students
- Thinking of everyone while developing test items for exams
- Not being annoyed if any student asks any question in the class, and answering the questions
- Teaching and explaining all the contents of all pages of the books.
- Hands-on teaching for all the complex and difficult contents.
• Not being rude, and keeping smiling all the time.
• Making sure that all the students understood the topic or content.

These qualities make a teacher attractive in the class. As a result students feel interest in studying and they study.

4. **(a) For science stream students:**

   Why did you choose to study science?

**(b) For non-science stream students:**

   Why did you choose to study business studies/humanities rather than science?

   I took science to know the unknowns of nature. In order to utilise the blessings of science for mankind. In order to invent medicine/remedies for some incurable diseases (like Cancer or AIDS).

   I think science is the root for everything. We are at this modern age only because of science. After all, I have a strong desire to learn deeper knowledge of all of these.

5. **If you have any other comments related to the science that you study in your school, please write here:**

   Education is a business in our country now. Teachers are teaching students only for money. Some of them are earning more than one lac (hundred thousand) taka in a month while some are living on a very small amount of money. I condemn and reprimand those teachers who force student to go for private tuition only out of greed for money.

   As a result many teachers are spoiling many lives of poor students.

   Finally, if the textbooks were written properly and could be comprehended, we could learn and enjoy science at our home by studying the books ourselves, whatever our teachers teach.

   I wish the textbooks would be written following the western countries’ ways.
CHAPTER FOUR
GRAVITATION AND GRAVITY

In this universe every particle attracts each other. This force of attraction is called "gravitation". The magnitude of this force is determined from a law known as Newton's law of gravitation discovered by Newton. In this chapter we will discuss this law first. Later we will discuss about simple pendulum and its laws and also with the method of determining acceleration due to gravity by simple pendulum. We exist in the world because of our weight. If we did not have weight we would have been thrown out to the space. Detailed discussion about this weight, variation of weight, methods of determining weight etc. have been discussed in this chapter. Finally, there is a short history of man's travel to space.

4.1. Gravitation and gravity

In this universe every particle attracts every other particle towards each other. The attraction between any two bodies in the universe is called "Gravitation". If earth is one of the two bodies, then the attraction is called gravity, that is, the attraction of the earth on any other body is called gravity.

In the solar system, the attraction between any two bodies except the earth is gravitation, but attraction between the earth and any other body is gravity. The attraction between the sun and the moon is gravitation, but the attraction between the earth and a book is gravity. Gravity is itself a kind of gravitation.

4.2. Newton's law of Gravitation:

Any two particles in this universe attract each other. The magnitude of this force of attraction depends only on the masses of the particles and the distance between them— independent of their shape and nature and the type of the medium between them. This force of attraction is called gravitation. There is a law about this attraction known as Newton's law of gravitation.

Law: Every particle in the universe attracts every other particle towards each other and the magnitude of this force of attraction varies directly as the product of the masses of the particles and inversely as the square of the distance between them and acts along the line joining them.

Suppose, two bodies of masses $m_1$ and $m_2$ are separated from each other by a distance $d$ [fig. 4.1]
If $F$ is the force of attraction between them, according to the law of gravitation

$$F \propto \frac{m_1 m_2}{d^2}$$

or, $F = G \frac{m_1 m_2}{d^2}$ ..............................(4.1)

Here, $G$ is the constant of proportionality. It is called the universal gravitational constant. According to the law of gravitation, if the product of the masses of two bodies situated at a fixed distance apart, is doubled, the force will be doubled. If it is three times, the force will also be three times. And if the masses are constant and the distance is doubled then the force becomes one fourth, if the distance is increased three times then the force becomes one ninth.

**Gravitational Constant, $G$**

Magnitude of $G$: From equation (4.1) we see that,

When $m_1 = m_2 = 1$ kg and $d = 1$ m, then $F = G \frac{1 \times 1}{1}$ or $F = G$

Thus, it is seen that the force of attraction between two bodies, each of mass 1 kg placed at 1 m apart is called the gravitational constant.

**Dimension of $G$:** From equ. (4.1), it is seen that

$$G = \frac{Fd^2}{m_1 m_2} \text{ or } G = \frac{\text{Force} \times (\text{distance})^2}{(\text{mass})^2}$$

Or, $G = \frac{MLT^{-2} \times L^2}{M^2} = [L^3 M^{-1} T^{-2}]$

**Unit of $G$:** Again from equation(4.1),

$$G = \frac{Fd^2}{m_1 m_2}$$

The unit of $G$ is obtained by putting the units of the quantities in the right hand side of this equation. Hence, its unit is Nm$^2$/kg$^2$ or, Nm$^2$ kg$^{-2}$. **Magnitude of $G$:** To determine the magnitude of $G$, scientists carried out many experiments at different times. The values obtained by different scientists show small difference. The value accepted by
all is $6.673 \times 10^{-11} \text{Nm}^2\text{kg}^{-2}$. This means that if two bodies of masses 1kg each are placed 1m apart, they attract each other with a force of $6.673 \times 10^{-11} \text{N}$.

**Example 4.1:** Two bodies of masses 10kg and 20kg are placed 2m apart. If the value of the gravitational constant is $6.673 \times 10^{-11} \text{Nm}^2\text{kg}^{-2}$, determine the magnitude of the force between the bodies.

**Solution**

We know,

$$F=G \frac{m_1 m_2}{d^2}$$

Or

$$F=\frac{6.673 \times 10^{-11} \text{Nm}^2\text{kg}^{-2} \times 10\text{kg} \times 20\text{kg}}{(2\text{m})^2}$$

$$=3.34 \times 10^{-9} \text{N}$$

**Ans.** $3.34 \times 10^{-9} \text{N}$

Here,

mass of the 1st body, $m_1=10\text{kg}$

mass of the 2nd body, $m_2=20\text{kg}$

distance, $d=2\text{m}$

Gravitational constant, $G = 6.673 \times 10^{-11} \text{Nm}^2\text{kg}^{-2}$

Force $= ?$

**Example 4.2:** When the distance between the centres of two spherical bodies of masses 39.2 kg and 15 kg is 20 cm, they attract each other with a force $9.81 \times 10^{-7} \text{N}$. Determine the value of Gravitational constant.

**Solution**

We know,

$$F = G \frac{m_1 m_2}{d^2}$$

or

$$G = \frac{Fd^2}{m_1 m_2}$$

or

$$G = \frac{9.81 \times 10^{-7} \text{N} \times (20 \times 10^{-2} \text{m})^2}{39.2\text{kg} \times 15\text{kg}}$$

$$= 6.673 \times 10^{-11} \text{Nm}^2\text{kg}^{-2}$$

**Ans.** $6.673 \times 10^{-11} \text{Nm}^2\text{kg}^{-2}$

Here,

mass of the 1st body, $m_1=39.2\text{kg}$

mass of the 2nd body, $m_2=15\text{kg}$

distance, $d = 20\text{cm} = 20 \times 10^{-2} \text{m}$

Force of attraction $F=9.81 \times 10^{-7} \text{N}$

Gravitational constant, $G = ?$

### 4.3. Acceleration due to gravity

We know from the Newton’s second law of motion that when a force acts on a body, it gets acceleration. So acceleration of a body is produced due to the force of gravity as well. This acceleration is called acceleration due to gravity.

The rate of increase of velocity of a freely falling body on earth due to force of gravity is called the acceleration due to gravity.

The acceleration due to gravity is represented by the letter ‘$g$’.