Professional Learning of Secondary Science Teachers in Bangladesh

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Dedication

To

Shova

Samiha

Atif

For Your Understanding and Support

and

My Late Parents

Declaration

This thesis, except with the Research Graduate School Committee's Approval, contains no material which has been accepted for the award of any other degree or diploma in any university or other institution. To the best of my knowledge, the thesis contains no material previously published or written by any other person, except where due references is made in the text of the thesis.

S M Hafizur Rahman

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Abstract

The current reform efforts in Bangladesh require a substantive change in how science is taught; an equally substantive change is needed in professional practice. This research set out to explore two basic aspects of secondary science teaching in Bangladesh. One was to guide participant teachers in changing their traditional teaching approach through the use of a concrete example of a new teaching approach. The second was to assist participant science teachers to change the culture of their existing professional practice.

To address and explore both of these aims, a constructivist teaching approach (Prediction-Observation-Explanation, POE) was used as an intervention with participant teachers in an attempt to ascertain if it could influence their thinking and lead to a change in their traditional approach to teaching science. Simultaneously, all participant teachers involved were supported during the intervention regarding critique and challenge of lessons (theirs and their colleagues') in ways that were not a part of their regular culture of professional practice. The explicit intention being that through these collaborative ways a professional learning community might be developed through which their own professional learning might be enhanced in ways that would lead to improvements in their science teaching practice.

The findings of this thesis show that the use of the POE approach influenced participant teachers' thinking about science teaching and learning. Through the POE approach, these teachers were encouraged to: use teaching aids as a purposeful tool in their teaching; develop understanding of science content with their students rather than using recall and recognition of facts; find ways to look for the relevance of science within real life situations; overcome a reliance on rote learning and theoretical exercises; and, encourage students' interest and enthusiasm in the classroom learning environment. Moreover, the collaborative activities through the intervention process influenced participant teachers' practice. They became committed to finding gaps or mismatches between their teaching and their students' learning and making decisions about the challenges they faced regarding their practice through this process of job-embedded learning.

The results of this thesis ultimately carry implications for science teachers' practice in secondary schools in Bangladesh including teachers' own professional learning, as well as for curriculum developers and school administrators, and for pre and in-service education for secondary science teachers.

Chapter One
Introduction to the Study

1.1 Introduction to the Study

Professional learning (PL) has emerged as an important educational descriptor which is indicative of a shift in ways of understanding the development of teachers and teaching (Loughran, 2008). With increasing recognition of teaching as complex work (Goodson & Hargreaves, 1996; Loughran, 2010; Loughran, Berry, & Mulhall, 2006), professional learning has recently emerged as an issue of concern, because, as a construct it differs from that of traditional views of professional development. With the global trends in education over the past two decades, the nature of teachers' work has been challenged and that has led to a need to focus more on the subsequent professional learning (Pickering, Daly, & Pachler, 2007).

Professional development is, in general, related to being trained to perform particular tasks through the process of additional training or workshops related to policy guidelines or imposed change (Berry, Clemans, & Kostogriz, 2007; Hoban, 2002). Moreover, it is often viewed by participants as telling teachers what to do about their teaching (Loughran, 2008, 2010). It is often linked to the implementation of some form of educational change through a top down approach. Further to this, top down efforts have not always been successful because the ideas presented are not necessarily linked to teachers' existing classroom practice and therefore in most cases fail to take into account teachers' existing knowledge, beliefs, and attitudes (Driel, Beijaard, & Verloop, 2001; Hoban, 2002). Moreover, according to Hoban (2002), there has been little collegial support generated to promote educational change through professional development programs.

Professional learning deals with "what professionals do [to] learn about their own knowledge of practice" (Berry, et al., 2007, p. xiii). It is for supporting teachers in directing their own knowledge growth (Loughran, 2010). In most cases, issues in PL are not obvious or expected. PL encourages teachers to respond to the inherent contradictions between their intentions for teaching and their actual practice (Loughran, et al., 2006; Loughran & Northfield, 1996). Moreover, PL assumes some commitment to the change(s) that might be driven, or developed and refined by teachers themselves. When individual teachers question their own practice it helps them find new and innovative ways of making their knowledge of practice more meaningful.

According to Fullan (1993), changes in teaching practice require major changes in school culture. PL offers a new way of understanding those changes (Berry, et al., 2007). It encourages the development of knowledge of practice which is insightful, challenging, thought provoking and helpful. It provides opportunities to extend knowledge of practice beyond the individual and to share it with other professionals within their learning community. Professional learning communities (PLCs) then emerge as a collective framework for PL within the context of a cohesive group that focuses on collective knowledge of inquiry (DuFour, DuFour, & Eaker, 2008; Stoll & Louis, 2007). PLCs then work to improve the practice of particular groups of teachers through job-embedded learning.

With opportunities to work collaboratively in classes, such as through observing each other teaching (Berlinger-Gustafson, 2004; Louis & Kruse, 1995; Roberts & Pruitt, 2003, 2009), conditions such as isolation and physical proximity to colleagues begin to be addressed. Such changes can enrich subject matter knowledge, teaching strategies and other teaching practices. Besides facilitating a cooperative teaching role, PLCs also offer structures and opportunities for members to exchange ideas within and across organisational boundaries (Kruse, Louis, & Bryk, 1994). Better communication structures can then provide networks for the exchange of professional issues. At the same time, a PLC demands teacher empowerment and school autonomy through collective action (Berlinger-Gustafson, 2004; Boyd, 1992; Kruse, et al., 1994) and creates opportunities within a community for teachers to voice their specific needs and concerns.

Fullan (2007) also emphasised reculturing how teachers come to question and change their views and habits as a way to positively move forward. No reform or initiative can be sustained if teachers are not personally engaged in the struggle with their existing culture practice. Making a cultural shift is important for organisational improvement as opposed to simple structural changes (DuFour, et al., 2008; Eaker, DuFour, & DuFour, 2002). As Blanchard (2007) noted, it is easy to make a structural change in a school; however, it is difficult to make a cultural change which is less visible, and the aligning change with the existing culture of practice makes change itself more sustainable.

1.2 A Personal Perspective

I started my career in education as a physics teacher in the late 1990s in Bangladesh. There were three physics teachers in my institute. It is notable that both of my colleagues at the time had more than 25 years of teaching experience. I personally liked to talk to them to clarify my queries regarding my practice and sometimes observed their teaching in order to understand their use of particular teaching strategies and approaches. In some cases, I was fortunate enough to share and discuss many things with them about their teaching and soon realised, from participating in that collaborative process, that such experiences were helpful in enhancing my practice.

Later in 2003, I had an opportunity to work as a science teacher trainer in a program organised by a Non-Government Organisation (NGO). The training program was designed for secondary science teachers who were involved in teaching 'General science' in grades VI, VII and VIII. The focus of the program was on clarification of subject matter knowledge and pedagogy for science content. Moreover, the training sessions in that program also included demonstration teaching sessions by participant teachers. Working with them (around 500 secondary science teachers) for more than two years provided me with new experiences of the problems associated with secondary science teaching in Bangladesh. In some cases I found these teachers also had alternative conceptions about the science concepts we were studying, and also that they were reluctant to use teaching aids – there was a reliance on transmissive approaches to teaching. Moreover, I also could not help but see that, generally, there was a prevailing behaviour consisting of a lack of collaboration and collegiality. These experiences sparked my interest in researching science teaching in Bangladesh and created an impetus for me to try to do something about it.

In Bangladesh, the minimum entry for 'General Science' teaching at the junior secondary level is a Bachelors degree in Science (Latif & Johanson, 2000). A Bachelors student in science in Bangladesh has to take three majors, e.g., Physics, Chemistry and Biology, from a list of options of different science majors in order to graduate. On the other hand, the General Science unit, for Grade VI, VII and VIII, comprises subject materials from Physics, Chemistry, Biology, Population, Environment, Information Technology, Geology and Geography (National Curriculum and Textbook Board [NCTB], 1996). In my experience, I have found that teachers of General Science tend not to be familiar with all the concepts in the General Science unit, in particular those related to physics. They find difficulty or feel uncomfortable in teaching some particular aspects of the program. I also found that in my training sessions (in the NGO program) that participant teachers preferred to change their topics for their demonstration teaching session in order to avoid certain aspects of science. For example, teachers who did not take physics courses as a major in their graduate study felt uncomfortable explaining abstract concepts of physics (for example, electricity) in ways that might make it understandable to students. I also found in some cases that participant teachers read the book in their demonstration teaching instead of explaining the science concepts perfectly. This highlighted for me the lack of subject matter knowledge of some of these science teachers (teachers of General Science from grade VI-VIII) and the associated lack of confidence they displayed. In fact, I still remember one teacher who explained to the group that we can only see an object when a beam of light from the object falls on our eyes; alternative conceptions were highlighted in many ways.

I also recognized that teachers were not confident about selecting appropriate teaching strategies to teach particular content. They followed, in general, a traditional lecture method for science teaching that was far removed from constructivist views of learning. Their approaches to teaching failed to acknowledge students' prior knowledge about science concepts, and in many cases, I found them not to be concerned about maintaining a logical sequence for their lesson. It seemed to me that the more I experienced, the more I saw that many had limited skills for helping their students to see the links between theoretical discussions and real life science situations.

I also noticed that sharing knowledge and pedagogical experience was not part of a common culture among practicing science teachers in their schools and that collegiality was lacking. I illustrate the point through the following example. In a school in Bangladesh, there were two secondary science teachers Mr. Rahim and Mr. Ahmed (pseudonyms). They were responsible for teaching in grade seven and eight respectively. One day, Mr. Rahim noticed that he could not explain the concept of ‘Total Internal Reflection’ to his grade eight students so Mr. Rahim decided to ask his colleague Mr. Ahmed to explain this concept to him. Their conversation went as follows:

***Mr. Rahim**:* *Hello, I would like to discuss with you about some subject matter. I am facing difficulty in explaining to my students.*

***Mr. Ahmed**:* *No problem! I know that I am busy today, we will discuss it tomorrow.*

***Mr. Rahim**:* *It’s Ok. Thanks*

In the meantime, Mr. Ahmed complained to other colleagues including the Head Teacher about Mr. Rahim’s lack of subject matter knowledge. Mr. Rahim heard about this complaint and decided not to go to Mr. Ahmed to discuss the subject matter. Like Mr. Rahim, in many cases science teachers are confronted by the problem of explaining content properly to their students, but they find very little support for collaborating with others.

This type of incident works as an obstacle to sharing. It is also a very sensitive issue in relation to teachers’ image in the Bangladeshi context. This type of image is then a disincentive for teachers to observe each other’s classes or to reflect on their practice in any public manner. In most cases, they do not share their knowledge with others. However, paradoxically, I found these teachers enthusiastic to learn new knowledge and share with each other in the training sessions. At the same time, most were not satisfied with the professional development programs they experienced that were designed by different providers. In most cases, those programs did not address their needs. Moreover, when I shared my collaborative experience at my workplace with them, they found it interesting. They also expressed a desire to change their school culture for their professional practice to enhance their teaching for better student learning. These experiences shaped my concerns for science teaching and learning in

Bangladesh and impacted what I wanted to do, how and why as a science teacher educator in my country.

Quality education, especially in science education at the secondary school level, remains a major concern (Ministry of Education, 2005) in Bangladesh. Throughout at least the last two decades, measures have been taken to change science teaching practice mainly through government and donor funded projects. In Bangladesh, with the increase in the number of schools from its independence in 1971, there has been a significant increase in the number of teachers (Bangladesh Bureau of Educational Information and Statistics [BANBEIS], 2010; World Bank, 2005). In the last fifteen years, the number of teachers has doubled in secondary schools from 122,896 to 256,284 (BANBEIS, 2010). In the past, as a consequence of the lack of adequate capacity and appropriate mechanisms, no significant progress has been made in providing training to secondary science teachers. As a result, fewer than half (48.7%) of the teachers have had any in-service training (Ministry of Education, 2005). It seems quite impossible to train those untrained teachers in a reasonable time scale and it is also a big financial matter for a country like Bangladesh (Ministry of Education, 2005). Currently, a Teacher Quality Improvement (TQI) project is running to improve secondary teachers' knowledge and skills, following the cascade model of dissemination, with the aim of providing training to all non-trained teachers in Bangladesh. However, it is a common experience of stakeholders that professional development through these different initiatives has had little impact on the quality of teaching practices (Asian Development Bank [ADB], 1998). Moreover, the current professional development programs are questionable and have very low impact on the quality of teaching (Halim, 2004).

I have been driven by a question, "How can I help teachers to change their perceptions of the nature of teaching and the culture for their professional practice?" I have always been looking for suitable strategies that might help teachers to address different aspects of science teaching and also create a collaborative culture that that might allow them to share their understandings of their practice. Not surprisingly, when the opportunity arrived, I decided to design my research study around my concerns about secondary science teaching and teachers. When I came to learn about constructivist teaching approaches and the idea of professional learning through professional learning communities, it triggered my thinking to link the enthusiasm of science teachers to improvement in their practice through the theoretical aspects of a PLC. Moreover, from the ideas from Gunstone (1995) regarding the importance of genuine collaboration (teacher with teacher, teacher with researchers) in the development and use of constructivist teaching approaches, I found myself becoming more focused and guided in ways that supported my thinking and my plans for action.

In spite of teaching loads which are 26-36 hours per week and a lack of resources for their teaching (ADB, 1998), I decided that an intervention using new constructivist teaching approaches and the exploration of a PLC might just bring about a change in junior secondary science teaching. Research was needed to help identify the professional needs of teachers but that might also help to provide possibilities for a workable model for the provision of professional learning for secondary science teachers to improve the quality of science teaching in Bangladesh.

In this study I decided to ask science teachers to use a constructivist teaching approach, prediction-observation-explanation (POE), in their practice, and in order to support their learning about this strategy I also designed teacher collaborations within and across nearby schools (described in detail in Chapter Three). My understanding about the use of POE was that it guides teachers in their thinking about subject knowledge and pedagogy and creates new ways of sharing and discussing with their colleagues. My thesis therefore became an investigation into teachers' views about their current practice and their students' learning in science. The study thus offers an exploration of the issues that appear to impact teachers' views for teaching and learning in science by exploring how learning about a constructivist teaching approach influences teachers' thinking and how embedding that learning in a professional learning community influences the ways in which participant teachers learn about, and develop their practice.

1.3 Context of the Study

1.3.1 Bangladesh: an overview.

The People's Republic of Bangladesh is a south Asian country with a population of about 156,118,464 (July 2010 est.). This country is bordered on the south-east by Myanmar and on the south by the Bay of Bengal. The rest of the country is surrounded by India. It has a population density of about 1090/Km^2, with a total area of approximately 143,998 sq km. Bangladesh is ranked the seventh most densely populated country in the world. The population growth in Bangladesh is 1.55% (2010 est.). The rate of literacy is 47.9% for the total population (definition: age 15 and over can read and write) whereas for males it is 54% and for females, it is 41.4% (2001 Census) (World Factbook, 2010).

1.3.2 Structure of education in Bangladesh.

Education in Bangladesh is broadly divided into three major stages: primary; secondary; and, higher education. Primary education, which is compulsory, is a Five-year cycle while secondary education comprises seven years of formal schooling with three sub-levels: Three years of junior secondary; Two years of secondary; and, Two years of higher secondary. The entry age for primary school is six years. The junior secondary, secondary and higher secondary levels are designed for age groups 11-13, 14-15 and 16-17 years respectively. Higher secondary is followed by graduate level education in general, technical, engineering, agriculture, business studies, and medical streams requiring four-six years to obtain a Bachelor and/or Masters degree. The Master's degree is of one year's duration for holders of Bachelor Degree (Honours) and two years duration for holders of a Bachelor Degree (Pass). These levels are summarized in Table 1.1 (Ministry of Education, 2006).

In terms of curriculum, primary level education is provided through two major streams: general; and, madrasha (madrasha has an additional emphasis on religious studies). Secondary education has three major streams: general; technical-vocational; and, madrasha. Higher education, likewise, has three streams: general (inclusive of pure and applied science, arts, business and social science); madrasha; and, technical and professional education (Ministry of Education, 2006).

Table 1.1

Levels of General Education in Bangladesh

Age in Year	Grade	Phase of education (General Education Stream)	
22+	XVII	**Masters**	
21+	XVI		**Masters (Preliminary)**
20+	XV	**Bachelor (Hons.)**	**Bachelor(Pass)**
19+	XIV		
18+	XIII		
17+	XII	**Higher Secondary Education**	
16+	XI		
15+	X		
14+	IX	**Secondary Education**	
13+	VIII		
12+	VII	**Junior Secondary Education**	
11+	VI		
10+	V		
9+	IV		
8+	III	**Primary Education**	
7+	II		
6+	I		

Madrasha function parallel to the three major stages, they have similar core courses to the general stream (primary, secondary and post-secondary) but have an additional emphasis on religious studies. In major cities, English medium school is followed by O-level/A-level work as a stream for primary and secondary education sector.

Basically, there are three types of general junior secondary school in Bangladesh. These are junior secondary school itself (only for grade VI to VIII), in combination with Secondary (for grader VI-X) and with collegiate school (for grade VI-XII). The focus for this study is that of general junior secondary grades (Grade VI-VIII) regardless of types of school.

1.3.3 Junior secondary science curriculum.

The National Curriculum and Textbook Board (NCTB) prepares the curriculum for all levels of general education from primary to higher secondary education in Bangladesh. In primary, from grade III to V, science is taught as environmental science and there are separate books for each of the grades. In junior secondary level science is taught as 'General Science' as a compulsory subject. In secondary education, there are three streams of courses: humanities; science; and, business education. These start at class IX, where the students are free to choose their course(s) of studies. Students who choose science as a discipline have to take Physics and Chemistry as elective units. They also have to choose Biology or Higher Mathematics as a third elective unit. Students, who choose Biology as a third elective unit can choose Higher Mathematics as an optional unit and vice-versa.

The 'General Science' subject forms 10% of the total curriculum of the junior secondary education (NCTB, 1996). General Science is prescribed as an integrated course and content from Biology, Physics and Chemistry receive priority. Content has been selected according to prescribed learning objectives and distributed among different grades from six to eight. There is one General Science textbook for each grade from six to eight. In practice this curriculum does not maintain its integrated form. For example, the chapters in the text book for grade six comprise different areas of science that are not arranged according to any integrated theme. Generally, the books would not normally be described as inspiring and are heavily laden with facts.

1.3.4 Science teacher education in Bangladesh.

The Bachelor of Education (BEd) course is located in the education discipline of the National University of Bangladesh (National University, 2006). The curriculum of this course provides for a comprehensive program of initial teacher education for secondary teaching. The curriculum is structured into five Learning Areas (National University, 2006) and summarised in Table 1.2.

Table 1.2
Learning areas in teacher education program

Learning areas	Description
Professional Studies	Generic performance pedagogy
Teaching Studies	Pedagogical content knowledge of school subjects
Education Studies	Knowledge of educational policy, theory and practice in Bangladesh contexts
Technology and Research Studies	IT and Action Research skills for teachers and teaching
Teaching Practices	School based practice

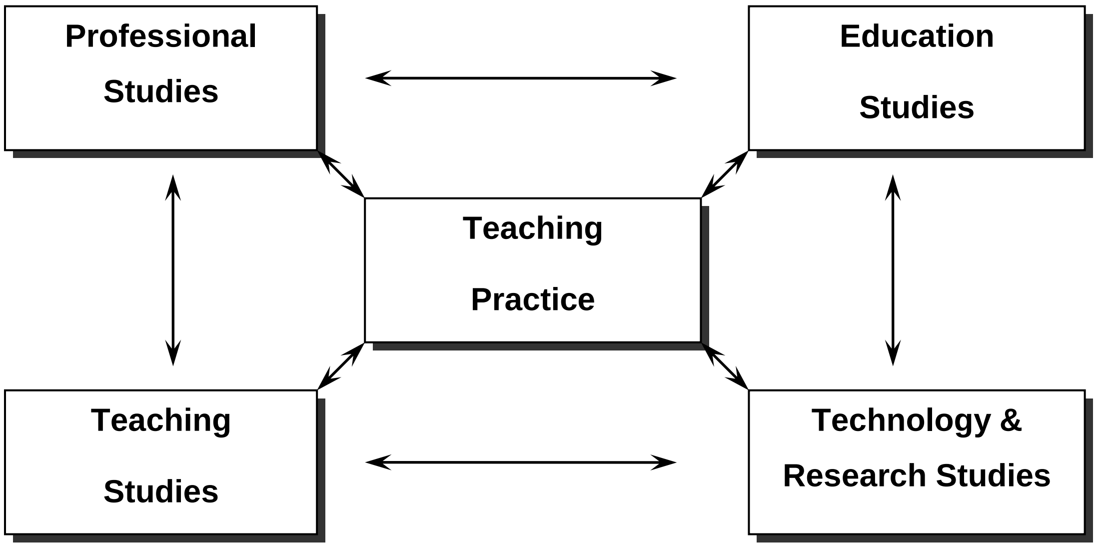

Figure 1.1: Different learning areas of one-year Bachelor of Education program

Figure 1.1 shows how the different learning areas are inter-related. Anyone holding at least a Bachelors or higher degree from any discipline rather than education may apply for admission into the BEd course. In this course, subjects not studied at degree level will generally not be able to be taken as teaching studies subjects in the BEd class. If subjects studied in the graduate degree are not included in the list of teaching studies subjects then the trainee students may select subjects they studied in grades XI and XII if they have the permission of the principal of the Teachers Training College (National University, 2006). In some cases, science teachers at junior secondary level do not have a science degree. So they have to select the teaching studies subject on the basis of their higher secondary science subjects.

The central one year teacher education program in Bangladesh has been structured according to and evolved following western education policy (Ministry of Education, 2004). In many cases, the contextual and short term needs have led to inappropriate teaching methods, inadequate supervision and management (Ministry of Education, 2005). The 'teaching studies' and 'teaching practices' learning areas for science teachers in this teacher education program are based on the science curriculum of year IX and X (National University, 2006). Therefore, it has little impact in terms of the content knowledge enhancement for science teachers who need to teach 'general science' in the junior secondary level. In most cases, teachers do not find time to explore the 'General Science' perspectives in this teacher education program.

1.3.5 Secondary teachers' qualifications.

Currently Bangladesh has approximately 18,500 secondary schools with 7.4 million students and 2,380,125 teachers (BANBEIS, 2010). There is no data available for the number of science teachers separately in the secondary level in Bangladesh education statistics. The highest academic attainment of the teachers in the secondary level shows that 2.69% have Secondary School Certificate (SSC) or equivalent, 8.16% have Higher Secondary School Certificate (HSC), (after 12 level), 69.00% are graduates of tertiary institutions, 11.17% are post-graduates and 8.78% have different religious education certificates (BANBEIS, 2003).

Among current teachers in secondary education, 1.17% secured 1st division (above 60% marks), 38.63% secured 2nd division (45-59% marks), and 60.20% secured third division (below 45%) in their graduate course (BANBEIS, 2003). As a whole, it is interesting to note that a large majority or 69.00% of the teachers are very well qualified as they have finished their graduate level. However, there is a question about subject matter knowledge for a significant number (60.20%) of these teachers, as they scored below 45% in their own graduate course.

1.3.6 School context and its influence on science teaching.

In Secondary schools in Bangladesh, the number of students in each class, particularly in junior sections (from grade VI to VII), is a major concern. In most cases, this number can exceed 100 students per class (Holbrook, 2005). In most schools, science teachers are over-loaded and have to teach about 27 classes every week (Haque, 1976). The situation is made all the more difficult when teachers also need to cover other teachers' absences in their school. Moreover, the majority of science teachers are also not trained in the use of the new science curriculum or the textbook. In particular, most of them are not fully acquainted with the new content and concepts introduced in the textbook (Tapan, 2010). Most of them (85%) are not confident about using appropriate teaching strategies in their science teaching (Maleque, Begum, & Hossain, 2004) and are very reluctant to use new methods of teaching due to a lack of motivation, interest and proper training and follow up (Tapan, 2010). The availability of suitable teaching aids is another concern for teachers in their science classes. Most schools do not have adequate teaching aids and teachers do not know where they can collect/produce them. This situation impacts students and encourages them to memorise textbook material rather than understand the science concepts or develop any kind of personal knowledge construction (ADB, 1998; Tapan, 2010). This also makes the classroom learning environment very likely to be dominated by a teacher centred approach thus minimising the likelihood that students' interest in learning science will be aroused (Hossain, 1994). Moreover, in most cases, teachers are not cognisant of the need to take into account students' prior knowledge in terms of influencing their practice. It is also very rare to find teachers sharing ideas with each other to improve their practice.

1.4 Purpose of the Research

The current reform efforts in Bangladesh require a substantive change in how science is taught; an equally substantive change is needed in professional practice. This research set out to explore two basic aspects of secondary science teaching in Bangladesh. One was to guide participant teachers in changing their traditional teaching approach through the use of a concrete example of new teaching approach (POE). The intention being that through that process they might re-think their understandings of practice and make a shift from their traditional ways of science teaching to something more in line with constructivist view of learning. The second was to assist participant science teachers to change the culture of their existing professional practice. The intention for this change in the culture of professional practice was based on a desire for teachers to have more conversations with their colleagues within and across the school in order to develop a learning community in the hope that through their professional learning their science teaching might improve.

Specifically, the following research questions offer one way of thinking how to map the terrain of science teaching in the junior secondary level in Bangladesh and how this research was organised.

1. What are secondary science teachers' views about their practice and their students' learning of science?

2. What issues appear to impact these views?

3. How does learning about constructivist teaching approaches influence science teachers' thinking about their practice and their students' learning of science?

4. How can establishing a Professional Learning Community influence the ways in which these teachers learn about, and develop, their practice?

1.5 Conceptual Framework

A conceptual framework is an explanatory device "which explains either graphically or in narrative form, the main things to be studied - the key factors, constructs or variables - and the presumed relationship among them" (Miles & Huberman, 1994, p. 18). It is an efficient mechanism for drawing together and summarizing accumulated facts (Bell, 2005). The conceptual framework in Figure 1.2 was developed to guide the conceptualisation of this study which ultimately was derived from mapping the issues that impacted upon and influenced the conceptualisation of this research (see Appendix 12 for this initial mapping approach).

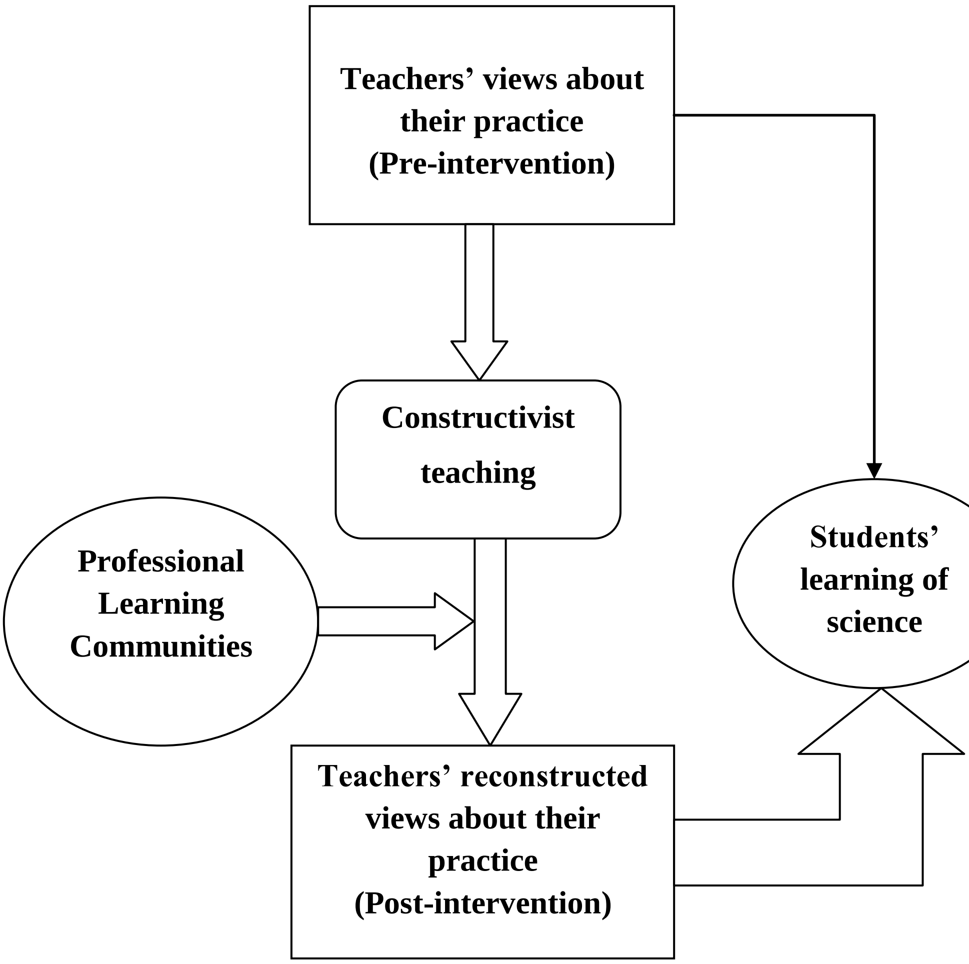

Figure 1.2: Conceptual framework of the study

As the conceptual framework of this study illustrates (see Figure 1.2), participant teachers have their own views about their practice which influence their students' learning. The research project attempts to facilitate teacher learning through experiencing and working with a constructivist teaching approach (POE) supported through teacher collaboration within professional learning communities in an attempt to facilitate reconstruction of participants' views of practice based on deeper understandings of students' learning of science (mark as different and thick arrow).

1.6 Significance of the Study

The status of secondary education in Bangladesh has drawn the attention of the government, educators, domestic and international NGOs and aid agencies. Improvement of the quality of secondary science teachers is the main focus of their concern (Ministry of Education, 2005). In Bangladesh, very little research has been conducted in the area of science teaching. Therefore, this study provides a new direction for policy in terms of what it might mean for implementing change in secondary science teaching in Bangladesh. The findings of this study may also help researchers in science education and the education authorities to come to grips with the current status of secondary science teaching and the extent to which that influences teacher and student learning. Through exploring a learning community and the attributes that foster PLCs, this study could also better inform teacher educators about the conditions that support (or hinder) collegial development. Moreover, the findings from this study should enable policy makers to plan more appropriately for the ongoing professional development, and then the more important professional learning opportunities, for secondary science teachers in Bangladesh.

1.7 Outline of the Thesis

This thesis comprises ten chapters.

Chapter One introduces the study with a personal perspective to conduct this study. It discusses the context of the study and outlines the purpose of this research, the conceptual framework and the significance of this study. This chapter also provides an outline of the structure of each chapter.

Chapter Two provides a literature review of science education in Bangladesh and other developing countries. It also discusses issues related to science teaching and learning, more broadly. Finally the chapter discusses literature on Professional Learning Communities focusing on their emergence, attributes, framing, learning, cultural shifts, benefits and challenges in participation.

Chapter Three includes an outline of the research design, strategies of inquiry, the intervention, instruments, sampling, ethical issues, legitimation and methods of data analysis.

Chapter Four discusses the pilot study of this research. It includes the purpose of the pilot studies, results and learning from pilot studies designed for this study.

Chapter Five presents results from the baseline survey to offer a broader perspective of teachers' views about their practice and their students' learning of science. To facilitate the presentation of this data, the responses from the baseline general questionnaire and semi-structured interviews are presented in separate sections followed by a common summary under different themes.

Chapter Six deals with the results of the intervention in this study. These results come from classroom observations, post teaching discussions and professional workshops conducted within this study. This chapter presents findings that identify change both in teaching perceptions and the culture of professional practice within the teacher participants and their professional community.

Chapter Seven looks at the results from the post intervention questionnaire and focus group discussions used in this study. The findings identify teachers' views in order to better understand the impact of the intervention process used in this study on their practice.

Chapter Eight presents discussion about how the findings of the previous three chapters have created an informed response to the two main research purposes. It outlines participant science teachers' views about their practice and students' learning of science, learning about constructivist teaching approaches, and professional learning communities and teachers' practice.

Chapter Nine provides the implications of the research findings from this study. It includes implications for researching science practice in secondary schools and implications for the further research.

Chapter Ten provides the conclusion of this study. It includes revisiting the research purpose and questions and answers to the research questions. The chapter concludes with some final remarks.

Chapter Two
Literature Review

2.1 Introduction

Education has been the subject of much contemplation, discussion, review and planning in post-independence Bangladesh. During the colonial period (under the British rule), science education did not take priority in the school curriculum (Tapan, 2010). During the 1960s, some efforts had been made; however, with a focus on preparing skilled technicians to get good jobs or to take part in higher education in western counties. After independence, the government initiated the development of a national science and technology policy. However, for a long time after its independence in 1971, Bangladesh still suffered from lack of improvement in the standard of scientific knowledge at all levels from school to university. Bangladesh did not have an environment which promoted research and the strengthening of the science education arena. A stable education policy did not exist and science education particularly struggled to identify objectives for learners. More recently, in line with attempting to develop a National Education Policy 2010, it was stated that the objective of science education in Bangladesh should be to prepare learners in such a way that they may achieve an international standard by realising their intelligence through the pursuit of knowledge and creativity (Ministry of Education, 2010).

In essence, the expectation was that the teaching of science should be imparted to children in such a way that they realised that science is a creative, dynamic and interesting method by which to study and explore the secrets of nature. Teachers therefore need to be confident in their subject matter knowledge and pedagogy to deliver science lessons that can meet this objective effectively. However, the effectiveness of teaching science in secondary school in Bangladesh raises many questions, issues and concerns among its stakeholders. The following section presents the scenario of science teaching and learning in secondary schools in Bangladesh.

2.2 Secondary Science Education in Bangladesh

Teaching science in secondary schools in Bangladesh is difficult because of such things as: class size; teaching load; resources; teachers' knowledge; teaching strategies; and, issues regarding professional development. The following sections outline these aspects from the perspective of different research outcomes.

2.2.1 Class size.

Class size is one of the major stumbling blocks to the use of regular group activities and student-centred science teaching. In Secondary schools in Bangladesh, the number of students in each class particularly in junior sections (from grade VI to VII) is a major concern. In most cases, this number can exceed 100 students per class (Holbrook, 2005). The Ministry of Education in Bangladesh has a recommendation for a maximum of 60 students per class but this number is hard to achieve both in government and non-government schools.

2.2.2 Teaching load.

The workload of science teachers is, in most cases, beyond the typical requirements of teachers in secondary schools in Bangladesh (Hossain, 2000). In most schools, science teachers are over-loaded and have to teach about 27 classes every week (Haque, 1976). The situation is made all the more difficult when teachers also need to cover other teachers' absences in their school. Moreover, in most cases, science teachers have to take both mathematics and science classes across the junior (General Science) and secondary level (Physics, Chemistry and Biology). This wide range of demands tends to overload science teachers such that they struggle to teach the appropriate content because regularly they find themselves teaching out of their particular specialism in science. This situation also impacts their preparation time for their teaching.

2.2.3 Subject matter knowledge of science teachers.

There are very few qualified teachers in secondary education in Bangladesh (Choudhury, 2008). Moreover, there is a shortage of trained subject-based science teachers at secondary level (Hossain, 2000). A recent study by Maleque, Begum and Hossain (2004) pointed out some aspects of teachers' performance in teaching 'General Science' in junior secondary school. According to their findings, 62.5% of science teachers have average (not good or excellent) content knowledge in science. Most of the science teachers are also not trained in the use of the new science curriculum or the textbook. In particular, most of them are not fully acquainted with the new content and concepts introduced in the textbook (Tapan, 2010). Hence, teachers, especially those in rural areas who may not have access to adequate training face difficulties teaching these subjects. As a consequence of this situation, Rashid (2001) recommended that science teachers needed more training in science content to enhance their knowledge in science and to ensure better teaching practice.

2.2.4 Teaching methods for science classes.

No major change has occurred up until now with regard to the teaching-learning methods of science used in Bangladesh (Tapan, 2010). Teachers, in most cases, tend to teach the same things in the same ways they were taught when they were students. In most cases, teachers' presentation style in science classrooms is unappealing to students (Choudhury, 2008). Moreover, according to Maleque et al.'s (2004) study most of them (85%) are not confident about using appropriate teaching strategies in their science teaching and are very reluctant to use new methods of teaching due to a lack of motivation, interest and proper training and follow up (Tapan, 2010). Even now science is taught everywhere in Bangladesh using traditional teacher-centred methods with less importance paid to student participation and interest. Largely, teachers encourage students to rote learn (Tapan, 2010).

2.2.5 Science textbooks.

The science textbooks at the secondary level are dominated by facts. Rana (2005) argued that what is used does not represent what is regarded as a good textbook and cannot be described as inspiring. On the other hand, Tapan (2010) suggested that the text books are fine but that the problem lies in how the information is implemented by teachers at the secondary level. Sarkar (2010) argued that these textbooks did not promote scientific literacy, and more specifically, Akhter (2010, July 01) found that these textbooks did not help students apply science in real life situations. Moreover, Siddique (2008) noted that an outcome of a textbook oriented approach was that the textbook becomes a de-facto curriculum.

2.2.6 Teaching aids.

The availability of suitable teaching aids is another concern for teachers in their science classes. Mondal (2001) identified that most schools do not have adequate teaching aids and teachers do not know where they can collect/produce them. Government projects rarely supply teaching aids and Bari (2007) found that schools do not have the available resources as required by the textbooks to implement the intended curriculum properly. Further to this, teachers are reluctant to find teaching aids on their own initiative due to a lack of motivation to improve their practice (Tapan, 2010).

2.2.7 Science teachers' professional development.

The quality of secondary education largely depends on the quality of teachers and so the provision of quality training is important. The Government has taken measures to increase the professional quality of teachers through different professional development programs. However, it is also true that secondary school teachers seldom receive recurrent training (Hossain, 1994, 2000). In most cases, training is conducted on an irregular basis depending on when funds are available, rather than the needs of teachers (Ministry of Education, 2005). Moreover, the content component of the professional development programs is particularly weak (Halim, 2004). Nine secondary education and science development centres (SESDC) were established within the campuses of the nine teachers' training colleges in Bangladesh for in-service training for secondary science teachers. However, in most cases, teachers' learning from those training sessions did not appear to impact students' learning to the extent envisaged in terms of better teaching practice in science (ADB, 1998; Hossain, 1994). Moreover, the teaching community also works in what appears to some to be a state of isolation with a lack of collegiality clearly apparent (Hossain, 2000).

2.2.8 A scenario of science teaching in Bangladesh.

Science teaching at the secondary level encourages students to memorise textbook material rather than understand science concepts or develop any kind of personal knowledge construction (ADB, 1998; Tapan, 2010). In most cases, teachers lack subject matter knowledge and pedagogical experience to an approach to learning for understanding. At the same time, the lack of resources, teaching and topic overload are common complaints of Bangladeshi teachers who mostly depend on the textbook for their knowledge (Begum & Rahman, 2004).

Maleque et al (2004) found in their evaluation of classroom performance of 200 secondary school teachers that 92.5% of science teachers were not conscious of the need for learner participation. This makes the classroom learning environment very likely to be dominated by a teacher centred approach thus minimising the likelihood that students' interest in learning science will be aroused (Hossain, 1994). Moreover, in most cases, teachers are not cognisant of the need to take into account students' prior knowledge in terms of influencing their practice. It is also very rare to find teachers sharing ideas with each other to improve their practice. By and large, the nature of science teaching in Bangladesh is similar to the nature of science teaching in other developing countries (Tapan, 2010).

2.3 Science Education in Developing Countries

An ideal of education is that it may be linked to the hopes, dreams, aspirations and struggles for a nation (Kyle, 1999). As Kyle (1999) explains, education is seen as one way of seeking a better life, dreams for a future world, aspirations for achievement and confronting different barriers to achieve a better life. However, within the education system, science education in particular has experienced a steady decline over the past few decades (Gray, 1999). Thus, the anticipated hopes for change through education are not so readily realized as the ideal might initially suggest.

2.3.1 Science education in developing countries.

Although developing countries differ according to their educational characteristics, in some cases, developing countries have some things in common educationally. In the case of science education, those characteristics that tend to be common include: (i) tradition; (ii) westernisation; (iii) centralisation; and, (iv) competition (Hsiung & Tuan, 1998). These characteristics are now explored (below) in the context of contemporary science education in developing countries.

Tradition: Traditionally, teachers in developing countries are expected to be knowledgeable in a particular subject area and because of their higher level of knowledge, teachers tend to be regarded as spiritual, intellectual and moral symbols in their society (Gray, 1999; Hsiung & Tuan, 1998). Teachers are also considered to be most influential in developing students' character formation. The achievement for a school and/or even for individual students is considered closely related to the quality of the teachers involved (Wu, 1992). Ultimately, these kinds of traditional beliefs lead to high expectations for the role that teachers play in many developing countries.

Westernisation: In most cases, developing countries follow developments in the developed world (Gray, 1999). Western countries significantly influence the goals and programs in science education in developing countries. One of the main reasons for following trends of western countries is that many developing countries were (or became) colonies of western countries such as the United Kingdom, the United States of America and Spain in the last 100 years (Hsiung & Tuan, 1998). Another reason is related to the high number of students in developed counties that have studied in developing countries (Wu, 1990). These students, when they return to their country, usually rise to influential positions in governments and universities. Therefore, their learning in developed countries influences the nature of educational policy they later implements (or shape) in their home country.

Centralisation: Another characteristic in most developing countries is its centralised system of education (Hsiung & Tuan, 1998; King & Orazem, 1999; Rondinelli, Middleton, & Verspoor, 1990). In most developing countries, "the education system is hierarchically structured, with most of the important decisions made by central government ministries" (Rondinelli, et al., 1990, p. 120). Therefore, a national authority tends to monitor and control the science curriculum as well as science teacher education programs. Teachers follow prescribed textbooks developed by central committees and work for the same curriculum goals irrespective of where the school is situated (Hsiung & Tuan, 1998; Wu, 1992). Typically, this does not meet the real needs of students or the diversity of needs in different regions of the country. At the same time, science teacher education is also controlled in a similar way by some central universities and colleges. In some countries, teaching positions are linked to successful graduation from those institutions (Hsiung & Tuan, 1998). Recently, in many developing countries, governments have been encouraging private universities to offer teacher education programs. However, curriculum approval is contingent on the central government authority; hence the same problems are likely to recur.

Competition: Competitiveness among schools for better results at the school final examination is another important educational characteristic in developing countries (Hsiung & Tuan, 1998). Teachers feel a need to adopt a teaching style to meet the local society's expectations. As a consequence, they concentrate on teaching knowledge from an approved textbook and prepare students for taking tests using a model test preparation training approach. Such an approach to teaching might lead to good results or high scores but the potential weakness of this teaching style is that students tend to memorise factual scientific knowledge instead of aiming to develop understanding. Because of this constraint, it is difficult for teachers to explore science learning through topics that might be relevant to students - rather they pursue the prescribed curriculum in a regimental manner.

2.3.2 Curriculum issues in science education.

This section focuses on subject integration and options for science education in developing countries from an intended curriculum perspective. An important issue in science education is how to improve teachers' understanding of how students learn science, and why students sometimes find the subject too difficult to apply their knowledge to their daily life problems. However, problems of daily life around the world are not often related to understanding in one science discipline alone. Changing understandings of learners and learning helps to shape the ways in which new curriculum structures and courses are designed (Driver & Oldham, 1986). Moreover, the commonalties in aims and objectives between the sciences are far greater than the differences (Lewin, 1992). This is very important when the focus shifts to cognitive skills rather than content to be taught. These deliberations ultimately lead, in many developing countries, to a preference for an integrated lower secondary science course (Caillods, Gottelmann-Duer, & Lewin, 1996; Lewin, 1992; Lewin, 2000; Ware, 1992b). Such integration at the lower secondary level allows a focus on science reasoning skills, which are encouraged across a range of learning content (Lewin, 2000) – at least that is the intention.

In developing countries, integrated or general science courses appear in several forms. Many of these integrated lower secondary science courses had their origin in, or were clearly influenced by integrated programmes designed in developed countries

(Caillods, et al., 1996). In many developing countries, integration is based upon concepts, or topics, or is little more than the mixing of traditional themes drawn from different science disciplines (Lewin, 1992). Most countries follow an integrated science or general science model in which science is taught as one subject (rather than separately as Chemistry, Biology and Physics) at the lower secondary level. In some countries, integrated science is taught as physical science (Physics and Chemistry) or biological science (Biology and Geology), whereas few countries offer it as separate subject, that is, as Physics, Chemistry and Biology (Caillods, et al., 1996). By implication, the integrated science curriculum, in some developing counties, incorporates content from agriculture, health, environment and earth science rather than attempting to teach them separately.

From a resourcing perspective, integrated science courses are cheaper to deliver at equivalent quality at the lower secondary level (Lewin, 2000). Reasons for this include: the simplification of textbook production; a simplified teacher education program; helping to address science teacher shortage by having all science taught in the same way; simpler preparation of school schedule; and, easier supply of laboratory provisions if all programs are the same. If the number of options of science courses increases, then more questions related to cost and logistic complications arise. A cross country analysis of curricula conducted by Lewin (2000) suggested that there were benefits to this kind of integration at the lower secondary level by reducing content where possible in favour of more emphasis on systematic attempts to develop higher order cognitive capabilities.

The implementation of integrated courses can also be problematic (Caillods, et al., 1996; Lewin, 1992). Reasons for these problems include inadequate teaching and learning materials, insufficient preparation time for teachers if they have are overly busy with their teaching load, and conflict with the school timetable and organization. Added to this, teachers are sometimes reluctant to teach outside their traditional disciplinary boundaries and consider teaching of integrated or general science as low status compared to teaching single subject sciences (Caillods, et al., 1996). In some cases, the curriculum becomes overloaded with ‘must learn’ content within the integrated science courses (Ware, 1992b) which makes it problematic for teachers to cover the required curriculum. As a result, teachers find no time to make the classroom a lively and creative place. On the other hand, in many countries, teacher training courses offer individual science disciplines rather than an integrated science course (Lewin, 2000). In some developing countries, the integrated science course is not taught by one teacher, but divided amongst several teachers that further reflect disciplinary boundaries and bring additional load for teachers.

Beyond these issues, other recent trends in science education in developing countries can be identified (Caillods, et al., 1996; Lewin, 1992). First, greater attention is being paid to 'Science For All' programs in curriculum design; second, integrated approaches, especially at lower secondary level, tend to stress scientific skills and cognitive processes above subject matter content; third, curriculum design and educational interventions are beginning to take into account findings from educational research, and fourth, curricula tend to be aligned with outcomes-based approaches. In general, recent common trends in science education are organized in ways that link science courses with children's everyday life, in particular dealing with health, nutrition, natural habitats, and sometimes with agriculture (Caillods, et al., 1996).

Efforts directed toward changing or reforming curriculum requires an analysis of need and a determination of how best to address this need (Lewin, 2000). In some cases, reform involves taking risks and initially becoming less expert (Ware, 1992b; White, Russell, & Gunstone, 2002). In recent years, there has been a renewed focus on curriculum reform around the world. In most developed countries the new wave of curriculum reform ties in with science for all, constructivism and equity issues (Gray, 1999; Ware, 1992b). The focal points of this reform include: nature of science; science as inquiry; scientific application; and, considerations of students' daily life. These reforms may change classroom practice significantly. Historically, most developing countries follow the structure and nature of the science curricula of their colonial ancestor (Gray, 1999). As a consequence, they typically experience problems with human and physical resources to support these kinds of curriculum initiatives during implementation or do not even consider whether it is contextually relevant. Therefore, it is difficult in many ways to develop a science curriculum that is authentic, contextually relevant and affordable within the resources of a developing country.

2.3.3 Resources in science education.

Resources for teaching science in developing countries have been the focus of attention of science education researchers and policy makers for the last three decades. There are well established connections between the availability of resource materials and achievement in secondary schools in developing countries (Gray, 1999; Lewin, 2000). The lack of availability of material resources greatly affects the quality of teaching science, in the secondary school particularly (Gray, 1999). The availability of adequate material resources for science teaching in the secondary school is a problem in almost all developing countries (Caillods, et al., 1996; DomNwachukwu & DomNwachukwu, 2006; Gray, 1999; Lewin, 1993; Lewin, 2000). Some countries, for example Sri-Lanka and Bangladesh, remain far behind developed countries in the resources available to support educational development (Lewin, 1993). This leaves science teachers poorly prepared to deliver lessons as they have to cope with the reality of a weak economy. At the same time, the cost of resource materials is problematic for developing countries (Lewin, 1993).

An equipped science laboratory is almost beyond the reach of the dream for science teachers in developing counties (Gray, 1999). In reality, the large majority of secondary schools in developing countries are not well equipped for hands-on science (DomNwachukwu & DomNwachukwu, 2006; Gray, 1999; Talisayon, 1994; Wahyudi & Treagust, 2004). In some cases, they have no equipment at all. Teachers in those cases normally teach the task as best they can. On the other hand, countries like Malaysia and Morocco have well equipped science laboratories. Unfortunately though, most those laboratories are unused because of the shortage of efficient science teachers (Caillods, et al., 1996). In essence, lack of equipment prevents teachers teaching science and so that teaching with less emphasis on practical activities tends to persist.

There is also increasing evidence of ineffective practical work at the secondary level in developing countries (Gray, 1999; Hodson, 1996). A number of developing world countries, to counter the problem of inadequate resource materials, have engaged simultaneously in very creative and useful thinking about instructional issues (DomNwachukwu & DomNwachukwu, 2006; Gray, 1999). Improvisation in science education, in this case, is of importance but such improvisation has resulted in “text-book oriented, theory-based, transmitted teaching and rote learning” (Gray, 1999, p. 264). In most cases, this outcome is due to insufficient knowledge about improvisation with equipment. In essence then, science teachers need to learn about how to design and construct improvised materials. DomNwachukwu and DomNwachukwu (2006) argue for improvisation as an area of specialization in science teacher education and think that it should be aligned with professional development. Yet as is consistently clear, science teachers in developing countries require significant support, over a period of time, to make substantial changes in their practice if their teaching is to be more contextually relevant.

2.3.4 Science teaching as a career.

One of the important influences on the quality of science education in schools is the quality of science teachers (National Science Standards Committee, 2002) and the quality of science teachers has an impact on student achievement. There is evidence, based on school-leaving and university-entrance examinations that the level of academic achievement of students depends on the status of teaching in the country. According to Ware (1992b):

> where the status of teaching is low, those students who enter science teacher training programs have, on average, a lower level of academic achievement than those students who enter programs for science majors (e.g., in Brazil, Indonesia, Nigeria, etc.). Where the status of the teacher is high, the quality of entrants into the profession is also high like Taiwan, Korea and Japan (p. 31).

In both developed and developing countries, the selection of teaching as a career depends on the actual and perceived rewards of teaching. These include remuneration, workload, employment conditions, opportunities for further education, career ladder and status of the teacher in the community (Department of Education Science and Training, 2006; Ware, 1992a). Reasons that encourage graduates to choose teaching as career include: working with children; high job satisfaction; opportunities to share knowledge; and, teaching as an enjoyable, challenging and responsible career (Reid & Caudwell, 1997). In contrast, the main reasons teachers give for leaving teaching include: workload; pupils' behaviour; new challenges with the complexity of teaching; the school situation; and, government neglect in terms of salary (Smithers & Robinson, 2001, 2003). These conditions are relatively bad in some developing countries where teachers' pay is usually tied to civil service pay structures. In some developing countries teachers need to take two or even three jobs to pay essential bills (Ware, 1992a). In Bangladesh, teachers do private tutoring for the same students in their home after or before school hours (Latif & Johanson, 2000).

It is not surprising that in many developing countries, students with higher levels of science achievement tend to involve themselves in science majors rather than science teaching (Ware, 1992a). They are more likely to be attracted by other careers like graduate research studies or employment in the private sector. In most developing countries, teaching, particularly in secondary level, is a negative choice by students who fail to find other employment opportunities (Lewin, 2000). This situation has resulted in a low quality teaching workforce in secondary schools in many developing countries. On the other hand, low SES and rural/regional students are more likely to consider teaching as an attractive career option (Ware, 1992a). They may perceive teaching as an attractive option because in most cases it enables them to live in their own regional area and provide a significant opportunity to do some work for their own community. To retain teachers in teaching it is necessary to look for factors that lead them to leave the job. At the same time, it is essential to design appropriate in-service training programs to enhance their professional development.

2.3.5 Secondary science teachers' qualifications.

The level of qualification of secondary science teachers is one of the variables that contribute to student achievement in science (Ware, 1992a). The subject matter knowledge of the science teachers, the ways in which they deliver instruction and their attitudes toward science have an impact on student achievement. Higher levels of student achievement tend to be associated with more qualified and experienced secondary science teachers (Lewin, 2000; Ware, 1992b). Teachers' level of qualification also influences students' attitudes toward further study in science (Ware, 1992b). These factors are positively correlated with the achievement of their students, especially in developing countries (Haddad, 1985; Husen, Saha, & Noonan, 1978). Therefore, studies suggest that an effective science teacher needs a strong science background in terms of their content and pedagogical knowledge.

Internationally, initial teacher training programs for secondary science teachers vary in length, content and curriculum organisation (Lewin, 2000). Ware (1992b) reports that in most developing countries, qualified and certified secondary science teachers are generally prepared through four different pathways:

(i) a three or four-year program leading to an undergraduate degree in science followed by a year of post-graduate teacher preparation for professional certification; or,

(ii) a four-year program that combines science and education courses, leading to an undergraduate degree in science education (a BSEd or BEd), with the greater percentage of the courses in science; or,

(iii) a three or four-year program that combines science and education courses, leading to an education degree, with the greater percentage of the courses in education; or,

(iv) a one or two-year program leading to a teaching diploma or certificate that may include little more science content beyond that delivered to the student teachers while they were themselves in secondary school.

(Ware, 1992a, p. 9)

In most initial teacher training programs, there is a balance between the upgrading of content knowledge, educational and pedagogical knowledge and professional studies including school based teaching practice (Lewin, 2000). Teachers require an adequate level of content knowledge to teach science effectively.

In many developing countries, secondary schooling is expanding rapidly (Caillods, et al., 1996; Ware, 1992a), creating a shortage of teachers, science teachers in particular (Caillods, et al., 1996; Talisayon, 1994; Ware, 1992a). Consequently, there has been a need to produce a large number of trained science teachers as quickly and as economically as possible. In this case, different institutions in some developing countries offer a one or two-year diploma or certificate program to meet this challenge. In most cases, these types of courses are not as able to develop competent science teachers because they do not allow sufficient time to cover the formal coursework considered essential for a well-prepared science teacher. The period of classroom practice which most essential is also not sufficiently catered for (Ware, 1992b).

In most cases, the background of the teacher does not match the content to be taught at the junior secondary level (Caillods, et al., 1996; Ware, 1992a). For example, teachers who graduated with physical science courses may find themselves teaching upper secondary Biology. Some will have limited content knowledge, whereas others have limited pedagogical knowledge. These teachers are urgently in need of upgrading their content knowledge and pedagogy. Therefore, it is important for teachers to take advantage of in-service training to reach a level where they can teach effectively.

2.3.6 Teaching practice in science classes.

The quality of science teaching at the secondary school varies significantly across developing countries (Guo, 2007) and many developing countries have experienced a considerable decline in science teaching as a consequence of the development of technology in the past few decades (Gray, 1999). In theory, science teachers need to inspire scientific attitudes, values, processing skills and higher order skills in their students (Guo, 2007). They also require a certain level of professionalism for their teaching practice. This includes the "acquisition of teaching techniques, basic understanding of science, experience in scientific research, acquisition of basic understanding of children and experience in educational practice … [as] the basis for developing practical teaching skill" (Hsiung & Tuan, 1998, p. 738). However, all of these aspects are rarely observed among science teachers in most developing countries (Caillods, et al., 1996; Guo, 2007).

Teachers' beliefs play an important role in the science teaching and learning process (Wahyudi & Treagust, 2004). Beliefs influence teachers' decision making. According to Wahyudi and Treagust, teachers have beliefs about the nature of subject matter, the nature of teaching subject matter and the process of students' learning of subject matter. However, teachers' actions are not always consistent with their stated beliefs (Wahyudi & Treagust, 2004). In developing countries, science teaching is seldom linked to the development of thinking skills related to real world problem solving. The teaching approach is more often based on rote learning and theoretical exercises. In most cases, the purpose or what outcome is valued is unclear (Caillods, et al., 1996). At the same time, in practice, much teaching addresses little of the curricula expectations, and mostly fail to develop intellectual skills related to science in any systematic way.

Class size is one of the substantive issues for group work and student-centred science teaching (Caillods, et al., 1996). Student centered activities also need sufficient space, books and equipment to be successful. Large class sizes in developing countries (Caillods, et al., 1996; Lewin, 1992; Lewin, 2000; Talisayon, 1994) present considerable challenges in terms of resources and student management and it is questionable when some kinds of practical work can be undertaken with large classes. In larger classes, students face difficulties in even seeing the demonstrations presented by their science teacher. On the other hand, large class size does not necessarily mean that the teaching is ineffective. For example in Korea, where there are large class sizes, students performed better in the International Association for the Evaluation of Educational Achievement (IEA) science test than their western counterparts.

In most cases, the literature suggests that teachers are not all that interested in organising demonstration work during their teaching even when the facilities exist (Caillods, et al., 1996). Therefore, students tend to learn science through memorisation, theoretical exposition and reasoning. In some countries, for example Malaysia, lessons are generally teacher centred and presented didactically with little input from students. In very few cases, science teachers arrange a demonstration for their science lesson. The role of students, in most cases, is passive, following instructions or copying from the blackboard. Some teachers use question and answer techniques in class. However, in most cases, questions tend to be confined to lower cognitive levels.

2.3.7 Subject matter knowledge of science teachers.

Science teaching is currently going through a process of change in most developing countries. In most cases, this reform in science education is related to dissatisfaction with how science is traditionally taught (Ware, 1992b). This includes when teachers may have difficulty in teaching certain subject matter content because of insufficient understanding of that content. Teachers are then often not able to explain the important substantive concepts to their students (Kennedy, 1990). The pedagogical behaviour of “explaining”, therefore, cannot succeed if teachers do not adequately understand the content they are supposed to explain (Ball & Williamson, 1989).

Teachers’ own understanding and engagement in ideas and processes about subject matter knowledge influence their endeavour for their students’ learning. In essence, they need to understand the core aspects of subject matter knowledge. Core aspects include the content of the subject, its organisation and structure and method of inquiry (Kennedy, 1990). Teachers need to understand a network or relationships among facts and ideas of the content. When science teachers possess inaccurate information and conceive of knowledge in a narrow way for the content, their students are likely to learn these ideas in the same way (Ball & Williamson, 1989). They may then fail to challenge their students’ misconceptions/alternative conceptions. Teachers’ views of knowledge also influence the way they ask questions during class and the ideas they try to reinforce and the nature of assessment tasks they assign to their students (Ball & Williamson, 1989).

Typically, science teachers in developing countries present science as a rigid body of facts, theories and rules to be memorized and practised, rather than as a way of knowing about natural phenomena (Caillods, et al., 1996). This approach to science teaching, in most cases, does not adequately prepare students as future citizens who will understand science issues. Contemporary approaches to science education demand students' understanding of everyday science. Accordingly, science teaching requires emphasis on a variety of activities which will enable students to learn actively instead of transmitting content knowledge for passive memorisation only. In general, teachers' pedagogical preferences for lower or higher order level learning may well reflect their understandings of the nature of the subject matter knowledge. Their basic knowledge about the subject as well as higher order thinking, conceptual development, analytic and problem solving ability support them to learn specific pedagogies for science teaching together with the complex aspects of each subject separately (Ball & Williamson, 1989).

Different views exist about the amount of subject matter knowledge that teachers need to know to teach effectively. The argument for less subject matter knowledge for teachers is that teachers need to know only what the curriculum or textbook provides to students. Therefore they need to be a bit ahead of their students. Others argue that teachers need higher levels of subject matter knowledge since to be 'fluent' in a subject requires a great deal of content specific knowledge. This enables a variety of complex relationships among different pieces of content to be formed. Also, a higher level of content knowledge enables teachers to understand how to approach new problems or dilemmas and how to produce ideas within the subject. A further argument about teachers having higher levels of knowledge is that, in addition to subject matter, teachers need to be aware of social norms, various social issues, and the utility and relevance of the subject to everyday life (Kennedy, 1990). Teachers' knowledge about their subject matter knowledge therefore must be explicit and conscious if they are to explain it to their students.

2.3.8 In-service science teacher professional development.

Professional development is a significant component in science education reform. Over the past few decades, educators have implemented a variety of programs aimed at increasing teacher knowledge and skills. From these efforts, much has been learned about what constitutes effective professional development as well as the attributes and principles of best practice. Loucks-Horsley, Hewson, Love and Stiles (1998) express the essentials for effective development as:

> Effective professional development experiences foster collegiality and collaboration; promote experimentation and risk taking; draw their content from available knowledge bases; involve participants in decisions about as many aspects of the professional development experience as possible; provide leadership and sustained support; supply appropriate rewards and incentives; have designs that reflect knowledge bases on learning and change; integrate individual, school, and district goals; and integrate both organisationally and instructionally with other staff development and change efforts. (p. 36)

Effective professional development does not occur as isolated strategies. Rather, it draws on a variety of strategies in combination to form a unique design (Loucks-Horsley, et al., 1998). The challenge for professional development program designers is to assemble a combination of learning activities or strategies that best meet the specific goals and contexts of the participants. In developing countries, the number of students in secondary education is expanding with time. To face this challenge, many countries allow large numbers of unqualified prospective student teachers to enter teaching without any form of training (Ware, 1992b). As a result, these teachers do not provide quality science teaching. A well designed in-service professional development program is needed to raise the quality of their science education.

Science teachers in many developing countries have the opportunity to participate in a variety of in-service programs. These include extended coursework leading to a formal qualification, short-term workshops or seminars, or short courses like micro-teaching (Stowitschek, Cheney, & Schwandt, 2000; Ware, 1992a). Extended coursework gives in-service teachers an opportunity to upgrade their knowledge and skills. Coursework is designed with a balance between content knowledge, pedagogy and professional studies and provides scope for teachers to re-examine aspects of their practice. At the same time, they can practise their teaching under supervision. In most cases, such courses are conducted through residential programs at colleges and universities. Teachers can attend these programs during vacations or, more rarely, study leave of some kind (Ware, 1992a). The problem is that a substitute teacher needs to be employed to replace a teacher who has been granted leave to study and this is a major resource drain for many schools in developing countries.

Two important cost-effective in-service programs noted in the literature are distance education and the cascade model of dissemination. According to United Nations Educational, scientific and Cultural Organization [UNESCO] (2001):

> The term 'open and distance learning' is used as an umbrella term to cover educational approaches of this kind that reach teachers in their schools, provide learning resources for them, or enable them to qualify without attending college in person, or open up new opportunities for keeping up to date no matter where or when they want to study. The flexibility inherent in open and distance learning, and the fact that it can be combined with a full or near full-time job, makes it particularly appropriate for the often widely distributed force of teachers and school managers. (p. 3)

In most cases, in-service training for science teachers needs to include hands-on science and facilitator interaction (Ware, 1992a). This presents problems for a distance learning approach for science teachers' professional development. Alternatively, a cascade model of dissemination can be effective both for master trainers and the trainee teachers. According to McDevitt (1998), "In this model a small team of trainers train a larger group who will in turn pass on their knowledge and skills to a further group" (p. 425). This may be a relatively inexpensive way to reach large numbers of teachers in a short period of time. In most cases, however, the quality of the message down the cascade raises a question for educators.

The short-term workshop is a popular approach for in-service teacher education. This is usually designed to convey the greatest amount of information to the largest number of participants at the least expense (Stowitschek, et al., 2000). Short term workshops may be used for the implementation of specific new curricula, new textbooks, new approaches to classroom teaching, or to introduce new materials, including science kits into schools (Lewin, 1991; Ware, 1992a). Ware (1992a) outlined reasons for using short term workshops as introducing teachers to the content of a new syllabus or a new examination, the format of a new textbook, new regulations related to reporting functions, specific pedagogical techniques, the operation of new instruments, ways of making or repairing low-cost equipment and approaches to improving laboratory practice. In some countries, these types of shorter programs are often mandatory, even if held during school vacations for science teachers (e.g., Malaysia and Thailand) (International Labour Organisation [ILO], 1991). However, it is also well documented that didactic workshops and content courses alone are inadequate for the purpose of changing teachers' practice (Stowitschek, et al., 2000). The short-term in-service instruction is therefore unlikely to have any long-term impact on teacher participants who are minimally qualified. Common criticisms of in-service courses include that they:

- are too short to be effective;
- have little effect on teachers' actual practice because they do not take into account the contextual realities of many schools and students;
- are ephemeral, with no follow-up or support materials;
- are sometimes run by those without adequate knowledge/experience themselves; and,
- concentrate on description rather than the acquisition of new skills. (Caillods, et al., 1996).

In-service trainers also face difficulties in trying to introduce change to teachers through a short term program. Their difficulties often stem from efforts to move secondary science teachers from a teacher-centered to a student-centered approach (MacDonald & Morgan, 1990). Part of the problem lies in teachers' lack of confidence with the science content - because teachers are often not able to explain important substantive concepts to students (Kennedy, 1990). There is also the issue of moving from the culturally accepted relationship between the teacher and the student toward a different relationship in the student-centred classroom. It has been demonstrated that teachers' willingness to change their classroom practices and make change is a slow process.

Trainers also face difficulty with the range of teachers they are expected to work with. The needs of a well qualified and a poorly qualified science teacher vary significantly during a training workshop. Being able to address this difference is necessary especially in developing countries where the range of teacher qualifications and expertise may be extreme. However, despite their differing needs, all of these teachers have to be enrolled in the same in-service programs (Al-Mossa, 1987;

Kamariah, Rubba, Tomera, & Zurub, 1988). The trainer therefore faces the problem of managing the needs of both groups in the same session.

Andrews, Housego, and Thomas (1990) identified some ways for ensuring that in-service programs are implemented in the classroom. According to these researchers, the most important factor for ensuring better implementation is to establish a continuing study group for the in-service participants. This also includes organizing in-service visits to teachers' classrooms by consultants, or as part of the regular supervision process (Ware, 1992b). Moreover, the motivation of teachers towards change is viewed as the next most important factor; being associated in particular with increased teacher pay and ministry certification.

Teachers also need supportive, collegial communities when inquiring into significant questions about science subject matter as well as into questions concerning learning and pedagogy (Loucks-Horsley, et al., 1998). Professional development activities include daily structured time for collegial discussion and planning with teaching colleagues from the same school or their peers from other schools. Coherence between professional development activities, school policies and professional experience supports increased teacher learning and improved classroom practice (Biman, Desimone, Porter, & Garet, 2000). At the same time, reading science and science education journals, joining science teacher organisations, attending workshops, participating in science Olympiads with their students and organizing science fairs, are some of the activities which contribute to the professional development of science teachers. These activities are worthwhile for all teachers. However, it is common to most developing countries that science teachers rarely observe the teaching practice of other colleagues (Wahyudi & Treagust, 2004). In most cases, they are too busy with their own classrooms.

From above discussions regarding teachers’ professional development programs, it is clear that teachers have to face different kinds of barriers to address their ongoing problems from their practice. To challenge or address teachers’ everyday problems as well as with increasing recognition of teaching as complex work (Goodson & Hargreaves, 1996; Loughran, 2010; Loughran, Berry, & Mulhall, 2006), professional learning has recently emerged as an area of focus, because, as a construct it differs from that of traditional views of professional development. With the global trends in education over the past two decades, the nature of teachers' work has been challenged and that has led to a need to focus more on professional learning (Pickering, Daly, & Pachler, 2007). Professional learning deals with "what professionals do [to] learn about their own knowledge of practice" (Berry, et al., 2007, p. xiii), and is concerned with supporting teachers in directing their own knowledge growth (Loughran, 2010). In most cases, issues in professional learning are not obvious or expected; unlike professional development which tends to be largely prescriptive and pre-defined. Professional Learning encourages teachers to respond to the inherent contradictions between their intentions for teaching and their actual practice (Loughran, et al., 2006; Loughran & Northfield, 1996) within the practice context. Moreover, professional learning assumes some commitment to the change(s) that might be driven, or developed and refined by teachers themselves. When individual teachers question their own practice it helps them find new and innovative ways of making their knowledge of practice more meaningful.

2.4 Issues Related to Science Teaching and Learning

2.4.1 The nature of science.

The concept of the nature of science is an important aspect of science teaching and learning but the meaning of this concept has changed over time (Lederman, 2004, 2007). Generally, it is considered as a way of knowing (Abd-EL-Khalick & Lederman, 2000). According to Hammrich (1997), "the nature of science is how science proceeds, how the scientific community decides what to accept and reject, and how much faith there is a large body of scientific knowledge and beliefs that are continuously developing" (p. 141). A functional understanding of the nature of science by teachers could be a prerequisite to any reform efforts of science teaching and learning in order to understand the critical aspects of scientific knowledge (Lederman, 1998). At the same time, the concept of the nature of science works as beliefs and values inherent to the growth of scientific knowledge (Lederman & Zeidler, 1987). Understanding the conception that way may also help learners to frame scientific knowledge in relation to the epistemological underpinnings of science (Abd-EL-Khalick & Lederman, 2000; Gess-Newsome, 2002).

Science invites some basic questions about the scientific world such as: What is there? How does it work? and, How did it come to be this way? (Lederman, 2007). It allows the sharing of certain basic beliefs and attitudes about what scientists do and how they view their work. Learners need to develop interconnected ideas about the world in order to build an understanding akin to a scientific worldview (American Association for the Advancement of Science [AAAS], 1989; Hammrich, 1997). These ideas could be developed through observing, thinking, experimenting and validating. These ways characterize the basic aspects of the nature of science and how science is different from other ways of knowing. Developing researchable questions, collecting and analysing data, and ultimately communicating results are key aspects of the nature of science.

Lederman (2004) identified three criteria to determine aspects of the nature of science to focus upon research and curriculum development: knowledge that is accessible to students; general consensus; and, usefulness for all citizens. Based on these criteria, the nature of science includes different characteristics or aspects. These aspects are empirically-based, tentative, subjective, creative, unified, culturally and socially embedded (Gess-Newsome, 2002; Lederman, 2004). In most cases, scientific knowledge derives from observations of the natural world. These aspects of the nature of science assist one to recognise the function of the subject matter and distinguish among observations, assumptions, scientific facts, laws, and theories.

Science involves the creativity that is essential for invention. As scientific knowledge is subjective, the theoretical commitments, beliefs, previous knowledge, training, expectations and experiences can have an influence on the development of creativity (Lederman, 2004). At the same time, science as a human enterprise is practised in the context of the larger culture and the practitioners are the product of that culture. So, scientific theory and analysis of data need to be involved in creativity.

Scientific knowledge is never absolute or certain (AAAS, 1989; Lederman, 2004; Lederman & Lederman, 2004). Science is basically a process of producing knowledge. Change in knowledge is inevitable because scientific claims change as new evidence is developed and validated. In science, the testing, improving and occasional discarding of theories, whether new or old, goes on the all the time (AAAS, 1989). It is difficult to find a way to secure complete and absolute truth in science. So, in most cases, accurate approximations can be made to account for the world and how it works.

2.4.2 Scientific inquiry.

Scientific inquiry could be described as a systematic approach to the development of process skills such as observing, inferring, classifying, predicting and measuring, questioning, interpreting and analysing data, scientific reasoning and critical thinking for the purpose of developing scientific knowledge (Lederman, 2004; Lederman & Lederman, 2004). Such inquiry can be perceived in three different ways. Firstly, it can be viewed as a set of skills to be learned by students and merged in the act of a scientific investigation. Secondly, it can be viewed as a cognitive outcome of students' achievement. It is basically related to what students actually know about the inquiry. This is different from what students are able to do as inquiry. Finally, it can be considered as a teaching approach used to communicate scientific knowledge to students. Here students experience scientists' daily work. This helps to construct the student's own knowledge where all of these help to develop their understanding about the natural world (Lederman & Lederman, 2004).

There are also other aspects of scientific inquiry (AAAS, 1989). One crucial aspect being that science demands evidence. Such evidence is gathered from observation and measurement taken from both natural and laboratory settings. Another aspect is that science is a blend of logic and imagination. The scientific arguments must conform to the principles of logical reasoning. To validate this argument it is necessary to test by applying criteria of inference, demonstration and common sense. At the same time, science explains and predicts about facts. These explanations must be logically sound and incorporate a significant body of scientifically valid observations. Scientists also try to identify and avoid bias in interpreting, recording and reporting the data. Understanding the nature of scientific inquiry then plays an important part in conceptualizing school science teaching and learning.

2.4.3 The purposes of science learning in school.

The question about the purpose of school science education has been widely debated in recent years in the science education community (Reiss, 2007). The purposes of junior secondary science in Bangladesh are prescribed at the junior secondary curriculum level (NCTB, 1996). These purposes are related to encouraging students to engage in the scientific process, development of scientific attitudes and values, encouraging students to investigate the environment around them, to be better informed about some basic principles, concepts, theories and laws and help them to solve daily life problems with the knowledge and skills they have already achieved. These purposes of science in school are therefore aimed at helping students acquire knowledge of the physical world and to learn about our universe (Reiss, 2007). The American National Science Education Standards also underline the purposes for school science and include:

- experience the richness and excitement of knowing about and understanding the natural world;
- use appropriate scientific processes and principles in making personal decisions;
- engage intellectually in public discourse and debate about matters of scientific and technological concern; and,
- increase economic productivity through the use of the knowledge, understanding, and skills of the scientifically literate person in their careers.

(National Research Council [NRC], 1996, p. 2)

These purposes are basically related to developing a scientifically literate society. In most cases, these purposes of science education are almost the same everywhere in the world. Clearly, science education should not be aimless (Reiss, 2007). People design curriculum, run schools and even train teachers in order to afford more control over approaches to and learning about and through science which goes to the heart of what it means to be scientifically literate.

2.4.4 Scientific literacy for all students.

There is some agreement within the education community that the purposes of science education are inherently intended to develop scientific literacy (Goodrum, 2004). Scientific literacy involves understanding not only science knowledge, but also understanding the nature of science (Tobin & McRobbie, 1997). Students develop an understanding of the nature of science as a key element for achieving scientific literacy (Moss, Abrams, & Robb, 2001). Scientific literacy includes specific types of abilities (NRC, 1996).

Goodrum, Hackling & Rennie (2001) defined some of the attributes of scientifically literate students which they saw as informing the type of learning that might be expected from the compulsory years of schooling. They suggested that a scientifically literate pupil should be interested in and understand the world about them and able to engage in discussion of and about science. Such pupils would be able to identify and investigate questions and draw evidence-based conclusions and also be sceptical and questioning of the claims made by others. Finally, scientifically literate pupils are those who make informed decisions about the environment and their own health and wellbeing. Therefore, scientific literacy implies that a person can identify scientific issues underlying national and local situations and influences and express positions that are scientifically and technologically informed.

2.4.5 Constructivist views of science teaching and learning.

The constructivist view of knowledge and learning has led to changes in teaching approaches in science education. These ideas have had a major influence on the thinking of science educators over the last two decades (Fensham, Gunstone, & White, 1994) Students come to class with their existing ideas from which they make sense of their world. Teaching needs to lead students to interact with these ideas by making them explicit and then promoting consideration of whether or not other ideas make better sense (Carr, et al., 1994). From a constructivist teaching point of view, the main concern in teaching science is "how to organize the physical and social experiences in a science classroom so as to encourage development or change in learners' conceptions from their informal ideas to those of accepted school science" (Scott, Asoko, Driver, & Emberton, 1994, p. 201). However, Scott et al. also asserted that there is no unique method or instructional route for teaching a particular topic. On the other hand construction needs guidance. Therefore constructivist teaching involves "judgments about how much and what form of guidance is best for any topic and any group of learners, and when to provide it" (Fensham, et al., 1994, p. 6). Fensham et al. also argued that judgement about guidance is an advanced skill and requires both pedagogical and content knowledge; the pedagogy is learner centred but teacher controlled in a way that there is always something the students are asked to construct.

A constructivist teaching sequence, suggested by Driver and Oldham (1986), has been used widely by researchers and curriculum developers (White, Russel, & Gunstone, 2002), and it has been found to provide pupils with opportunities to develop a sense of purpose and motivation for learning the topic. The sequence brings students to conscious awareness by making their ideas about the concept to be learned explicit.

This is done through various activities such as group discussion, designing posters, concept mapping, writing and the like. The sequence comprises several stages - clarification and exchange of ideas, exposure to conflict situations, evaluation of alternative ideas including the scientific one, and construction of new ideas. In this phase, students may become dissatisfied as a result of the clarification, exchange, exposure and evaluation of their alternative conceptions. The teacher introduces the scientifically accepted idea at some stage if it has not yet been presented by any student. Next students are provided with opportunities to use their developed ideas in various situations, both familiar and new; to consolidate and reinforce the new ideas. Finally, students are asked to reflect on how their ideas have changed by comparing their present thinking with their thinking at the start of the unit. They may be given opportunities to monitor their learning progress throughout the unit by writing journals. This reflection and monitoring encourages students to be more metacognitive.

2.4.6 Alternative conceptions in science.

Over more than three decades, a considerable amount of education research has shown that students develop their own “naive theories” and beliefs which they use to explain natural phenomena in the world around them (AAAS, 1989; Chou & Tsai, 2002; Driver, 1989; NRC, 1996; Palmer, 2001). Driver (1989) questioned the extent to which children’s conceptions are theory-like and whether or not they were used consistently in different contexts. She concluded that nearly all students used some mixture of their conception in a context and suggested that students did not have a scientist’s view of how concepts were applied.

As a constructivist view of learning illustrates, students’ minds are not “blank slates” to receive all the instructions that teachers want to deliver (Driver, Guesne, & Tiberghien, 1985). They come to formal science instruction with a diverse set of alternative conceptions of the real world that are highly resistant preconceptions (Anderson & Mitchener, 1994). These alternative conceptions are often parallel explanations of natural phenomena offered by previous generations of scientists and philosophers. Alternative conceptions arise from the diverse set of students’ personal experiences drawn from direct observation and perceptions (Anderson & Mitchener, 1994; Guo, 2007). Teachers often subscribe to the same alternative conceptions as their students and these can be seen to exist in their explanations of science concepts and the instructional materials they use. In such cases, learners’ prior knowledge interacts with knowledge presented in formal instruction. This ultimately comes together in a diverse set of unintended learning outcomes. Teachers therefore need to be more conscious when planning for and selecting teaching strategies that will help to elicit students' alternative conceptions. So, it is important for teachers to know, and be able to work with, examples of constructivist teaching approaches if they are to help address this notion of alternative conceptions. The teaching procedure Prediction-Observation-Explanation is one such approach.

2.4.7 Prediction-Observation-Explanation (POE).

Prediction-Observation-Explanation (POE) is a constructivist teaching strategy developed by White and Gunstone (1992). The POE strategy is often used in science teaching. It requires three tasks to be carried out. This strategy helps to uncover individual students' *predictions*, and their reasons for making these about a specific event. Then students describe what they see in the demonstration - *observation*. Finally, students must reconcile any conflict between their prediction and observation – *explanation*. POEs can therefore be used to explore students' ideas at the beginning of a topic, or to develop ideas during a topic, or to enhance understanding at the end of a topic (Gunstone & Mitchell, 1998). Through this teaching procedure, students are assisted in attempting to apply their learning to a real context.

In essence, this strategy (POE) is useful for uncovering students' initial ideas, providing teachers with information about students' thinking, generating discussion, motivating students to want to explore the concept, and generating investigations (Palmer, 1995; White & Gunstone, 1992). It is not about telling students the right answer at the end (Loughran, 2010). Moreover, this strategy focuses on linking students' existing ideas and beliefs relevant to a situation and the appropriateness of these ideas and beliefs (Gunstone, 1995). Clearly though there is also a link between teachers' beliefs and the manner in which they work with teaching procedures to develop students' learning of science.

2.4.8 Teachers' beliefs.

Teachers' beliefs are considered important in science teaching. Challenging individual teachers' beliefs is also a powerful way of encouraging and structuring understanding of both learning and teaching (Loughran, 2007). It is considered a common beginning point for reshaping teachers' views of practice. Teachers develop their beliefs about teaching from years spent in the classroom as both students and teachers (Lumpe, Haney, & Czerniak, 2000). Different studies confirm that there are strong connections between teachers' beliefs and their classroom behaviours (Brown & Rose, 1995; Tosun, 2000). Decisions that teachers make throughout their teaching can be linked to their beliefs. According to Wahyudi and Treagust (2004), teachers have beliefs about the nature of subject matter, the nature of subject matter for teaching and the process of students' learning of subject matter. However, as this literature makes clear, teachers' actions are not always consistent with their stated beliefs.

There are two systems of beliefs that are relevant in science teaching. These are outcome expectancy and self-efficacy beliefs (Bandura, 1997; Gibson & Dembo, 1984). According to the outcome expectancy belief, teachers believe that student learning can be influenced by effective teaching. In other words, in science teaching, outcome expectancy refers to teachers' beliefs that effective science teaching will help students to learn science (Lumpe, et al., 2000). On the other hand, self-efficacy beliefs support teachers' confidence in their own teaching ability. Recently, there has been a growing interest in understanding what teachers believe about the nature of knowledge and learning or knowledge acquisition in science (Chan & Elliott, 2004). This is known as epistemological beliefs. Educators want to understand how this belief affects science curriculum implementation, instructional approaches and cognitive processes of thinking and reasoning (Hofer & Pintrich, 1997; Schommer, 1994). When considered together, these aspects of beliefs become important shaping factors in the way that science teaching is conducted and the understanding that develops about students' experiences of learning.

2.4.9 Student learning.

Understanding student learning is an important factor for teachers in science teaching and learning. Students are involved in different learning processes when they attempt learning tasks. The nature of processing obviously influences how learners make sense of information (Loughran, 2010). They take approaches depending on their needs and background (Norton, 2005). From both qualitative and quantitative (Biggs, 1987) studies, two general approaches to learning have been identified: the deep and surface approaches. Biggs (1987) has also identified another type of student learning approach called the achievement approach, and of course there are myriad other learning theories and approaches that have been well argued in the literature (Bloom, 1956; DeBono, 1992; Gardner, 1983).

The surface approach is one in which the main intention of the student is to complete the task requirements (Norton, 2005). In this case, students treat the task as an external obligation and concentrate on discrete components instead of integrating the ideas. Therefore, increasing knowledge, memorising and in some cases acquiring facts and learning conceptions are linked to the surface approach of learning. In contrast, through the deep approach, the student concentrates on the meanings about that which they are learning (Norton, 2005; University of Technology Sydney[UTS], 2006). In this case, students adopt more of a constructivist approach to learning, that is, they try to connect the new knowledge with their previous knowledge and experience. They examine the logic of the argument in their learning and in so doing, abstract meaning in order to interpret and understand the reality and the associated changes through learning the particular conception.

In the achievement approach, students enhance their personality and self value through the return they get from their learning (UTS, 2006). They are looking for high scores and other rewards. In this approach, first of all, students try to identify the assessment criteria of a particular unit. Then they estimate the learning effort required to obtain a good grade. They also follow a particular schedule to control the time. Actually students can take the achievement approach along with either the deep or surface approach; in fact there is likely a mixture of all three occurring in individuals depending on their intentions for learning as determined by the task at hand.

Students' learning approaches also depend on the nature of the teaching strategies (James & McInnis, 2001). The point being that a well designed teaching approach can lead to enhanced student learning and that is what science teaching in schools ultimately is meant to achieve, so a consideration of all of these issues matters in thinking carefully about what it might mean to introduce new ways of thinking about science teaching and learning in a developing country such as Bangladesh. However, change involves more than this alone, the ways in which change is supported also matters and it has been suggested that Professional Learning Communities have an important role to play in that regard.

2.5 Professional Learning Communities

2.5.1 Introduction to PLCs.

Professional learning communities (PLCs), in general, focus on the process of learning for improvement and change in schools (Alberta Education, 2006; Kruse, et al., 1994). These communities also commit to fundamental changes in teaching practice (Kruse, et al., 1994). They endeavour to come to grips with queries associated with the what, when and how for learning to take place.

A PLC consists of a group of people who take “an active, reflective, collaborative, learning-oriented and growth-promoting approach toward both the mysteries and the problems of teaching and learning” (Mitchell & SacKney, 2001, p. 2). A PLC is also defined in terms of an “educator’s commitment to working collaboratively in ongoing processes of collective inquiry and action research to achieve better results for the students they serve” (DuFour, et al., 2008, p. 14). In essence, a PLC is explicitly a place where caring, responsible people nourish others’ learning in the context of authentic interactions (Manzaro, 2003; Miller, 2000). Authentic interactions usually take account of “openly sharing failures and mistakes, demonstrating respect and constructively analysing and criticising practices and procedures characterised by collegiality” (Alberta Education, 2006, p. 3). In most cases, participants involved in a PLC become more intellectually mature and responsible for their learning. They like to develop the capacity to care about the learning of their peers and are focused on collegiality and professionalism (Manzaro, 2003).

PLCs work to broaden understanding of the interactions and relationships that exist within schools. The impact of those interactions and relationships on learning among its participants is crucial (Alberta Education, 2006). However, community structures, relationships and the nature of individuals within a community are also important to expand understandings of ways in which community members can work collectively to facilitate school change and improvement. There is increasing consciousness about the need to better articulate change, reform and improvement initiatives around the context of improved of learning within such learning communities. At the same time, the expressions of individuals’ aspirations, building their awareness and developing their capabilities together is also important (Senge, 1990). PLCs then can be viewed as supportive organisations for schools that allow them to continually remake themselves through their own internal capacity (Morrissey, 2000).

In general, members of a PLC need access to collaboration, continuing leadership support, information and their colleagues (Roberts & Pruitt, 2003). Clearly then, a highly directive leadership style and a lack of meaningful opportunities to engage in learning activities can limit the capacity of schools to become learning organizations (Lashway, 1997). Research indicates that the nature of schools as organizations typically do not encourage shared thinking; rather, teachers are generally free to make their own instructional decisions (Roberts & Pruitt, 2003). Moreover, teachers' isolation, lack of time, and the complexity of teaching presents barriers to their continued professional learning (Lashway, 1997). However, school based professional learning communities can support and motivate teachers and encourage them to overcome problems associated with a lack of resources, isolation, time constraints and other obstacles they commonly encounter (Kruse, et al., 1994). PLCs offer teachers the possibility to connect with one another within and across the school in order to improve students' learning outcomes and their own professional learning (Roberts & Pruitt, 2009).

2.5.2 Emergence of PLCs.

In the 1980s, as a part of the change and reform process in schools, educators focused on accountability, collaborative environments and teacher efficacy for creating schools as learning communities rather than adhering to the traditional model of education in developed counties (Alberta Education, 2006; Hord, 1997). Within a traditional model, teachers typically practised in isolation from their colleagues (Easton, 2009). For the majority of the school time teachers find themselves busy with students' activities. On the other hand, within a PLC teachers find ways to provide time to interact with their colleagues about students' problems and they reflect critically and continually upon their practices. This approach to transforming schools into learning communities can of course also pose some significant challenges for educators (Roberts & Pruitt, 2003). Among them, Rosenholtz (1989) focused on teachers' workplace factors and discussed teaching quality, maintaining that teachers who felt supported in their own ongoing learning and classroom practice were more committed and effective than those who did not receive such conformation. Support by means of teacher networks, cooperation among colleagues, and expanded professional roles, he argued, increased teacher efficacy in meeting students' need.

Rosenholtz emphasised teachers' own efficacy in adopting new classroom behaviours. McLaughlin and Talbert (1993) authenticated Rosenholtz's findings and recommended that teachers develop and share their knowledge and experience through collaborative inquiry and the related learning outcomes derived of such opportunities. Darling-Hammond (1996) stated that shared decision making was a further factor in the transformation of teaching roles in some schools. In that case, working together to plan instruction, observing each other's teaching practice and sharing feedback were considered to be significant. Educational researchers then started to look more closely at the nature of change and reform in the educational setting. In particular, Peter Senge's (1990) book "The Fifth Discipline" influenced the understanding the nature of a learning organization. According to Senge (1990) learning organizations are:

> … where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning to see the whole together. (p.3)

The fundamental justification for such an organisation is to work better for people who are flexible, adaptive and productive (Senge, 1990). Senge's learning organizations involve the five key disciplines of organizational learning: personal mastery; building shared vision; mental models; team learning; and, systems thinking. Learning organizations have parallels to the ways that current literature conceptualises professional learning communities.

Alberta Education (2006) also sought to examine key understandings for a PLC approach. The following summary offers a synthesis of the features of PLCs that draws on and adds to the key features:

- PLCs adopt constructivist approaches to learning that allow for deep advancement of knowledge characterised by reflection and exploration. The continuous learning process involves teachers engaging in conversations about the challenges for teaching and learning, relationships, structures, functions and assumptions that are part of the organizational climate (Easton, 2008; Thiessen & Anderson, 1999).

- PLCs are successful because they help to build capacity for leadership, learning and growth. PLCs operate under the assumption that the key to improved learning for students is continuous, job-embedded learning for educators (DuFour, et al., 2008; DuFour & Eaker, 1998).

- PLCs emphasise the learning process of teaching and recognize and respect the professional knowledge embedded in their practice. They respect the principles of adult learning and provide relevant and meaningful professional development activities (Smylie & Hart, 1999).

- PLCs are themselves an impetus for change that is focused on the improvement of teacher quality and student learning, growth and achievement (Morrissey, 2000).

- PLCs provide a true collaborative culture (not just for specific project or events), through which teachers get moral support and collective strength to set priorities among all the demands they face (Hargreaves, 1994).

- PLCs emphasise collegial learning for that is the common purpose of a community working to increase its effectiveness (Hord & Sommers, 2008).

2.5.3 Attributes of a PLC.

The research-based literature on the attributes that characterise PLCs has grown up over the last couple of decades and much of that literature centres on Hord's (1997) research-based characteristics of PLCs and the work of Dufour and Eaker (1998). At the same time, PLCs have also been influenced by Senge's (1990) notion of learning organisation and culture. The other significant contributions have been that of Kruse, Louis and Bryk (1994), Berlinger-Gastafson (2004) and Patterson and Rolheeiser (2004). The Annenberg Institute for School Reform (Annenberg Institute for School Reform, 2003) and Alberta Education (2006) also worked toward system wide reform and change initiatives. The following section discusses this literature in more detail.

2.5.3.1 Supportive and shared leadership capacity.

Supportive and shared leadership capacity is one of the attributes that characterise professional learning communities (Annenberg Institute for School Reform, 2003; Berlinger-Gustafson, 2004; DuFour & Eaker, 1998; Hord, 1997; Kruse, et al., 1994; Patterson & Rolhiehieser, 2004; Senge, 2000). Shared leadership capacity empowers all members of a PLC to share in support of school improvement. One of the five key disciplines identified by Senge (1990) for a learning organisation, personal mastery, is aligned with this supportive and shared leadership capacity. According to Senge (2000), personal mastery involves a coherent image of personal vision for expanding personal capacity. It is seen as a special kind of proficiency.

One of the defining characteristics of a PLC is that of power, authority and decision making as being both shared and encouraged (Hord & Sommers, 2008). It is common practice that both principals and individual teachers find it difficult to share power and authority within a school. It is also a common understanding that teachers find it difficult to propose any new ways of thinking and doing when the school or head of the department/principal is viewed as unwilling to share power. However, PLCs are places where both the principal and teachers are learners and distributed leadership positively impacts the situation (Hargreaves & Fink, 2006). Moreover, Kleine-Kracht (1993) emphasised the need for everyone to contribute to teaching for teachers, learning for students and managing for administrators within PLCs. Importantly, sharing decision making with others in the school and determining the boundaries for such sharing matters for understanding the parameters within which involvement in decision making is performed (Hord & Sommers, 2008).

Shared leadership structures are important in PLCs. Hord (1997) emphasised shared leadership structures in which participants in PLCs have the ability to question, investigate and seek solutions for school improvement. Barth (2006) described a culture of collegiality for developing this attribute where participants share with others about their practice; share their craft knowledge; observe others' practice and investigate for one another's success. Intrator and Kunzman (2006) commented that participants need to "feel from their soul" in order to address and explore their problems with their colleagues in turning a typical school into a culture of collegiality. Moreover, Kruse, et al. (1994) identified supportive leadership as one of the necessary human resources for school-based PLCs. They suggested that supportive leadership "needs to keep the school focused on shared purpose, continuous improvement and collaboration" (p.5). They also focused on teachers' empowerment and school autonomy for supportive leadership.

Flexibility of participants in PLCs is also important in allowing them to respond to the specific needs they see. In essence then, they are able to guide themselves by the norms and beliefs of the PLC rather than be guided by any specific rule. Berliger-Gastafson (2004) emphasised collegial and facilitative participation of the leader of the school. She encouraged participation without dominating power. The Annenberg Institute for school reform (Annenberg Institute for School Reform, 2003) also focused on the development of internal capacity for supportive and shared leadership. This included sharpening skills in communication, group-process facilitation, inquiry, conflict intervention, and reflective dialogue.

2.5.3.2 Shared mission, vision, values and goals.

PLCs work as a solid foundation consisting of collaboratively developed and widely spread mission, vision, values and goals (DuFour & Eaker, 1998). Shared mission, vision, values and goals are also considered as a collective focus on and a commitment to student learning (DuFour, et al., 2008; Hord & Sommers, 2008; Kruse, et al., 1994). When schools work as PLCs, teachers find themselves with a fundamental responsibility for their students' achievement. To attain this shared purpose, participants are encouraged to be involved in the process of developing a clear and compelling vision that works as a guidepost in decision making about challenges they face in schools on how their collaboration must contribute to their students' learning. They ultimately build collective commitments that clarify the responsibility of individual teachers' contributions to their students' learning. They use their result-oriented goals which include different indicators, timelines and targets to mark their progress towards their shared mission. In essence, this foundation of shared mission, vision, values and goals are unswerving commitment of the participants involved in PLCs where values are embedded in day-to-day actions (Berlinger-Gustafson, 2004; DuFour, et al., 2008; Hord, 1997).

Senge (2000) also emphasised mutual purpose to nourish a sense of commitment. The practice of shared vision fosters shared mission that simultaneously fosters authentic commitment rather than conformity. This view is similar to that of shared norms and values as defined by Kruse et.al (1994) who also considered trust and respect as a social and human resource in a PLC. Therefore, respect, trust and a shared wisdom of devotion combine to build professional commitments. Together, these ultimately guide change through a reculturing together in concert with a meaningful focus (Patterson & Rolhiehieser, 2004).

2.5.3.3 Collective learning and its application.

A PLC is a place where participants find opportunities to study together and work collaboratively (Hord & Sommers, 2008). Teachers expect that all students can learn at reasonably high levels as a consequence of their collaborative work. In practice, it does not happen due to different types of obstacles that students face outside the teaching institution. However, these opportunities help them to be involved in a continuous learning process and apply what they have learned to their practice. Such a collaborative process mainly emphasises the need to seek new knowledge collectively (Hord, 1997). It is an expectation through this collective learning that an individual learns more than if they were learning independently. This collective learning is the "process of aligning and developing the capacities of a team to create the results its members truly desire" (Senge, 2000, p. 236). In this case, groups interact to transform collective thinking and learning for mobilising an individual's energy (Senge, 2000) and action to achieve common goals (DuFour & Eaker, 1998; Senge, 2000). The ultimate purpose of teaching is to promote collective learning that when implemented with students will lead to continual learning from both inside and outside the classroom (Jalongo, 1991).

Learning and reflection on practice are also considered two very important aspects of collective learning (Hord & Sommers, 2008). Teachers like to base their learning on collegial inquiry and their dialogues about their reflections because, ultimately, they help them to pay attention to ways of improving their instruction by focusing on student learning. For teachers, it has been suggested that attention may need to be devoted to learning new teaching strategies, new curriculum, and assessment policies (Berlinger-Gustafson, 2004; Hord, 1997; Hord & Sommers, 2008) as well as a need to explore where learning genuinely occurs, i.e., is it from their school colleagues, colleagues from other schools or an external consultant? There may also be a need to plan for collaboration to incorporate the new learning into practice in order to revise, strengthen, change or continue the agreed new approach. In essence, participants find reflection, learning and assessment of effects as being continuous if new approaches are to be implemented and impact student learning (Hord & Sommers, 2008).

A strong PLC encourages teachers to work together to develop relationships within the community through their collective learning (Kruse, et al., 1994). These relationships ensure that they share, observe and discuss each other's teaching methods and philosophies. They also ensure content-based, outcome-focused experiences and ongoing opportunities for learners to increase subject matter knowledge (Annenberg Institute for School Reform, 2003; Kruse, et al., 1994). This can be done either to develop shared understandings of students, curriculum and instructional policy or to produce materials and activities that improve instruction, curriculum and assessment for students. Within the community, teachers can produce new and different approaches toward their own development, not least by examining current research.

Socialization is also considered an important factor in collective learning (Kruse, et al., 1994). This, in particular, is very important for how a newly recruited teacher might adapt to the vision of a school. Staff need to communicate a sense that all new members of PLCs are a productive part of a meaningful collective. The new members need to know what they should learn for the wellbeing of a community. They are encouraged by some behaviours and at the same time have to discourage others within a school culture.

2.5.3.4 Shared personal practice.

Just like students, teachers need appropriate environments for their professional learning (Hord, 1997, 2004). Such environments value and support "hard work, the acceptance of challenging tasks, risk taking, and the promotion of growth" (Midgley & Wood, 1993, p. 252). Shared personal practice is one of the attributes that contributes to the development of such a setting for teachers' professional learning and sensibly can be considered as one of the conditions that supports a professional learning community (Hord, 1997; Pickering, et al., 2007).

In PLCs, members of the community discuss the situations and the specific challenges they face in their daily academic activities (Kruse, et al., 1994). They develop a set of shared norms, beliefs and values that form a basis for action (Hord, 1997, 2004; Kruse, et al., 1994). For this purpose, teachers review each other's practice

(Hord, 2004) and behaviour (Hord, 1997, 2004; Kruse, et al., 1994) in their daily practice. There is a focus on a "peers helping peers" process (Hord, 2004, p. 11), not on any evaluation of teachers' learning or teaching (Hord & Sommers, 2008). Teachers conduct this review through visiting each other's classrooms on a regular basis to observe, write notes, discuss their observation with their visiting peers, as well as through staff meetings and specifically designed planning sessions (Hord, 1997, 2004; Patterson & Rolhiehieser, 2004).

In the above stated process, teachers act as a "change facilitator" for individual and community improvement (Hall & Hord, 1987; Hord, 2004; Patterson & Rolhiehieser, 2004; Roberts & Pruitt, 2003). Change facilitators encourage, support and participate in strategies that allow teachers to plan together and to talk with one another about their work (Morrissey, 2000). At the same time, the process depends on mutual respect and trust among members (Hord, 2004). Such trust and respect is also considered as fundamental for sustaining a learning community (Hord, 1997; Patterson & Rolhiehieser, 2004). According to Patterson and Rolhiehiser (2004), trustworthiness makes teachers feel safe and makes discussions more open and productive. However, these are considered as the last dimensions to develop in a PLC because of the lack of trust and history of isolation most teachers have experienced (Hord, 2004; Hord & Sommers, 2008).

The classroom peer observation process, as mentioned earlier, supports teachers in different ways. Although it might be sensitive (Hord, 1997), it has a fundamental purpose of gathering information that teachers can use to learn, reflect on and improve their instructional behaviour (Roberts & Pruitt, 2003, 2009; Sullivan & Glanz, 2000). It fosters a culture in which teachers collaborate, learn from one another, and construct shared pedagogical beliefs and strengths (Roberts & Pruitt, 2003). It helps teachers to identify their needs and to be able to provide support accordingly. It ultimately helps to develop the ability to "reflect-in and on-action" (Senge, 2000, p. 5), where teachers expose their own thinking effectively and make that thinking open to the influence of others. Through collaboration it acts to 'turn the mirror inward' for learning and unearthing internal pictures of an individual's personal activities.

Another purpose of shared personal practice is to support the adoption of new teaching practice. Members help each other to adopt a new teaching strategy through action research, coaching, mentoring, feedback, collaborative and collegial decision making (Alberta Education, 2006; Hord, 2004). In most cases, they use notes for discussion purposes during the feedback. Members also use these discussions to critique themselves.

These critiques can go in several different directions but are mainly focused on subject matter knowledge and the teaching strategies usually employed (Kruse, et al., 1994; Louis & Kruse, 1995). They also examine and question their existing teaching practice (Patterson & Rolhiehieser, 2004). They even encourage debate, agreement or disagreement about their teaching practice (Hord, 1997; Wignall, 1992). This allows for sharing of both failures and successes (Hord, 2004) and for analysing the problem for taking action (Patterson & Rolhiehieser, 2004). This ultimately brings a level of accountability, pressure and support for adoption of teaching practices to the members of PLCs through shared personal practice. The characteristic sharing of understanding and experiences of personal practice is, of course, directed toward improvement of both teaching and professional learning.

2.5.3.5 A commitment to continuous improvement.

School improvement is a part of the overall culture of all school beliefs, values and practice (Alberta Education, 2006). In essence, it emphasises the role of collecting data that establishes a base for decision making, problem solving and inquiry. Two factors are considered important in this case. These are internal support from other members of the community (Kruse, et al., 1994; Louis & Kruse, 1995) and documenting evidence for commitment within the community (Annenberg Institute for School Reform, 2003; Morrissey, 2000). Teachers must have support from the school community if they are to take risks with any new techniques and ideas. This is also a requirement for sustaining any serious and long-lasting change effort in their teaching practice (Kruse, et al., 1994). If that is the case, then teachers feel that they are supported in their effort to learn new knowledge about their profession; new knowledge that helps them to make decisions about problems about, and inquiries into, their teaching practice.

The current focus of learning communities is on documenting evidence of improved practice of teachers (Annenberg Institute for School Reform, 2003). Schools need to develop strategies for documenting how teachers work together in PLCs to improve their collective practice. Teachers work within a learning community to develop a process to identify, collect and analyse specific examples of changes made in their practice. They participate in either grade-level or subject-area meetings, communicating with colleagues about their teaching and learning decisions and practice (Morrissey, 2000). These ultimately impact on the culture, norms and outcomes to show evidence that the professional learning community works to improve teachers' learning experiences. However, a PLC also needs appropriate support to make it successful.

2.5.3.6 Supportive conditions.

Supportive conditions determine "when, where, and how the staff regularly come together as a unit to do the learning, decision making, problem solving, and creative work that characterise a professional learning community" (Hord, 2004, p. 10). These are basically considered as logistics of PLCs (Hord & Sommers, 2008). Kruse, Louis and Bryk (1994), Boyd (1992) and Berlinger-Gustafson (2004) worked to identify several categories that must be met in order for a PLC to be effective. These categories can be grouped in two over-arching categories: (1) Structural and physical factors regarding logistical conditions; and, (2) the Relational factors and human capacities which deals with the capacities and relationships developed across the participants (Hord & Sommers, 2008).

The necessary conditions for physical and structural factors as mentioned by Kruse, et al. (1994) are time to meet and talk, physical proximity, independent teaching roles, communication structures, and teacher power and empowerment. Boyd's (1992) list of physical factors in a context conducive to school change and improvement is similar. These are the availability of resources, schedules and structures that reduce isolation, policies that provide greater autonomy, foster collaboration, provide effective communication, and provide for self development. Berlinger-Gustafson (2004) added that the size of the school is also a physical factor that impacts a PLC.

Time to meet and talk is essential to maintain a meaningful PLC (Berlinger-Gustafson, 2004; Hord & Sommers, 2008; Kruse, et al., 1994). Lack of time is a significant issue for teachers who wish to work together collegially (Hord, 1997). It works both as a barrier when it is not available and a supportive factor when it is present. A proper process with a substantial and regularly scheduled block provides teachers with opportunities to conduct ongoing self-examination and self-renewal. In essence teachers find an opportunity for discussion among small groups with common interests. Different PLCs find different ways to provide opportunities to discuss, however, little substantive change can be accomplished when frequency and regularity is missing (Hord & Sommers, 2008). Together with time, physical isolation also works as a barrier to work collegially (Berlinger-Gustafson, 2004). In PLCs, "open door" (Kruse, et al., 1994, p. 5) policies work better to support teachers to continually observe and discuss what they see.

Teachers, in general, interact mutually within a professional learning community. However, in the classroom, they often work independently. With opportunities to work collaboratively in classes, such as through team teaching or integrated lesson design (Berlinger-Gustafson, 2004; Louis & Kruse, 1995), they can improve on this condition of physical isolation and act in the physical proximity to colleagues. This can enrich subject matter knowledge, teaching strategies and other teaching practices. Besides facilitating a cooperative teaching role, PLCs also offer structures and opportunities to exchange ideas within and across organisational boundaries (Kruse, et al., 1994). A better communication structure provides a network for the exchange of professional issues. At the same time, a PLC demands teacher empowerment and school autonomy through collective action (Berlinger-Gustafson, 2004; Boyd, 1992; Kruse, et al., 1994). These also give teachers the opportunity within a community to voice their specific needs.

The significance of the relational factors and human capacities which are considered social resources in a productive learning community is that they address teachers' enthusiasm to acknowledge feedback and work for improvement (Boyd, 1992; Hord, 1997; Kruse, et al., 1994). According to Kruse, et al. (1994), these resources have five different dimensions. Firstly, members expect respect and trust from their colleagues. Such trust and respect, together with a shared sense of loyalty, build professional community. Otherwise, bringing together individuals who do not trust or respect each other is problematic (Hord & Sommers, 2008). Secondly, members support each other in taking risks and in their efforts to learn new knowledge. Thirdly, members help marginal or ineffective teachers improve based on sharing their expertise, knowledge and skills. Fourthly, leadership focuses on shared purposes, continuous improvement and collaboration and learning about these through social as well as professional interaction. Getting to know each other on a personal level sometimes contributes to collegial attitudes and relationships. Lastly, the school culture influences the learning community to encourage some behaviour and discourage others, in a daily process aimed at working toward the school mission.

In most cases, according to Boyd (1992), these two dimensions (stated above) are extremely interactive and have an influence on each other as they contribute to students' learning. Boyd & Hord (1994) grouped these factors into four major functions that help develop a situation for change and improvement. These functions are: reducing staff isolation; increasing staff capacity; providing a caring and productive environment; and, improving the quality of the school program.

2.5.4 Framing PLCs.

The idea of improving schools through developing professional learning communities is becoming more and more popular. In one sense, PLCs are everywhere. DuFour, Eaker and DuFour (2008; 2005) who are the leaders in this area of shaping the idea of PLCs identified three big ideas, these ideas are:

Ensure that students learn: The fundamental purpose of school is to ensure all students learn at high levels. The future success of students depends on the extent to which teachers within a school prepare themselves to act in order to achieve that fundamental purpose. A commitment is needed for each individual teacher that is based on a question of doubt. To ensure their commitment teachers must align all practices, procedures, and policies in light of that fundamental purpose.

A culture of collaboration: A culture of collaboration is essential for a school to achieve its fundamental purpose. It is not possible to achieve the fundamental purpose if teachers work in isolation. They have to work together and have to take collective responsibility to improve their own practice in order to ensure learning at a high level.

A focus on results: Results work as a criteria to judge the effectiveness of professional learning communities. Focusing on results means collecting evidence of any change after implementing any effort in collaboration. Schools need a policy to maintain an ongoing systematic monitoring process to gather evidence. The evidence is then used to focus on individuals' difficulties, to bring up to date individual and collective practice for a commitment to continuous improvement.

2.5.5 Learning through classroom observation within a PLC.

Teachers who are committed to improving their teaching practice consider their students' learning at the core of their instructional plan (Roberts & Pruitt, 2003, 2009). They like to be involved with their colleagues to improve their strategies. This includes discussing instructional issues, sharing ideas, observing one another's teaching and making plans to support their students with meaningful content and authentic learning activities (Roberts & Pruitt, 2009). The opportunity for observing each other's classes provides teachers with constructive feedback from their peers.

It is very important to participant teachers individually and collectively that the purpose of classroom observation is to support their practice. It is not for collection of evidence for critique or evaluation of their teaching. According to Roberts and Pruitt (2009) classroom observation helps peers to collect evidence to critically analyse and work toward improving teaching practice. This ultimately helps teachers to learn about, reflect on and improve their instructional practice. Sergiovanni and Starratt (2007) argued that, the peer classroom observation processes help teachers to construct a shared pedagogical belief and strength as well as foster a culture in which they collaborate and learn from one another. In essence, the outcome helps to build a community and a culture of collaborative instruction that enhances teaching and learning.

2.5.6 Cultural shift through activities within a PLC.

All schools have their own culture. These cultural norms exert a powerful influence on how people think, feel and act (DuFour, et al., 2008). The school culture influences the life and learning of its members (Barth, 2001). Making a cultural shift is important for organisational improvement rather than its structural changes (DuFour, et al., 2008; Eaker, et al., 2002). It is easy to make a structural change in a school; however, it is difficult to make a cultural change which is less visible.

The school culture influences teachers' cultures of professional practice. DuFour, Eaker, DuFour, and Many (2006) cited some of the cultural shifts in teachers' practice regarding: purpose; students' responses; teachers' work; focus of daily activities; and, approaches to professional development. Carroll, Fulton, Yoon, Irene, & Lee (2005) also highlighted the paradigm shift that moves teachers into practice based on PLCs. Table 2.1 (below) lists some of these shifts for the culture of professional practice as expected in terms of Bangladeshi secondary science teachers.

Table 2.1

Cultural shift of professional practice in a professional learning community

From Focus on Teaching	**To Focus on Learning**
Emphasis on what was taught.	Fixation on what students learn.
Individual teachers determining the appropriate response.	Systematic response that ensures support to every student.
Remediation.	Intervention.
Fixed time and support for learning.	Time and support for learning as variables.
Isolation.	Collaboration.
Individual teacher clarifying what students must learn.	Collaborative teams building shared knowledge and understanding about essential learning.
Individual teachers attempting to discover ways to improve results.	Collaborative teams of teachers helping each other improve.
Privatization of practice.	Open sharing of practice.
Decisions made on the basis of individual preferences.	Decisions made collectively by building shared knowledge of best practice.
External focus on issues outside of the school.	Internal focus on steps the teachers can take to improve the school.
Focus on input.	Focus on results.
Independence.	Interdependence.
Language of complaint.	Language of commitment.
Depend on external training (workshops and courses).	Depend on job-embedded learning.
Expectation that learning occurs infrequently (on the few days devoted to professional development).	Expectation that learning is ongoing and occurs as part of routine work practice.
Learning individually through courses and workshops.	Learning collectively by working together.

2.5.7 Benefits of PLCs.

The benefits of PLCs are well established in the literature. According to Hord (1997, 2004), involvement in PLCs helps to reduce isolation and encourages collaborative cultures between teachers. It also mobilises teachers in making major changes in how they interact with their colleagues in school. This process leads to increasing conversations between colleagues to demonstrate a higher commitment to their vision, mission, values and goals. In addition teachers find opportunities to gain deeper understandings and meaning related to their content area and to the overall curriculum in the school.

PLCs also increase efficacy and collective responsibility of teachers (Hord, 2004; Louis & Kruse, 1995). Teachers in a PLC demonstrate higher confidence as they support each other, which leads them to feel renewed and inspired professionally. Moreover, PLCs also help to develop greater commitment to change and increase participation in decision making through increased leadership capacity among all participating teachers. PLCs interconnect communities of practice through ongoing development and continuous improvement through change in classroom pedagogy (Louis & Kruse, 1995; McLaughlin & Talbert, 1993; Mitchell & SacKney, 2001). As a whole, PLCs engage educators at all levels in collective, consistent, and context specific learning. Moreover, in order to achieve the desired student learning outcome, Hord and Sommers (2008) outlined the relationship between professional learning of teachers and the student learning through a ‘backward map’ (p. 19) (see Figure 2.1 below).

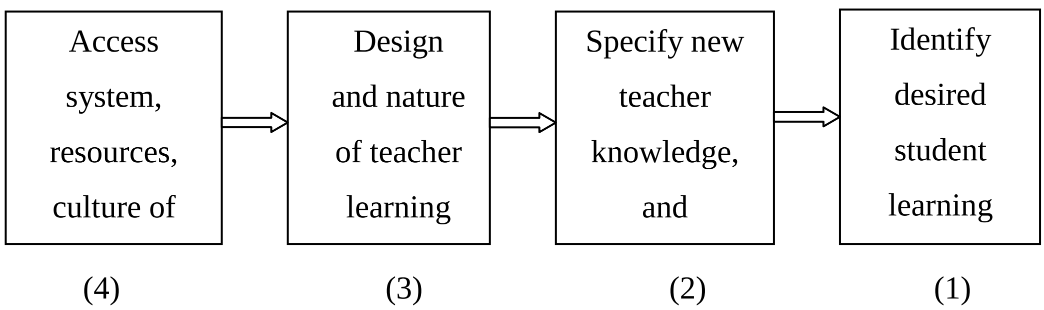

Figure 2.1: The relationship between professional learning and student learning

Source: (Hord & Sommers, 2008)

This backward map reflects the view that the PLC is focused on teachers' professional learning in order to enhance student learning. According to this theory of change, it is necessary to specify the desired student learning outcomes. Teachers then design and give attention to their professional learning in PLCs. Their learning is then supported by the resources and access to the system of the school in order to develop a culture of collaboration.

2.5.8 Challenges in participating in PLCs.

Every existing system has a well-entrenched structure and culture already in place. Members within a school typically resist change and fight to preserve the same status (DuFour, et al., 2008). They also identified three major challenges in developing PLCs, these are: developing and applying shared knowledge; sustaining the hard work of change; and, transforming school culture. Beside these challenges teachers have assumptions which work as dilemmas when involved in a PLC, which include: learning for all vs. teaching for all; Collaborative culture vs. teacher isolation; collective capacity vs. individual development; focus on results vs. focus on activities; assessment for learning vs. assessment of learning; widespread leadership vs. charismatic leadership; and, self-efficacy vs. dependence (DuFour, et al., 2005). It has been noted in the earlier sections that it is not necessary to wait for a perfect situation to start a PLC, however, participants need to be ready to confront these dilemmas through the process of participating in a PLC in order to move forward. Church and Swain (2009) argued strongly the need for such confrontation if serious participation in a PLC is to occur. Moreover, they also considered finding evidence to understand whether the progress to learning goals was achieved.

2.6 Chapter Summary

This chapter has discussed different literature regarding issues underpinning this study. The literature pertaining to science education and the influence of teaching learning on the secondary science teaching has been discussed. Special attention has been paid to literature on science education in developing countries to supplement the lack of adequate literature for Bangladesh itself. The last section of this chapter discussed issues regarding PLCs and was designed to demonstrate how the different attributes of PLCs support teacher learning which is important in order to change school cultures with a view to improve practice and enhancing students' learning.

This thesis uses ideas based on a PLC to implement an approach to teaching science for quality learning in ways that are designed to confront the myriad of issues outlined through this literature review. The intervention created for this project is based on a constructivist approach to learning embedded in teaching for conceptual understanding in ways not currently common in Bangladesh. The intervention is then supported through attempting to develop PLCs to encourage and help teachers improve their practice and therefore enhance their students' learning of science.

Chapter Three
Method

3.1 Introduction

This research set out to explore two basic aspects of secondary science teaching in Bangladesh. One was to guide participant teachers in changing their traditional teaching approach through the use of a concrete example of a new teaching approach. The intention being that through that process they might re-think their understandings of practice and make a shift from their traditional ways of science teaching. The second was to assist participant science teachers to change the culture of their existing professional practice. The intention for this change in the culture of professional practice was based on a desire for teachers to have more conversations with their colleagues within and across the school in order to develop a learning community with the hope that through their professional learning their science teaching might improve.

To address and explore both of these aims, I selected a constructivist teaching approach (POE) to use as an intervention with participant teachers in an attempt to ascertain if it could influence their thinking and lead to a change in their traditional teaching of science content. Simultaneously, I allowed all participant teachers to be involved in conversations regarding critique and challenge of their colleagues' lessons in ways that were also not a part of their regular culture of professional practice. The explicit intention being that through these collaborative ways a professional learning community might be developed through which their own professional learning might lead to improvements in their science teaching practice.

The following sections of this chapter addresses the research approach developed for this study and presents the research design in detail.

3.2 Research Questions

The following research questions offer one way of thinking about how to map the terrain of science teaching in the junior secondary level in Bangladesh.

1. What are secondary science teachers' views about their practice and their students' learning of science?

2. What issues appear to impact these views?

3. How does learning about constructivist teaching approaches influence teachers' thinking about their practice and their students' learning of science?

4. How can establishing a Professional Learning Community influence the ways in which these teachers learn about, and develop, their practice?

3.3 Research Design

A research design concerns a plan involving several decisions associated with carrying out that research (Creswell, 2009; Robson, 2002). The following briefly considers the philosophical worldview that influenced this research design, the strategies of inquiry related to that worldview and the specific methods or procedures that were employed for the study that comprises this thesis.

3.3.1 Philosophical worldview.

A worldview is a general orientation of the world and the nature of the research that a researcher holds (Creswell, 2009; Mertens, 2010). It is also considered as "all-encompassing ways of experiencing and thinking about the world, including beliefs about morals, values and aesthetics" (Plano Clark & Creswell, 2008, p. 33). These philosophical ideas have an influence on the practice of research and help to make it explicit. For this study, I chose a 'Social Constructivist' worldview. According to this worldview, every individual has their own understanding or meaning directed toward a certain phenomenon. This understanding or meaning may be subjective and be varied and multiple (Mertens, 2005, 2010; Schwandt, 2000). The hegemony of social constructivism is to negotiate this subjective meaning of individual understanding socially, culturally or historically. Therefore constructed knowledge is continually tested and modified in the light of new experience. This knowledge construction and interpretation does not occur in isolation.

The main purpose of this research was related to developing a deeper understanding of an attitude of collaboration and sharing among science teachers through a change in their existing perceptions of teaching and their culture of professional practice. In so doing, I used an intervention (see section 3.4) that provided opportunities for participant teachers to interact with others within the research cohorts in this study.

3.3.2 Strategies of inquiry.

Detailed knowledge about different strategies in research is important for any investigation. It helps to understand and have insight into different methods before planning an investigation (Bell, 2005). These research strategies can be quantitative, qualitative or a mixture of both qualitative and quantitative components in an integrated design. A strategy of inquiry then provides specific direction for the procedure in a research design (Creswell, 2009). This study followed a mixed method research design with a mixture of both quantitative and qualitative approaches. An individual research method might have different strengths and weaknesses. However, a mixed research design allows a better understanding of a research problem than either qualitative or quantitative data alone (Creswell, 2008; Plano Clark & Creswell, 2010). Moreover, it is also important to consider the fundamental principal of the mixed method research, which results in the mixing with complementary strength and non-overlapping weakness (Johnson & Christensen, 2008; Teddlie & Tashakkori, 2003, 2010). In this study, one type of research strategy was not enough to address the prevailing situation or to answer the research questions. Therefore through a combined quantitative and qualitative data approach, a very “powerful mix” emerged (Miles & Huberman, 1994, p. 42) that helped to shed light on the research problem and provide answers to the research questions in an appropriate fashion.

A mixed method design can incorporate both quantitative and qualitative approaches within the same phase or across two stages in the research process (Creswell, 2008;

Johnson & Christensen, 2008). In this study, I used both quantitative and qualitative research strategies concurrently. The research design of this study was based on four broad research questions (outlined above). The first question (RQ1) is related to secondary science teachers' views about their practice and their students' learning of science. The second research question (RQ2) is concerned with issues that appear to impact these views. The third question (RQ3) involves how learning about constructivist teaching approaches might influence teachers' thinking about their practice and their students' learning of science. The fourth question (RQ4) is related to how establishing a Professional Learning Community might influence the ways in which participant teachers learn about, and develop, their practice.

To address RQ1 and RQ2, I conducted a baseline survey through the use of a general questionnaire (a quantitative focus with some open ended questions) followed by a semi structured interview. The main purpose of a survey design is to describe trends in attitudes, opinions, behaviours or characteristics in large populations of individuals (Burns, 1994; Creswell, 2008). Both the questionnaire and interview have advantages and disadvantages (Johnson & Christensen, 2008). In terms of advantages, the questionnaire helped me to get a broad view (Gall, Gall, & Borg, 2007) of the science education situation at the secondary level in Bangladesh. However, it is difficult to probe deeply into respondents' trends in attitudes, opinions, behaviours or characteristics using a questionnaire only. In this case, the responses from interviews enabled me to complement the questionnaire data on science teachers' perspectives in detail with further information to help me better understand or unpack how they confronted problems regarding their current practices (Gall, et al., 2007). To answer RQ1 and RQ2 I therefore employed both the quantitative focus baseline questionnaire and a semi structured interview that ensured a concurrent mixed method strategy of inquiry for this study (all instruments and protocols are outlined in detail in latter sections of this chapter).

To address RQ3 of the study, I used a series of interventions. I employed a quantitative focus (with an open ended comment box after each section) classroom observation schedule for providing teachers' reflections from their notes after the classroom teaching. The changes of reflection on classroom schedule over the teaching sessions enabled me to better understand how the intervention influenced teachers as a guide to understanding changes in their perceptions of their teaching.

To address RQ4, I used a qualitative strategy of inquiry. The instruments included my field notes as a participant observer in this study from classroom observations as well as from post-teaching discussions and professional workshops; an open-ended post-intervention questionnaire and focus group discussions (FGDs). The questionnaire was designed to help participant teachers reflect on their understanding about the intervention. As this understanding is subjective, varied and multiple, the focus group provided scope to negotiate their subjective meanings, to interact, listen and then negotiate with others, perhaps to reach a consensus about respective issues or disagree about others and to offer a good airing of the issues. Therefore, the focus group was intended as a space for participating science teachers to reconstruct their knowledge in the light of this new experience.

The combination of both the quantitative and qualitative data provided a powerful mix of methods and data that enabled me to more deeply understand how the intervention influenced teachers as a guide to understanding changes in their teaching perceptions and the culture of their professional practice.

3.3.3 Outline of research design.

Phase one in this research was conducted via a baseline survey as mentioned above. This baseline survey included the pilot testing of the general questionnaire; administration of a general baseline questionnaire to science teachers to find a broader view about current science teaching practice at the secondary level and interview selected science teachers to unpack how they confronted their problems regarding their current practice (See Figure 3.1). At the last stage of this first phase, two professional workshops for participating science teachers were arranged to discuss the findings of the baseline survey. In the workshop I presented a summary of the findings from the baseline questionnaire. As participant science teachers at the workshops also took part in the baseline survey, they were privy to the extent to which their own teaching practice was similar to, or different from, the broader views. This approach also provided them with the possibility of developing an understanding for the current status of science teaching at the secondary level. This first professional workshop for this stage ended with an information session for the overall implementation process of the intervention according to the full research plan. The second workshop of the first phase was arranged for the training sessions for use of new constructivist teaching approaches (e.g., POE), and classroom observation schedules (details of these processes are outlined in the section 3.4).

Phase two of this study was conducted using an intervention (see section 3.4 for details). In this phase, both qualitative and quantitative data were collected to develop deeper understandings about the intervention implementation process. As RQ3 is related to an intervention used in this study leading to an understanding of change in science teachers' teaching perceptions and RQ4 is related to change in teachers' culture of practice through an exploration of PLCs, mixed method research offered one way of capturing rich data for this aspect of the study. This aspect of the research investigated how science teachers worked collaboratively to support their learning using a new constructivist strategy as a way of changing their teaching perceptions and engage them in changing their culture within their professional setting and begin to develop a PLC in their schools to share and improve their teaching experiences.

The intervention implementation stage started with combined peer pair classroom observation, reflection on classroom observation schedules and subsequent post-teaching discussions. In this stage, two science teachers from the same school formed a peer pair for classroom observation purposes. Seven such peer pairs worked in this intervention implementation process. In this stage, firstly, all peer pairs conducted 'Teaching session-One' using a constructivist teaching approach (the use of a POE). All pairs followed the same science teaching topics from the junior secondary level. Within each peer pair, one teacher taught while the other observed the peer's full lesson. For example, in peer-A, teacher 1 taught while teacher 2 observed the lesson. Secondly, both the teacher observer and the teacher reviewed their notes individually after the

Baseline survey

Pilot Study:
Pilot testing for baseline questionnaire.

Administered baseline questionnaire:
To find a broader view about current science teaching practice at the secondary level.

Teachers' Interview:
To complement the baseline questionnaire and unpack how they confront their problems regarding their current practice.

Professional workshops:
1. Discuss concerns about current practice from the results of Baseline survey to develop an understanding among teachers for the current status of science teaching at the secondary level.

2. Introduce Researcher's Research plan and conduct training session for interventions and classroom observation schedule.

Duration: 10 weeks

Phase Two: Intervention Implementation Phase

Stage 1

Classroom teaching-One:
One Teacher from each peer pair teaches using constructivist approach (POE), the other teacher observe the class.

Reflection:
Both two teachers reflect on the same classroom observation using the schedule.

Post-teaching discussion:
Discussion based on the reflection; Issues for resources, subject knowledge, pedagogy and classroom learning environment raised and documented.

Stage 2

Professional workshop: One
Discuss documented issues about which they were undecided or were notable for some important reason with all peer pairs from all seven different schools.

Stage 3

Classroom teaching-Two:
Teachers back to teaching and observation as before with a swap of responsibility. Then they continue the same as stage 2 and 3.

Stage 4

Professional Workshop: Two
Discuss same as professional workshop one to refine their ideas about to change teaching perceptions.

Duration: 12 weeks

Phase Three: Impact phase

Professional workshop:
Teachers meet again to discuss the changes and their impact on their current perception of science teaching and understanding of the aspects of professional practice needing further attention.

Post Intervention questionnaire:
Administered to understand the teachers' views of the intervention.

Focus Group Discussions:
Conducted to interact and listen to other colleagues, perhaps to reach a consensus about respective issues or disagree about others and to give a good airing to the issues; reconstruct their understanding.

Duration: 4 weeks

Figure 3.1: Research design for this study

teaching session using the same classroom observation schedule. Thirdly, these individual reflections formed the basis of discussion between both teachers in which they shared, provided feedback and critiqued and challenged each other's observations. At the same time, I took field notes as a participant observer.

When all of the peer pairs had completed the classroom 'Teaching session-One', they came to stage 2 'Professional Workshop-One'. Issues about which they were undecided or were notable for some reason including those that I had recorded as a participant observer during class and post-teaching discussion time for all pairs was considered. I then included all of these as issues to be discussed with the whole cohort of teacher participants for this subsequent workshop after each teaching cycle. At this stage, teachers worked with their science colleagues as a research cohort from nearby schools to discuss together the situation with the aim of improving their practice.

In stage 3 of phase 2, all participant teachers went back to a further round of classroom teaching and observation, 'Teaching session-Two' with a swap of responsibilities within each individual pair, i.e., in peer-A, teacher 2 then taught while teacher 1 observed the lesson. After that, they reflected on their notes using the same classroom observation schedule and then joined the subsequent post-teaching discussion the same as in stage 1. In this stage teachers found scope to apply their learning from the stage 1 and 2 they attended. They also started to construct meaning for the intervention process they were using in collaboration with their colleagues.

Participant teachers met again for 'Professional Workshop-Two' which was Stage 4 of phase 2 to discuss again the issues about which they were undecided or were notable for some important reason as recorded by myself from teaching round two. This workshop also provided them with opportunities to refine their ideas regarding their practice as an initial guide to change their teaching perceptions and the culture of their professional practice. Stages 1 to 4 in this phase constituted a cycle. In this research, I conducted this cycle twice, in order to better understand the intervention and possible changes to teachers' practice.

Phase three of this research was conducted to understand the impact of the intervention process among participating science teachers. The third phase involved another professional workshop to discuss the changes and their impact in their current settings. This was followed by administering an open-ended post-intervention questionnaire to gather in-depth information about change and its impact on their teaching practice. This phase ended with focus group discussions designed to uncover in-depth information about the situation. The focus group discussion was then designed to provide participating science teachers with opportunities to interact and listen to other colleagues, perhaps to reach consensus about respective issues or disagree about others and to give a good airing of the issues. Hence, they found scope to reconstruct meaning from the intervention. I, at the same time, developed field notes for all activities to support better understanding and additional data sets especially during the professional workshop to address RQ3 and RQ4.

3.4 The Intervention

Introducing an intervention may be effective in resolving school changes or problems (Murphy & Duncan, 1997, 2007). As change is a process, not an event, effective change takes time (Fullan, 1982) and substantial value can be gleaned from the efforts associated with an intervention (Robson, 2002). In this study I chose the particular intervention as a process of clarification for participant science teachers of their existing teaching perceptions and their culture of professional practice. Intervention in this research is not a single component but a combination of several components. The intervention combined the following items sequentially:

(i) using a new constructivist teaching approach Predict-Observe-Explain (POE);

(ii) observing colleagues' teaching practice;

(iii) reflecting on classroom observation schedule;

(iv) attending subsequent post-teaching discussion; and,

(v) attending the subsequent professional workshop

Firstly, participant teachers were introduced to a constructivist teaching approach Predict-Observe-Explain (POE) (see chapter 2.4.7) for a full description) which they were expected to use as part of the intervention. This teaching approach was not familiar to them before my introduction. The purposes of this strategy was to help teachers to: change their perceptions about what might be useful in finding out students' initial ideas; provide teachers with information about students' thinking; generate discussion; motivate students to want to explore the concept; and, generate investigations (Palmer, 1995; White & Gunstone, 1992).

Secondly, the peer classroom observation process had as a fundamental purpose the gathering of meaningful information as it was essential that both the teachers and observer learnt from one another through this classroom observation process. The information they gathered from peer observation could then be used to learn about and, reflect on the classroom observation schedule, and improve their instructional behaviour (Sullivan & Glanz, 2000). This ultimately helped them to construct shared pedagogical understandings about a new constructivist teaching strategy.

Thirdly, the purpose of using the observation schedule was to record individual teachers' actions in using a new constructivist teaching approach. According to Johnson and Christensen (2008), noting observation is very important as people do not always do what they say they do. Moreover, the reflection on the schedule served as a basis for the subsequent post-teaching discussion. Fourthly, the purpose of arranging the subsequent post-teaching discussion was to reconstruct the meanings from the classroom observations about different pedagogical aspects. The discussion process also provided participant teachers with scope to construct an understanding about how to change the culture of their professional practice. Finally, attending the professional workshop provided scope to refine understandings through interaction with a comparatively broader community. One of the purposes for arranging these workshops was to raise and discuss issues that were undecided or were notable from individual peer pairs. One of my expectations for the outcome of the professional workshops was that participant teachers might be able to resolve or explain any issues that were listed for discussion in the workshops that persisted in their minds as concerns or unresolved issues.

3.4.1 Learning to use the intervention

Participant science teachers were not familiar with all of the components of the intervention. I therefore needed to introduce these components through organising a training session. The first step was to introduce the POE approach. In that training session I, as a participant observer, demonstrated a teaching session based on the POE approach. As a topic for the POE demonstration I used the scenario of two balls of different weights (same volume) being dropped from the same height. Participants had to predict which ball would hit the ground first and why (I also used this scenario in piloting this study - see section 4.3.2). I then asked them to observe the situation and to reconcile the possible differences between their observation and prediction. I then completed the whole teaching session by summarising the main concepts of the topic.

After my teaching session I provided the teachers with a classroom observation schedule that they used for this study. They read through the schedule and asked questions for clarification. For example, three teachers asked for clarification on the item in the schedule ‘the teacher explained ideas with clarity’. When the teachers had no further questions about the schedule, I requested a volunteer science teacher to trial the teaching approach with the group using the same topic. After the teaching session, all teachers again used the same observation schedule, and noted their reflections. As a group, they shared their reflections on the schedule and discussed how they differed from each other. The training session concluded when the teachers were satisfied that they understood how to use this intervention in their practice.

I also discussed issues and offered responses to any query from teachers at the last professional workshop during the third phase. This was basically for their better understanding of the items in the post intervention questionnaire. Teachers needed to clarify some meanings in relation to that questionnaire.

3.4.2 Selection of science topics for the intervention.

At the end of the training session, teachers were asked to identify topics from their junior secondary science classes which could be suitable to teach using the POE approach as an intervention. From the many topics proposed, a set of criteria was collaboratively developed (the teachers and me) in order to determine which topics would be suitable for selection. The criteria were:

- able to accomplish teaching well using POE approach;

- covers major discipline (Physics, Chemistry and Biology) from General Science;
- covers as many different grades at junior secondary level as possible;
- most teachers have the science class required at any particular level (for example, most have no science class with grade six, so they do not want any content from General Science in grade Six); and,
- each teaching session introduces more complex concepts (i.e., using higher order thinking) than the previous sessions.

Based on the above criteria, the final selection of topics was completed (as outlined in Table 3.1 below). None of these selected teaching topics came from class Six. This was because 8 out of 16 participating teachers did not have any science teaching with class six. All participant teachers agreed that the four selected teaching topics involved higher order thinking.

Table 3.1: Final topics for teaching using the intervention

Teaching session	**Teaching Topics**	**Content Area**	**Target Grade**	**Page on The NCTB text book**
One	The pressure of a liquid	Physics	Grade Seven	22
Two	Saturated and unsaturated solutions	Chemistry	Grade Seven	94
Three	Refraction of light	Physics	Grade Eight	145
Four	Human Brain and its function	Biology	Grade Eight	263

3.5 Instrumentation

A set of instruments was developed to address the research questions of this study. Wellington (2000) pointed out the importance in any research of determining how instruments impact the research questions. Therefore, the list of instruments to be used in this study and their contribution to the broad research questions are outlined in Table 3.2 below.

Table 3.2: The relationship between research questions and instruments in this study

Research question/ Instrument	What are secondary science teachers' views about their practice and their students' learning of science?	What issues appear to impact these views?	How does learning about constructivist teaching approaches influence teachers' thinking about their practice and their students' learning of science?	How can establishing a Professional Learning Community influence the ways in which these teachers learn about, and develop, their practice?
General Questionnaire for base line survey	√	√	√	√
Follow-up interview	√	√	√	√
Classroom observation schedule			√	√
Field notes: Participant observer comments			√	√
Professional workshop notes			√	√
Post workshop questionnaire			√	√
Focus Group Discussion			√	√

The main aspect of RQ1 is to know science teachers' views about their practice and their students' learning of science that will help in understanding the development of any kind of intervention. In this case, the survey questionnaire and the follow up interview provided information about existing teaching practice. These instruments also supported an exploration of RQ2, RQ3 and RQ4. The objective of RQ3 was to understand how a new teaching strategy might lead to change in the teaching conceptions. Basically, in this case, participants' reflections on their classroom observation schedule provided information to answer RQ3. Finally, the intention of RQ4 was to explore how a PLC supported (or otherwise) teachers to learn about constructivist teaching as a meaningful approach to practice in a Bangladeshi school setting. The conversation in post-teaching discussions and professional workshops, notes from the participant observer and responses from the post-intervention questionnaire, discussions from focus groups and the researcher's field notes therefore all contributed to answering RQ4.

3.6 Constructing the Instruments

A range of different instruments was used in all three phases of this study. These included a general questionnaire for the baseline survey, guidelines for follow-up interviews, classroom observation schedule, guidelines for the professional workshop, post-intervention questionnaire, guidelines for focus group discussion and participant observers' comments (field notes). Each of the instruments is discussed briefly in the following section, in terms of how and why they were designed.

3.6.1 General baseline questionnaire.

The baseline questionnaire (see Appendix 1) was designed to elicit the nature of science teachers' existing teaching practice in secondary science classes. The questionnaire focused on their teaching load, views about science and teaching and learning in science. It also attempted to uncover teachers' thinking about subject matter and teaching strategies and the ways of upgrading this knowledge. It also looked to unpack the status of teachers' professional development in terms of the nature of collaboration amongst science teachers. The questionnaire had both open (N= 12) and closed (N= 72) questions some of which I will discuss here. Section A of the questionnaire had five questions aimed at determining teachers' general characteristics regarding their preferences to: teaching (science or math); teaching experience; classes they used to teach; number of science students; and, number of teachers for a particular class and school respectively.

Section B of the questionnaire was designed to understand the teaching load of science teachers. Seven multiple choice questions were set to uncover the overall as well as the specific load for science teaching and how much time they spent in class preparation. Section C was designed to ascertain teachers' views about science and teaching and learning of science. For this section, I chose a Likert scale for a set of questions arranged in a grid form (De Vaus, 2002). The participants were given five alternatives ranging across degrees of agreement to disagreement. These were strongly agree, agree, uncertain, disagree and strongly disagree. There were three sub-sections in this section: science concept; science teaching; and, students' conceptions in science. This section concluded with an open ended question providing an opportunity for teachers to illustrate any alternative conceptions regarding the relevant science concept they may have experienced.

Section D of the questionnaire was for ascertaining aspects of teachers' subject matter knowledge. Firstly, I tried to understand whether teachers experienced any difficulty regarding their knowledge about particular subject matter in science. To accomplish this, I considered a 'semantic differential scale' (Creswell, 2008) with a choice of four degrees of frequency: always; frequently; sometimes; and, never. This was followed by asking how participants updated their subject knowledge. Again I used a semantic differential scale with three choices of frequency: frequently; sometimes; and, never.

The baseline questionnaire was administered in order to elicit data on teachers' teaching strategies and availability of resources as shown in section E. To find out the method that teachers liked to use, I used a semantic differential scale with choices of frequencies: always; frequently; sometime; and, never. In that case, I used the grid form which listed six methods and an option for 'others' in order to ascertain any methods they used for science teaching. This was followed by three open ended questions regarding the influencing factors in planning the lesson. This section concluded with another semantic differential scale with a choice of five degrees of frequencies: not at all; little; some; quite a lot; and, a great deal. The individual sub-section was designed in order to uncover the extent to which teachers shared in preparing lessons, use of different ideas and resources in planning a lesson.

Section F of the questionnaire was designed to map teachers' professional development experiences and the nature of their collaborative work with their colleagues. Firstly, I set two multiple choice questions followed by an open ended question to understand science teachers' participation in professional development programs. After that I used another likert scale for a set of five questions arranged in a grid form to understand science teachers' nature of collaboration in section G. The participants again were given five alternatives in degrees of agreement and disagreement. This was followed by four multiple choice questions to understand whether teachers were involved in collaborative activities or if any learning communities existed amongst them.

3.6.2 Follow-up interview.

A follow-up interview was conducted using a semi-structured, open-ended interview schedule (see Appendix 2). This interview schedule consisted of 14 guided questions and was conducted with 16 science teachers individually. It took around 30 minutes for each interview, with the interviewee's permission, and was audio recorded for later transcription. The Interviewees were given their interview transcript to check. The focus for these interview questions was mainly on problems with resources, teaching load and its relation with: quality teaching; knowledge of subject and pedagogy; teachers' attitudes towards new teaching strategies; teachers' professional development; and, the nature of collegiality among science teachers. The responses from these interview conversations helped me to unpack the existing problems that arose from the responses in the earlier baseline survey questions. The responses also allowed finding in depth information for any particular issues to complement the baseline questionnaire response. For example, the baseline questionnaire helped to understand the teaching load of teachers; however, the interview responses helped to clarify to what extent this load may have had an impact on, or implications for, quality teaching. Sometimes, it was necessary to verify some responses from the baseline questionnaire. For example, I needed to ask questions of teachers during the interviews regarding the nature of collegiality to verify their responses from the questionnaire.

3.6.3 Classroom observation schedule.

The voluntary participant science teachers planned their teaching based on the POE teaching approach. The classroom observation schedule (see Appendix 3) was then developed to help teachers to reflect on their notes and observations individually after each teaching session. This also gave an opportunity to record information as it occurred in settings to individuals who had difficulty in articulating their ideas (Bell, 2005).

The observation schedule comprised four sections: (i) resources; (ii) content knowledge and its organization; (iii) pedagogy; and, (iv) classroom learning environment. Each individual section contained several items of interest from the total of 25 items listed in a grid form. The schedule provided a choice based on three categories in terms of the extent to which the teacher emphasised each of the four sections: did not emphasize; recommend more emphasis; and, accomplished very well for an individual item. For example, when any reflection was recorded as 'recommend more emphasis', the usual meaning was that teachers needed to provide more emphasis on that particular individual item in their teaching.

An open comment section was also provided after each of the sections mentioned above. The purpose for this space was to allow teachers to reflect on any other teachers' observation in using the POE during the class. Both the reflection and open ended comment enabled me to understand the extent to which the intervention engaged participant teachers to learn and then turned this learning to action in order to change their existing perceptions in favour of a constructivist teaching approach. It has been already mentioned that the reflection on the observation schedule also served as a basis and prompt for conversation for the post-teaching discussion.

3.6.4 Professional workshop guidelines.

The workshop guidelines (see Appendix 4) helped participants to be on track while they discussed different issues regarding their practice. I developed a workshop guideline before each of the professional workshops. These guidelines were developed on the basis of issues arising after classroom observation and conversation from the post-teaching discussions. The guidelines consisted of undecided issues during the conversation in post teaching discussions, notable real life examples, anecdotes and examples from the teaching session, exemplary pedagogical aspects from the teaching session, issues about alternative conceptions, and issues about resources from the teaching sessions.

3.6.5 Post-intervention questionnaire.

A post-intervention questionnaire (see Appendix 5) was administered after the intervention implementation process. This questionnaire was designed to gain open ended and descriptive responses from the participants who were involved in the intervention implementation process. Basically, the questionnaire was used to ascertain participant teachers' views regarding the intervention. There were 27 questions regarding different components of the intervention. The questionnaire gathered information to investigate the effectiveness of the PLC in helping teachers to change or develop deeper understandings of their science classroom practices. These included: how participants felt about the intervention; how they benefited from the intervention; whether the intervention influenced them in changing their teaching practice; and, what suggestions they had for the effective use of these intervention components. The questions were designed to elicit participants' experiences with available examples. I allowed two weeks to complete the questionnaire and offered contact with me (via mobile phone) for any further enquiries regarding understanding of items or content of the questionnaire.

3.6.6 Focus group discussion (FGD).

The Focus Group Discussions (FGDs) were designed to examine, in detail, how the participant teachers thought and felt about the intervention. The purpose of these FGDs was to complement the post-intervention questionnaire and allowed participant teachers to reconsider their thinking about the outcome of the intervention. Guidelines for FGD were designed to help focus group discussion in terms of changes in their practices. This information helped me in understanding more deeply about the changes teachers suggested about their practice.

The FGD guideline (see Appendix 6) comprised three main sections. These were content knowledge and teaching strategies, collaborations with colleagues and professional learning community. There were two issues in the guidelines regarding content knowledge in respect to the extent to which the intervention helped participant teachers overcome their difficulties with subject matter knowledge. The next four issues were designed to discuss the constructivist teaching approach which they used as a part of intervention. The four issues in the collaboration section mainly led to uncovering the extent to which the collaborative activities within the intervention guided teachers in becoming more confident in their teaching. The last four issues mainly discussed whether the notion of a learning community had an impact on their science teaching practice.

3.6.7 Participant observer's field notes.

As a participant observer I took notes to explore patterns and themes emerging during the intervention process. I took these field notes (see Appendix 7) during different stages of this study. Field notes taken during the post-teaching discussions and professional workshops were most significant as these helped to shape my understanding of the intervention in particular.

3.7 Sampling

The sampling for this study followed the 'Nested' mixed sampling design (Mertens, 2010; Onwuegbuzie & Collins, 2007). A nested relation means that the participants selected for one phase of the study represent a subset of those participants who were selected for the following phase of the study. In this study, I needed to consider three kinds of sampling to administer the different instruments outlined below.

The necessity for the first type of sampling was for administering the general baseline questionnaire during phase one. This was basically for gathering the general information about science teaching and learning in the secondary schools in Bangladesh. I administered the questionnaire to 174 science teachers (called the 'sample') for this stage. The results of this questionnaire provided me with a broad view of a large group of secondary science teachers ('population' of this study) who were involved in the 'General Science' teaching in junior secondary section (Class VI-VIII).

To select these 174 participants I chose the 'multistage clustered random' sampling (De Vaus, 2002; Johnson & Christensen, 2008) from all six divisions of Bangladesh. More specifically, I chose 10 clusters (UpaZilla), each of two UpaZilla from the larger division of Dhaka, Chittagong, Rajshahi and Khulna division, while each of one UpaZilla from the smaller Barisal and Sylhet division. To access the participants for this purpose, through the Directorate of Secondary and Higher Education, Ministry of Education in Bangladesh, I was granted a general approval letter (See Appendix 11) which accompanied my letter for recruitment inviting participants to complete the questionnaire. To gain easy access to individual teachers, I contacted the local UpaZilla academic supervisors for secondary schools who helped me to find these participants for their own local area.

The necessity for a second type of sampling was to conduct and facilitate the semi-structured interview. The semi-structured interview basically enabled me to complement (Gall, et al., 2007) the baseline general questionnaire data in more detail from participants' perspectives (Creswell, 2008). Therefore, I used 'maximal variation sampling' to select 16 science teachers from participants who completed the questionnaire and considered volunteering to be involved in the follow up study. Here I considered teacher participants who represented a broad age spectrum with diverse backgrounds and experience.

The necessity for the third type of sampling was for the intervention phase of the study. I used 'convenience' sampling from those who volunteered to be further involved in the study. The consideration was based on availability, easy recruitment and willingness to participate in the study (Mertens, 2010; Robson, 2002). Moreover, the nature of the intervention demanded participants from nearby schools within a local area. To fulfil that purpose, I selected seven nearby schools form Ashuganj UpaZilla of Brahmanbaria district of Bangladesh in order to make further involvement easy for participants and to attend the follow up professional workshop. The reasons for selecting schools in Ashuganj were that schools there are very close to each other as it is a densely populated suburb and transport is available for easy communication to attend the professional workshops for teachers. Besides, according to my experience, schools are ranked differently according to achievement at public examination (SSC) for the secondary level in this geographical area. One peer pair of participant science teachers was formed in each selected secondary school and data was collected from seven such schools. Each individual peer pair then followed up through classroom observation, post-teaching discussion and professional workshops to see how ideas from different components of the intervention influenced their science teaching practice.

In the end, I only considered the notion of ‘homogeneous’ sampling to divide the above mentioned 14 participants to form two focus discussion groups. According to Johnson and Christensen (2008), homogeneous sample selection works better on a topic of common interest. Each individual teacher from each pair mentioned above then followed up in a particular focus group discussion grouping. This choice helped me to understand how individual teachers found scope to reconstruct their ideas about the outcomes of using the intervention. Table 3.3 illustrates the composition of the sample that participated in this study.

Table 3.3: Sample for the study

Activity	**In Phase**	**How many people**	**Group of people involved**
General Baseline questionnaire	One	174	Secondary science teachers
Follow-up Interview	One	16	Secondary science teachers
Intervention	Two	14	Secondary science teachers
Post-intervention Questionnaire	Three	14	Secondary science teachers
Focus Group Discussions	Three	14 (7 & 7)	Secondary science teachers

3.8 Ethical Issues

The literature points to the complexity of research involving humans as subjects. It is a requirement of research to ensure that participants are fully aware of the purpose of the research and that they understand their rights (Bell, 2005). It is a major responsibility of the researcher to protect research participants against misconduct and impropriety that might reflect on their institutions (Isreal & Hay, 2006).

I conducted the pilot study to established trust and respect with the participants. This helped me to avoid any marginalisation that was an important ethical issue before conducting my research (See Appendix 10). For data collection in this study, I obtained participants' names from a public domain source and I used an anonymous survey. I had permission from the Directorate of Secondary and Higher Education (DSHE), Ministry of Education, Bangladesh and Monash University Human Ethics Committee for all aspects of involvement in my study with teachers. I provided a photocopy of the approval to all involved participants. I also provided explanatory statements (See Appendix 9) and consent forms (See Appendix 8) to participant teachers. To complete the questionnaire, I asked participants to find a suitable time. For the baseline interview, participants were informed that they would be sought to attend an interview at a time convenient to them. All of these measures helped me to avoid any possibility of 'deception' or coercion (Johnson & Christensen, 2008, p. 116) in my study.

Besides the letter of approval from DSHE, I personally went to talk with the Head teacher of each involved school during the second phase of data collection. I formed the individual peer pair based on their own choice. I also explained to students the purpose of my research before conducting the classroom observations. Students were enthusiastic and participated voluntarily in conducting the research. Moreover, in collecting data, I used the regular schedule of respective teachers rather disturbing their regular settings. For teachers who were observers, they made an arrangement with other science teachers with permission from the Head teacher. For the post-teaching discussion, teachers were happy to use their leisure time. To attend the professional workshop after each teaching cycle, all participating teachers discussed and decided on the time.

In analysing and interpreting results from the data, no participants were identified. The results from all baseline questionnaires were reported as anonymous. For interviews I allocated pseudonyms to all participants. The questions that I asked were not likely to cause distress, all of the questions related to their understanding of science teaching and learning in their own experiences of teaching in Bangladesh. To avoid any embarrassment, I informed them that should they choose not to continue in the project they could withdraw at any time without the need to explain why and if any distress were to occur, referral to appropriate counselling services would be suggested.

3.9 Language and transcription issues

In conducting this research in Bangladesh, I used our official language "Bangla". This was to ensure a better understanding by the science teachers as the medium of instruction in Bangladeshi schools is Bangla (except in a very few schools, likely less than 1%). I developed all research tools basically in English (see Appendix 1-7 and then translated each into Bangla. I did all these translations).

In administering the baseline questionnaire, in most cases, teachers needed to simply place a 'tick' in the appropriate place. In some cases, where words were offered, I analysed from the Bangla responses, and then reported in English. The quotation was then translated directly into English from Bangla. I also conducted the interviews in Bangla and recorded them. I listened to the audio tapes of all the interviews and then transcribed them directly into English. The Interviewees were given their interview transcript to check. My notes as a participant observer developed directly into English from the post-teaching discussion and professional workshops. Teachers also responded to the open ended post-intervention questionnaire and FGDs in Bangla. I then translated all of these responses into English before analysing the data.

3.10 Legitimation

Legitimation or validity (Onwuegbuzie & Johnson, 2006) in mixed method research, is overall a complex concept (Bell, 2005). The usual meaning of validity, whether an item or instrument measures or describes what it is supposed to measure or describe, leaves questions unanswered regarding design, interpretation and conclusions of the research data need to be validated. Sapsford and Jupp (2006) refer to validity as "the design of research to provide credible conclusions: whether the evidence which the research offers can bear the weight of the interpretations that is put on it" (p. 1). They also argued that what has to be established is whether:

> the data do measure or characterise what the authors claim, and that the interpretations do follow from them. The structure of a piece of research determines the conclusions that can be drawn from it (and, most importantly, the conclusions that should not be drawn from it). (p. 1)

The type of legitimation I chose for this research is ‘weakness minimization validity’ (Onwuegbuzie & Johnson, 2006). This type of legitimation offered me the degree to which I combined qualitative and quantitative approaches to have non-overlapping weakness. That is the weakness from one approach is compensated by the strengths from the other approaches. I designed in-depth semi-structured interviews following the survey with a baseline questionnaire to complement any possibility of misrepresenting quantitative data. Also, during the intervention the comments section of the observation schedule and my notes from the discussion helped me to minimize any subjective nuances together with the numeric results. Moreover, for the impact phase, the responses from the FGDs compensated for the responses from the post-intervention questionnaire.

3.11 Data Analysis

In this study, I used a variety of data analysis techniques to address the research questions. The brief summary about how I analysed the data from the different research instruments is presented in the following sections. The details of each data analysis procedure are outlined in the respective chapters in this thesis.

It has already been mentioned that the general baseline questionnaire had both open (N = 12) and closed (N = 72) questions. Basically, it followed quantifying qualitative data approaches. The quantitative data were descriptively analysed for frequency of occurrence using the SPSS Statistics 17.0 software programme. Output frequency tables and Pie/Bar charts were also produced through Microsoft Excel. On the other hand, responses from the open ended questions were coded according to the different themes.

The semi-structured baseline interviews were analysed using NVivo 8 software. This software made it possible to find the responses from different interviewees and code each under different themes in relation to the research questions. After that, codes were assigned by numbers and the number of times codes appeared was able to be developed as numeric data from responses for each category. These two sets of data then helped to understand the current setting for science teaching and learning in secondary schools in Bangladesh.

In analysing the classroom observation schedule I used an analytic framework named 'ARLA'. ARLA means Activity-Reflection-Learning-Action. This is basically derived from analysis ideas of Roberts and Pruitt (2003, 2009) for learning through classroom observation. They discussed learning and then reflected on that learning from the classroom observation process. However, for this study, I analysed how activities in the classroom prompted participant teachers to reflect on their understanding of the observation schedule. The analysis mainly looked at how this reflection changed (both positively and negatively) over the intervention cycles. Participants then found scope to learn through reconsidering their meanings about the interventions that guided their teaching perceptions in collaboration with their colleagues. The analysis then followed the extent to which participant teachers transformed their learning from the intervention process into action. At the same time, themes from my notes and workshop notes complemented the data gathered from the above mentioned analysis.

Lastly, the post-intervention questionnaire and FGDs were transcribed and analysed using NVivo 8. In this case, I again followed the quantifying qualitative data approaches under selected themes. This analysis guided the determination of the key characteristics to identify the changes or deeper understandings of science teaching practice through professional learning. Table 3.4 shows a summary of the relationship between research questions, instrument and data analysis method.

Table 3.4: The relationship of instruments and analysis methods of this study

Research questions	Instrument	Analysis Methods
What are secondary science teachers' views about their practice and their students' learning of science?	General Questionnaire for base line survey	Frequency count with illustrative examples and identify themes and quantify
What issues appear to impact these views?	Semi-structured baseline interview	Identify themes and relevant extract from interview transcription and used quantifying qualitative data approaches
How does learning about constructivist teaching approaches influence teachers' thinking about their practice and their students' learning of science?	Classroom observation schedule	Following ARLA analysis frame Identify themes for open ended comments
	Participant observer's note	Identify themes and relevant extract from participant's observer note
	Professional Workshop Notes	Identify themes and relevant extract from professional workshop note
How can establishing a Professional Learning Community influence the ways in which these teachers learn about, and develop, their practice?	Post-intervention Questionnaire	Identify themes and relevant extract from post-intervention transcription and used quantifying qualitative data approaches
	Focus Group Discussions	Identify themes and relevant extract from interview transcription and the quantifying qualitative data approaches

3.12 Chapter Summary

This chapter has discussed the methodological issues associated with conducting this study. At the beginning, it discussed the research design including the philosophical world view underpinning this research and the rationale for using a mixed method approach for this research. In the following sections it described the instruments, sampling procedures, ethical aspects, language and transcription issues as well as legitimation issues associated with this study. In the last section the method of data analysis was discussed with reference to a framework of action for analysis of improvements in teachers' practice though the intervention used in this study.

Chapter 4
The Pilot Studies

4.1 Introduction

Two pilot studies were carried out before the actual implementation of the research design. The first pilot study was organised as a way of checking the feasibility of a constructivist teaching approach for the full scale study in the classroom situation in Bangladesh. The second pilot study was a trial of the questionnaire which would be used for baseline data acquisition.

4.2 Purpose of Pilot Studies

During the planning of this research project I decided to use a constructivist teaching approach to engage the target teachers in Professional Learning (PL). Through my experience as a teacher educator I found that teachers in Bangladesh experienced problems in engaging students in the learning process. Besides this, I also sometimes found that students had alternative conceptions regarding their science concepts. When I was thinking and searching for a suitable teaching approach that might open up new possibilities for addressing these issues with teachers I found the constructivist teaching strategy POE (Prediction, Observation and Explanation). I then decided to trial the use of POEs as a good strategy for secondary science teaching in Bangladesh. I was of the view that such an approach could help these teachers to engage their students in the learning process in ways that had not previously been recognized or understood. Moreover, I was of the view that the power of the process might help both students and teachers to identify alternative conceptions.

This pilot study was therefore designed to determine the feasibility of the POE strategy and sought the views of participant science teachers about the extent to which the POE strategy worked for them in their classroom setting in Bangladesh. The pilot study was conducted with teachers in the classroom setting as a way of determining how teachers might react to the feasibility of them using a similar approach in their own teaching. On completion of the pilot of the teaching, I conducted a small survey with these participant secondary science teachers to determine their views on the use of the POE approach to opening up students' understandings of science in their classrooms.

For the second pilot study I trialled the baseline general questionnaire. The purpose was to identify any ambiguity in understanding or misinterpretation of any of the questions. In so doing, it allowed me to determine whether or not I needed to translate the questionnaire into Bangla and secondly it helped me to refine the questionnaire to be more readable and understandable for the target secondary science teachers across different districts in Bangladesh. Hence, trialling the questionnaire served two important purposes.

4.3 Pilot Study-1

This section describes the participant selection procedure of this pilot study, the experimental design, the results, the implications for the classroom and overall learning from this pilot study.

4.3.1 Participant selection procedures.

To organise the first pilot study, I invited a total of eight teachers from four different schools (who did not participate in the main study) in Dhaka city. The selection of Dhaka city was purposive for it was convenient to get these teachers together. To find these teachers I first contacted the head teachers of a number of schools. Then I explained my situation and asked to if I could work with two teachers from each school for the purpose of trialling the POE teaching procedure with them. The head teachers talked with their science teachers and were forthcoming with the names and contact details of their science colleagues who volunteered to participate.

The participant teachers taught general science in the junior secondary (Grade VI-VIII) section. They also taught individual science subjects in the secondary section (Grade IX and X). They showed their interest in participating in the workshop willingly. It was during the examination period in the secondary schools and so I had to work hard to manage a common time for all participants because they were very busy administering the second term examinations.

4.3.2 Design of POE for pilot study-1.

I was looking for a common way of using the POE teaching strategy to explore the prior knowledge of these participant science teachers. I used an experiment that is also commonly used for exploring ideas about gravity using a POE strategy (White & Gunstone, 1992). This experiment involved dropping two balls of different weight (one solid ball and another was sponge ball) from the same height and asking participants to observe when they arrived at the ground. As this strategy started with a prediction it needed a genuine application of the knowledge that the respondent believed to be most pertinent (White & Gunstone, 1992). All participant science teachers participated in the process very actively and it took two hours to complete the whole process of experiencing and learning about this approach to teaching science.

4.3.3 Results from pilot study-1.

At the beginning of the experiment I distributed a format to the participants to take note of their observations. The format included four sections, namely: (1) prediction; (2) reasons for prediction; (3) observation; and, (4) reconciliation between prediction and observation. The summaries of their responses are listed as follows.

Prediction

- Appear to arrive at the ground at the same time – 3 teachers.
- Heavy ball appeared to arrive at the ground earlier than the lighter one - 5 teachers.

Reasons for prediction

- Appear to arrive at the ground for acceleration due to gravity- 2 teachers.
- There exists air resistance - 2 teachers.
- Gravitational energy depends on mass of the ball - 1 teacher.
- Attraction of earth is higher on heavy mass than lighter one, so air resistance is less - 1 teacher.
- Heavier ball can overcome the air resistance more quickly than the lighter ball – 1 teacher.

- Acceleration due to gravity does not depend on mass of the ball, so both will fall at the same time - 1 teacher.

Observation

- Both of them arrived at the ground at the same time – 5 teachers.
- Lighter one arrived earlier – 1 teacher (may be problem to release balls at the same time).
- Heavier ball arrived earlier – 2 teachers.

Reconciliation between prediction and explanation

- My conception has changed - 1 teacher.
- Conception remained as before - 1 teacher.
- Time interval is too short to observe properly - 1 teacher.
- Cannot explain why their conception has changed - 5 teachers.

The results indicated that participant teachers varied both in prediction and observation. They also provided different reasons including some that were in line with the accepted scientific theory. One teacher who predicted that the two balls would arrive at the ground at the same supported his view by stating that acceleration due to gravity did not depend on the mass of the ball. Most of them found their prediction did not match their observation. Most interestingly, teachers also observed differently. In most cases, they were not able to reconcile the change between what they individually predicted and what they observed. The reconciliation here involves holding to the prediction and interpreting the observations in these terms and is very important. This POE task explores the fact that the observation is influenced by a person's existing ideas and beliefs. The results indicated that in some cases teachers had alternative conceptions and these were able to be uncovered and explored in these groups of science teachers with the help of the POE teaching strategy.

4.3.4 Implications of using a POE strategy in classroom.

I supplied a questionnaire consisting of six open ended questions to receive instant responses to the teachers' reactions to this POE teaching strategy for their classrooms in Bangladesh. These questions were mostly related to knowing teachers' predictions for the effectiveness of this strategy as a new teaching strategy for

Bangladeshi science teachers. Participant teachers outlined some points that helped them to overcome their problems regarding regular teaching. These included explaining science content to students more easily, checking students' preconceptions, making the science teaching more attractive and guiding teachers' to make conceptions clearer.

All participants mentioned that the prediction step of POE was helpful for coming to know students' preconceptions. All participants also expressed the view that the observation stage of POE was effective to explore. Moreover according to them, reconciliation between prediction and observation could help their students to draw effective evidence based conclusions about the ideas where they had alternative conceptions and consequently arrive at a more 'scientifically correct' idea about their science concepts. All of them also believed that in following the POE strategy it would be easier to relate science content to students' daily-life situations. However, one of them was concerned about its proper implementation.

The participant teachers also predicted some problems for the use of the POE strategy for their teaching. Three participants envisaged that it may take extra time to collect teaching aids to use for this POE strategy. Another three participants mentioned that as teaching aids were not available in their schools they would face some difficulties in finding the teaching aids in order to use this strategy. However, one of them added that it might not be a problem if they used low-cost material from the local environment instead of any sophisticated materials. This also involved extra money which is difficult in the reality of the economic situation for most schools in Bangladesh - as mentioned by two participants. Moreover, one participant mentioned that he did not find any problem in collecting and finding teaching aids for the POE strategy.

The participant teachers made their views known regarding the workability of POE for Bangladesh classrooms. All of them were of the view that this approach was a really good teaching strategy for science classrooms in Bangladesh. Two of them mentioned that the POE strategy was an experiment based strategy that would help students to build a solid foundation of content knowledge to continue with science study in the future. Two of them mentioned that the strategy had the power to find alternative conceptions regarding science both from teachers' and students' perspectives. They also added that this strategy helped teachers to realise that they needed to be careful about their alternative conceptions in science.

4.3.5 Learning from pilot study-1.

The first pilot study provided much information on the practical aspects of implementing the POE teaching approach. The results from this pilot study and the opinions of these participant teachers helped me to realise and decide that I could go ahead with this strategy on a larger scale for my PhD research. Firstly I was impressed that teachers liked this study and recommended this strategy for the secondary classroom in Bangladesh. Secondly, the pilot study also made these teachers aware of their alternative conceptions - which is also a major aspect of this study. Teachers also mentioned the problem regarding finding and collecting teaching aids for their teaching practice which is the reality of Bangladeshi classrooms. Overall, participant teachers were enthusiastic about using this strategy for their teaching so I decided to use the POE teaching strategy for my research as a way of teaching about teaching science from a constructivist learning perspective.

4.4 Pilot Study-2.

The second pilot study was conducted in order to trial and refine the general baseline questionnaire. Trialling involved two aspects: (1) to understand whether the questionnaire needed to be translated into Bangla for better understanding by the participant teachers; and, (ii) to identify any ambiguity in understanding the developed questionnaire.

4.4.1 Participant selection procedures.

Two types of participants were selected for the second pilot study. For the first part I selected five participants purposively from Dhaka and Brahmanbaria district in Bangladesh. For the second part of this pilot study I also tried out the questionnaire with 10 secondary science teachers and also selected purposively from Dhaka, Serajganj and Brahmanbaria District in Bangladesh. To find these teachers I selected the schools for convenience and contacted the respective head teachers to find science teachers who might voluntarily participate in this pilot study.

4.4.2 Results of pilot study-2.

Results from part 1

I went myself to work with these individual teachers. I asked them to read and complete the questionnaire and wherever they found any difficulty in understanding the meaning of the English terms to underline those terms and make any appropriate comments. The participants' responses are summarised as follows:

- Two of them did not answer question 5 of section A and put a note that they did not understand the proper meanings.
- Four of them found it difficult to understand the meaning in question 1 in section B.
- All five teachers found difficulty in understanding the proper meaning in several questions in section C. They underlined different words related to not understanding the appropriate meaning. For example autonomy in question 12 and prior in question 15.
- None answered questioned 16 (b) in section C.
- None of them understood questions 2 and 3 in Section E.
- Two teachers did not answer a few items from question 1 in section G

Learning from their responses

The results of the first part of the second pilot study helped me to decide to translate the questionnaire into Bangla before applying it in the full project. Moreover, all participants expressed the view that for better understanding of the meaning of the questionnaire it should be in Bangla rather than English. One of them mentioned that English questionnaires made him work too hard to understand the meaning rather than to provide appropriate answers.

Results from part 2

The Bangla version of the questionnaire was then developed and trialled with ten purposively selected science teachers. The following summarizes the suggestions received by the participant science teachers in this part of pilot study.

- Provide the word 'abstract' in brackets after its Bangla version; this might help teachers to understand its real meaning for the item number 1 in section C.

- Provide English version with item number 6, 8, 9, and 11 for better understanding in section C.
- Redesign the stem of question 1 in section D for its Bangla version.
- Replace question 2 in section E to as item 5 in question 1 in section D. This was for the same meaning.
- Replace questions 17a and 17b in section C as question 2a and 2b in section D for the similar meaning.
- Add group discussion as item in question 1 in section E.
- Change question 3 in section E as multiple type question with three options rather open ended question.
- Separate training and working manual as individual item from item j for question 5 in section E.

Learning from results of part 2

The results suggested by the participant teachers were very useful in refining the baseline questionnaire. Their suggestions helped me to prepare a better baseline questionnaire for secondary science teachers. It was expected that the developed questionnaire could be administered easily and participant teachers would be able to provide their responses with their better understanding of the questionnaire as a result of the translation and refining of the questions for clarity and purpose.

4.5 Chapter Summary

The two pilot studies helped me to develop research instruments that I could confidently administer to secondary science teachers across different districts in Bangladesh. It was expected that this refined questionnaire would then allow me to gather reliable and valid data from the participants for the main PhD study.

Chapter 5
Teachers' Views about their Practice and their Students' Learning of Science

5.1 Introduction

This chapter looks at the results of data analysis dealing with the responses from the general baseline questionnaire and semi-structured interviews. To facilitate the presentation of the results they are presented in two separate sections (section 5.2 for results from baseline questionnaire and section 5.3 for results from baseline interview). The chapter is also organised around the presentation of a common summary to identify participant teachers' views about their practice and their students' learning of science at the secondary level in Bangladesh. Understanding their views about current practice is important in establishing a baseline from which to study participants' approaches to learning from a new teaching strategy as an intervention in this research. The following section of the chapter presents findings from different aspects of science teaching related to different variables identified in the first and second research questions for this study.

5.2 Results from the Baseline Questionnaire

5.2.1 Data sources.

The baseline survey in this research was implemented using a general questionnaire for the in-service secondary science teachers. The questionnaire had both open (N = 12) and closed (N = 72) questions. It was developed in English and then translated into Bangla to ensure better understanding of the questions by the science teachers. The medium of instruction in Bangladeshi schools is Bangla (except in a very few schools, likely less than 1%).

5.2.2 Variables in research question 1 (RQ1)

The first and second research questions were concerned with several variables that may well influence the quality of science teaching in secondary science classes. These variables include: teaching context; teaching load of science teachers; science teachers' views about teaching and learning in science; science teachers' difficulty with their subject matter knowledge; science teachers' awareness of their alternative conceptions in science; the nature of their preparation for science lessons; and, the nature of collaboration with their colleagues. Measurement of these variables was designed to establish an understanding of the participant teachers' views and their impact on science teaching and students' learning in their secondary schools.

5.2.3 Data analysis.

The baseline survey was conducted using a general questionnaire (see Appendix 1). Data analysis of these responses aimed to answer Research Questions One and Two. All of the participants' responses to the open ended questions were transcribed and the SPSS software programme was used for calculating all the frequencies/percentages of participants' responses to the closed questions. Output frequency tables and charts/diagrams were produced through the Microsoft Excel program. To facilitate the presentation, firstly, the data analysis is presented according to the sequence of individual questionnaire items and then the findings are summarised under different variables to provide answers to the individual research questions.

5.2.4 Teaching context.

Teaching preferences of teachers

In secondary schools in Bangladesh, in most cases, there is no specific mathematics or science teacher. As a result, science graduates who become teachers have to take both science and mathematics classes. It is noteworthy that prospective teachers usually choose their courses from mathematics and science in their graduate studies. In the first question of the general questionnaire, teachers were asked to respond about their subject preference in teaching. Out of the 174 respondents, 113 (64.9%) teachers responded that they preferred teaching mathematics (see Figure 5.1). The remaining 61 respondents (35.1%) preferred to teach science.

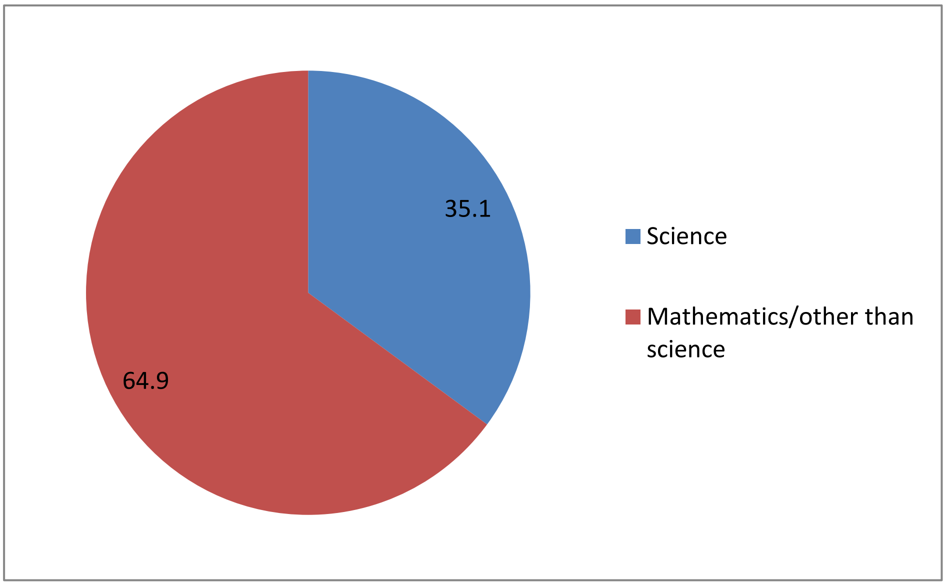

Figure 5.1: Teaching preference

The above results illustrate that the majority of the participant teachers prefer teaching mathematics rather than science teaching which also may reflects additional preparation and marking demand of science teaching.

Teaching experience of teachers

Substantial teaching experience has an impact on pedagogical decision-making in teaching (Tabachnick & Zeichner, 1984). They also highlight the role of teaching experience in the development of perspectives towards teaching formed around coordinated sets of ideas and actions that teachers use in dealing with problematic situations. From the data collected in the general survey, most of the participant teachers had more than 5 years teaching experience. Among them 41.4% teachers had more than 15 years experience, 17.2% teachers had 10-15 years and 28.7% teachers had 5-10 years teaching experience. In addition, 9.2% of the participant teachers had 2-5 years experience while only 3.4% of them started their teaching in the last two years (see Figure 5.2). As Figure 5.2 (above) indicates, most of the participant teachers had considerable teaching experience.

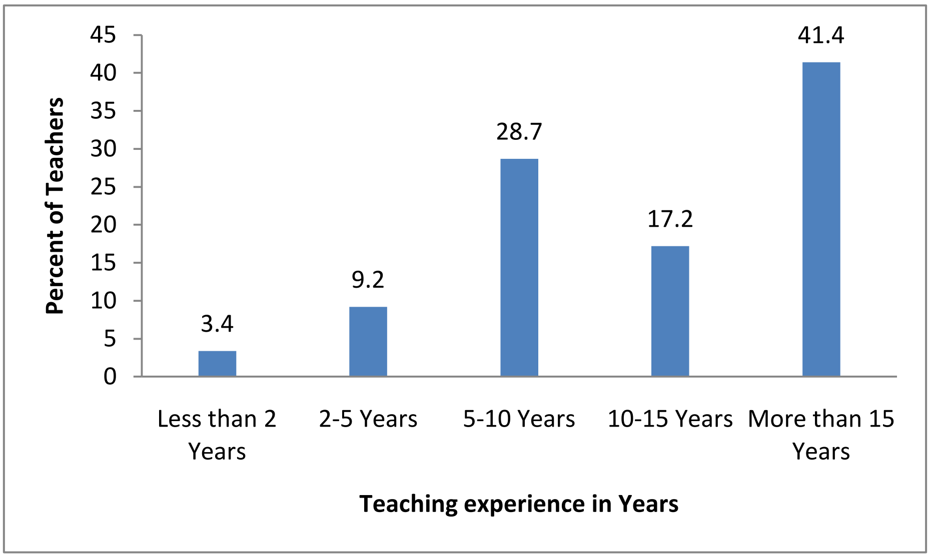

Figure 5.2: Teaching experience

Grades teachers are involved in teaching

Science teachers in Bangladesh need to teach General Science from grade VI to VIII. In grades IX and X, they take Physics, Chemistry or Biology with allocation to the latter subjects mostly depending on their specialization in their degree studies. Table 5.1 illustrates that 85.6% and 90.2% teachers are involved in teaching grades IX and X, respectively. 74.1% of the participant teachers are also involved in taking part in science classes in grade VIII. In addition, only 51.7% and 45.0% teachers were teaching science in grades VII and VI respectively.

Table 5.1

Grade level of teaching

Grade	**Total Participant Teachers**	**Number of teachers involved in teaching**	**Expressed as a Percentage**
Grade Six		80	45.0%
Grade Seven		90	51.7%
Grade Eight	174	129	74.1%
Grade Nine		157	90.2%
Grade Ten		149	85.6%

In the school system in Bangladesh grades IX and X are considered as secondary schooling, whereas grades VI to VIII are considered as junior secondary. The above data reflects that most of the participant science teachers teach more in the higher classes (Grades IX and X). Almost half did not teach in grades VI and VII - which is considered an elementary stage for students learning science.

5.2.5 Teaching load.

Class size

Class size is one of the major stumbling blocks to the practising of regular group activities and student-centred science teaching (Wahyudi & Treagust, 2004). Larger classes present challenges for teachers for doing different activities in science. At the simplest level, it is difficult for many students to physically see demonstrations; class size also influences how teachers approach their teaching in terms of what they might consider feasible and reasonable to attempt to manage.

Figure 5.3 illustrates that 15.5% of the participating science teachers teach science classes at the junior secondary level with an average of 40-50 students per class. 18.4% of the participating science teachers have 50-60 students in their science classes in the junior secondary classes. An overwhelming 55.7% of all participant science teachers were teaching science classes comprising more than 60 students.

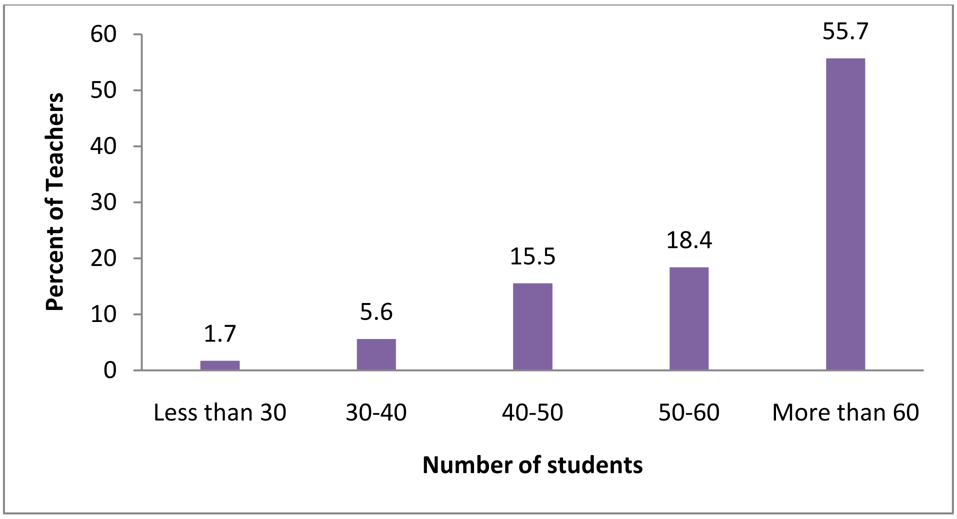

Figure 5.3: Number of students in one class (junior secondary science)

The above data reflects how different participant teachers teach different numbers of students in their science classes. In most cases, teachers have to teach science in a class where the number of students is more than 40. The above result reflects the large class size for the junior secondary sector in Bangladesh.

Number of science teachers in a school

There are different number of teachers in different schools in Bangladesh depending on the location and size of individual schools. At the same time, there are shortages in terms of the number of teachers in many schools. In many schools, each class, especially in the lower level, is divided into two or three different sections (sometimes by gender). The collected data shows (Figure 5.4) that 32.2% of participant teachers have five or more science colleagues in their school. Other 32.8% participant teachers have two or more colleagues in their school, while 2.3% of participant teachers (four participants) are the only responsible teacher for taking the entire science and mathematics course in their respective school.

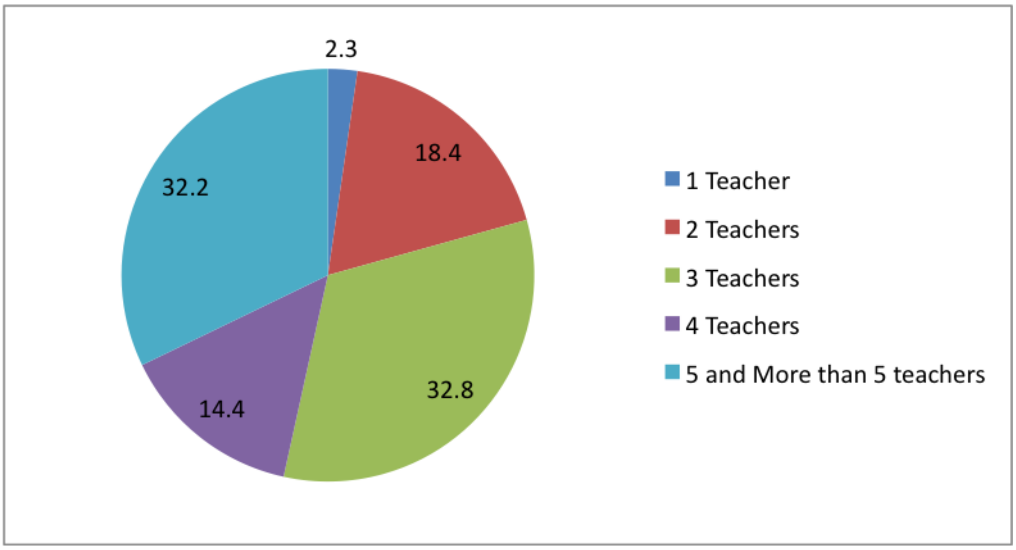

Figure 5.4: Number of science teachers in one school

On average, each school has two or three science teachers. These teachers have to take the entire science and mathematics classes from grade VI to grade X. So, it is easy to conclude that schools have an insufficient number of science teachers and hence the teacher-student ratio is problematic.

Duration of science classes

The duration of individual science classes is important as it is connected to the total contact hours assigned for the completion of a curriculum. There is a recommendation from the higher authority that each science class should be 40 minutes duration (NCTB, 1996. However, the data (Table 5.2) indicates that 48.9% of participant teachers are involved in science teaching for 35 minute classes and 40.8% teachers conduct 40 minute classes. As result, most of the teachers conduct science classes for 35-40 minutes. In some cases, (for 6.3% participant teachers) this time is extended to 45 minutes.

Table 5.2
Duration of science classes

Duration of Class in Minutes	Percentage of teachers Involved	Sum of 35 and 40 minutes
30	4.0	
35	48.9	
40	40.8	89.7
45	6.3	

The above data reflects that different schools maintain their individual routine, which leads to variations in the duration of science classes. In most cases teachers conduct science classes for 35-40 minutes in large classes, as stated in the previous section.

Overall teaching load

It has been suggested that a heavy teaching load has an impact on the quality of educational provision (Sanders, 1989). In most cases, a heavy teaching load puts pressure on teachers in relation to the preparation of their lessons. According to Table 5.3, 42% of participant teachers have to take 30-34 classes in science and mathematics in five full (10 am - 4 pm) and one half (10 am - 1 pm) working days in their school during a week. In addition, 79.9% of participant teachers take more than 25 classes per week. As the duration of each science class in most schools is 35-40 minutes, these teachers must be involved in teaching on average more than 17 hours per week (Figure 5.5).

Table 5.3

Overall teaching load by teacher

Number of classes per week	**Percentage of teachers**	**Percentage of teachers involved in teaching more than 25 classes per week (Six days)**
<15-19 Classes	8.6	
20-24 classes	11.5	
25-29 Classes	33.2	
30-34 classes	42	79.9
More than 35 Classes	5.7	

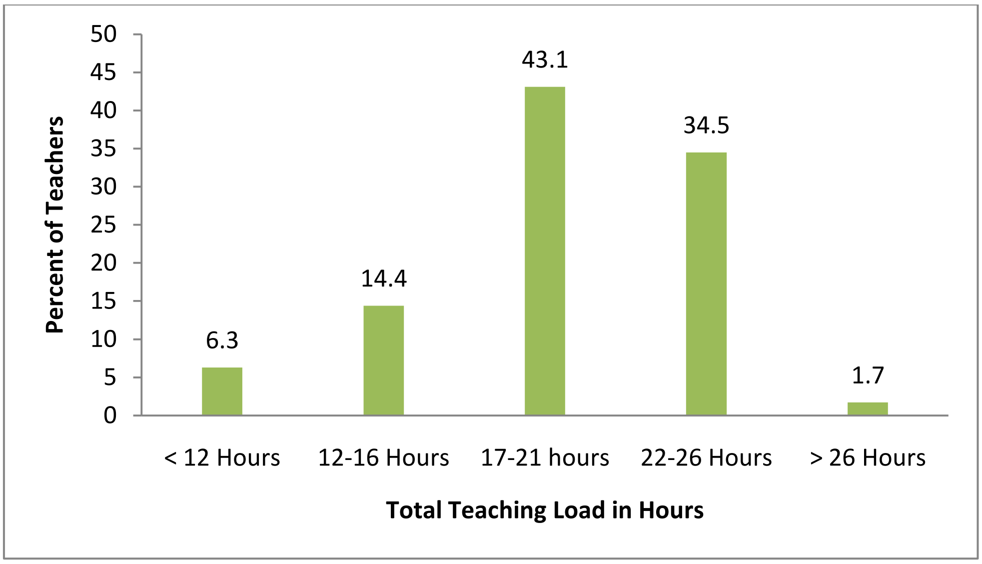

Figure 5.5: Overall teaching load by time

In most schools, every science teacher has to take five to six different classes every day. The above data therefore reflects these teachers' heavy workload.

Teaching load for science classes only

Science teachers in secondary schools in Bangladesh have to take both science and mathematics classes (as mentioned before). Figure 5.6 shows that more than half of the participant teachers (55.2%) spend more than 7 hours per week for only teaching science. In addition, 24.7% participant teachers are involved in science teaching more than 10 hours per week.

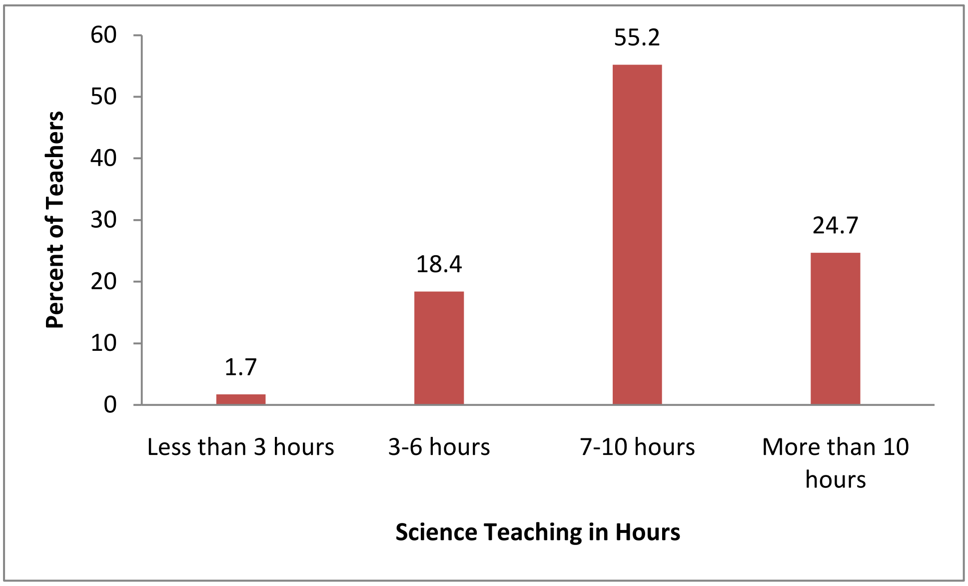

Figure 5.6: Teaching load for science classes

As science teachers have to take both science and mathematics classes, the above data reflects that most of them are involved, or spend more time in, mathematics teaching than in science teaching. This data also has a positive correlation with their preference in teaching as most of them spend more time preparing to teach mathematics than they do for science teaching, as explained in the next section.

Number of hours spent by teachers for science class preparation only

Teachers need time for preparation for their classes. As teachers are involved in a number of classes each day, they need a considerable amount of time for preparing lessons to conduct a quality teaching session. Preparation activities mainly include lesson planning, grading papers and developing teaching aids. In essence, they need to spend time both at home and school before the scheduled class. According to Figure

5.7, almost half of the participant teachers (45.4%) spend 1-2 hours per week during school time preparing for their science classes. On the other hand, 35.6% of participant teachers spend 3-5 hours per week during school hours for the same purpose. Moreover, half of the teachers (50%) spend 2-4 hours and 25.3% of teachers spend 5-7 hours per week preparing their science classes at home (Figure 5.8). A small number of teachers (17.8%) spend only 1-2 hours preparing their science lessons.

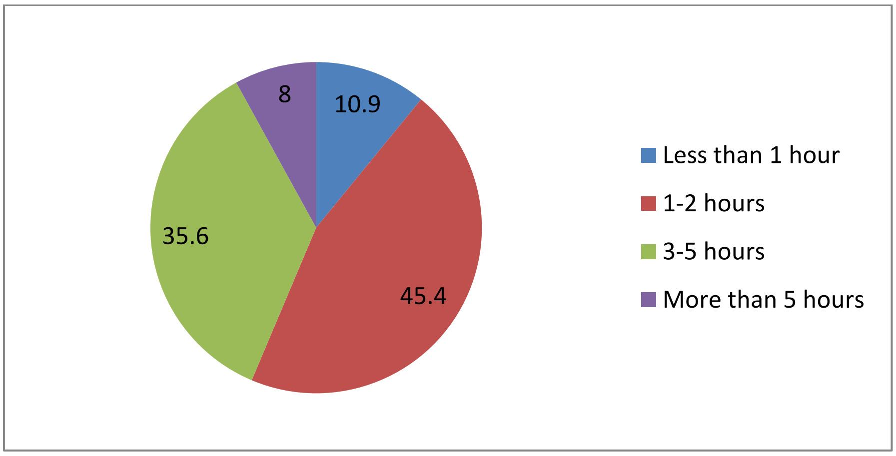

Figure 5.7: Preparation time spent at school

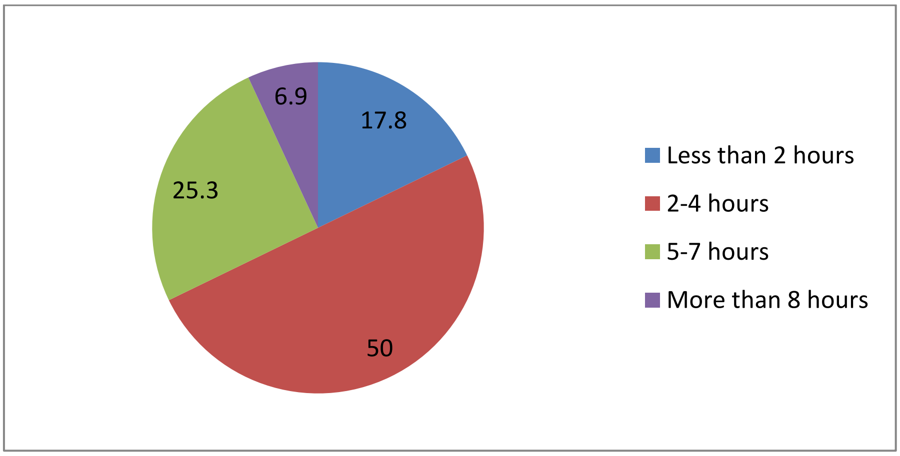

Figure 5.8: Preparation time spent at home

The above data shows that most of the participant teachers do not spend a great deal of time preparing their science lessons.

Number of hours spent on other activities

In the secondary school system in Bangladesh, teachers have to be involved in work other than teaching. 89.6% of participant teachers were involved in meeting for around one hour per week with other teachers to work on curriculum and planning issues for science teaching (Table 5.4).

Table 5.4

Teacher time spent on tasks other than teaching

Curriculum and planning issues			**Administrative activities (not teaching)**		
Time spent per week in hours	**Percentage (%) of teachers involved**		**Time spent per week in hours**	**Percentage (%) of teachers involved**	
Never	2.9		Less than 1 hour	19.5	
Less than 1 hour	40.2	89.6	1-2 hours	44.8	67.8
1-2 hours	49.4		2-3 hours	23.0	
2-3 hours	7.5		More than 3 hours	12.6	

Teachers also have to spend time on other school-related activities including administrative work and the counselling of students. In this case, 67.8% of participant teachers spent approximately two hours per week on different kinds of administrative work in their schools. On the other hand, 19.5% of the participant teachers customarily spent less than two hours per week. The above data reflects that almost every teacher is involved in some kind of administrative work besides their teaching.

5.2.6 Teachers' views.

Teachers' views about scientific knowledge

Teachers' views about scientific knowledge are considered to be an important shaping factor in science teaching. In this case, Nature of Science (NOS) refers to the values and beliefs inherent in scientific knowledge and its development (Lederman &

Lederman, 2004). In this section of the baseline questionnaire, participating science teachers were asked to present their views about scientific knowledge. The percentage calculations from the responses of teachers' views about scientific knowledge are summarized in the Table 5.5.

Table 5.5
Teachers' views of scientific knowledge as % (N = 174)

No.	Item	SA	A	UN	D	SD
1	Science is an abstract subject	6.3	13.2	4.0	31.6	44.8
		19.5			76.4	
2	Science is about the right answers	36.8	54.0	2.9	5.7	0.6
		90.8			6.3	
3	Science is a logical and ordered subject	50.6	44.8	1.1	2.3	1.1
		95.4			3.4	
4	Science is a strict discipline in which there is no place for personal opinion	16.7	27	5.2	30.5	20.7
		43.7			51.2	

All scientific knowledge is, at least partially, based on and/or derived from observation of the natural world (Lederman & Lederman, 2004). Consistent with this view, it is observed from the above (Table 5.5) that the majority of the participants (76.4%) stated that they did not agree with the view that science is an abstract subject. Most of them (44.8%) felt this position very strongly. On the other hand, 19.5% of participants perceived science to be an abstract subject (see Figure 5.9). So, the above data reflects that the majority of the science teachers did not consider science to be an abstract subject.

Science knowledge is never absolute or certain; this knowledge is tentative or subject to change (Lederman & Lederman, 2004). However, for item 2 pertaining to teachers' views, 90.8% of the participant teachers agreed with the statement that science is about right answers (Table 5.5). This data questions the understanding of most teachers regarding the nature of science knowledge. At the same time, almost all (95.4%) of the participant teachers agreed with the conception that science is a logical and ordered subject (Table 5.5).

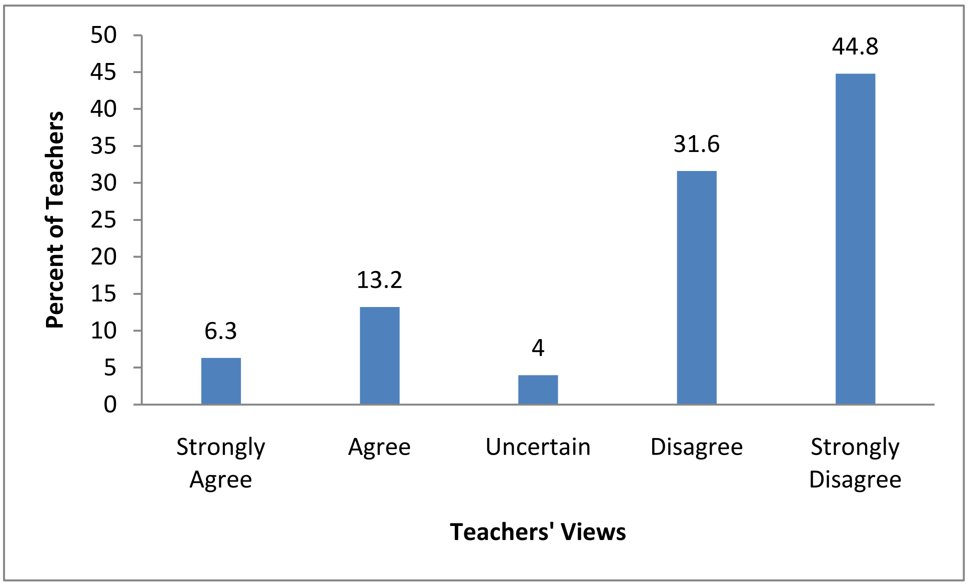

Figure 5.9: Science is an abstract subject

Scientific knowledge is also subjective or theory laden (Lederman & Lederman, 2004). However, an interesting result emerging from responses to item number 4 identified the extent to which teachers agreed or disagreed with the statement that science is a strict discipline in which there is no place for personal opinion. Participant teachers were divided into two groups (agree 43.7% and disagree 51.2%). This result indicates contradictory views among the science teachers about the subjectivity or objectivity of the nature of scientific knowledge (See figure 5.10).

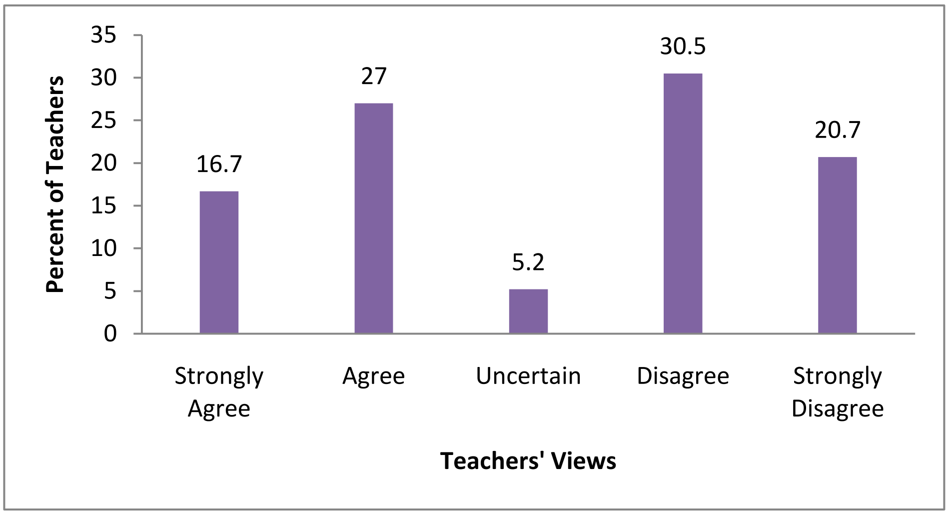

Figure 5.10: Science is a strict discipline in which there is no option for personal opinion

Teachers' views about science teaching

Teachers develop their views about teaching from years spent in the classroom as both students and teachers (Lumpe, et al., 2000). Different studies confirm that there are strong connections between teachers' views and their classroom behaviours (Brown & Rose, 1995; Tosun, 2000). The percentage calculations from the responses of teachers' views about science teaching are reported in Table 5.6.

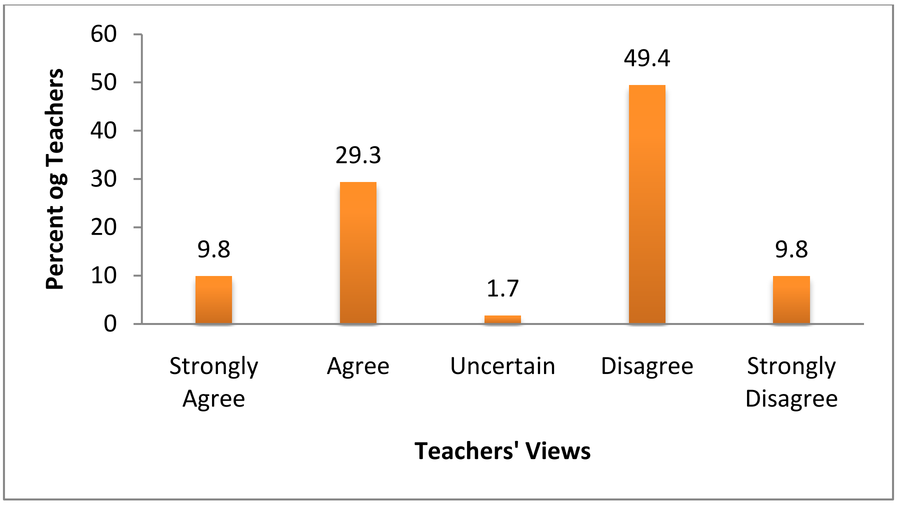

Figure 5.11: Science is harder than teaching other subjects

While 59.2% of the participant science teachers did not consider science teaching to be harder than other subjects (See Table 5.6), a considerable number 39.1%

believed science teaching to be harder than teaching other subjects (See table 5.6 and See Figure 5.11).

In response to the second item, the majority of science teachers (73%) stated that they felt confident about organizing science content in an appropriate teaching sequence, although some teachers (10.9%) were unsure about their decision. These results indicate that the majority of science teachers felt they had the ability to organize their lessons for teaching. This result also had a positive correlation with the previous item where the majority of the teachers did not consider science teaching to be harder than other subjects.

From the Table 5.6 (item 3), it is also noteworthy that participant teachers seemed to be more concerned with children's understanding and skill development in science. 93.8% of the participants agreed with the importance of developing children's understanding of the processes of science. In the same way they (94.8%) felt it was important to develop children's skills in science. However, they held opposing views regarding the responsibility of the teacher for their students' achievement.

Table 5.6

Teachers' views about science teaching

No.	Item	SA	A	UN	D	SD
Science teaching						
1	Teaching science is harder than teaching other subjects	9.8	29.3	1.7	49.4	9.8
	Sum of SA + A & D + SD	39.1			59.2	
2	I feel confident about organising science content in an appropriate teaching sequence	9.8	63.2	10.9	14.9	1.1
		73.0			16.0	
3	It is important to develop children's understanding of the processes of science	49.4	45.4	0.6	3.4	1.1
		93.8			4.5	
4	It is important to develop children's skills in science	42.5	52.3	0.6	3.4	1.1
		94.8			4.5	
5	The Teacher is responsible for students' achievement in science	9.8	39.7	5.2	41.4	4.0
		49.5			45.4	
6	Students' achievement in science does not change even when the teacher exerts extra effort	1.7	12.1	2.3	56.3	27.6
		13.8			83.9	
7	I am confident about trying new strategies for teaching science in my classroom	32.2	63.2	0.0	2.9	1.7
		95.4			4.6	
8	In implementing new teaching strategies, I enjoy autonomy in my school	10.9	58.6	6.3	16.7	7.5
		69.5			23.2	
9	When teaching science, I welcome student questions	36.2	54.0	2.9	4.6	2.3
		90.2			6.9	

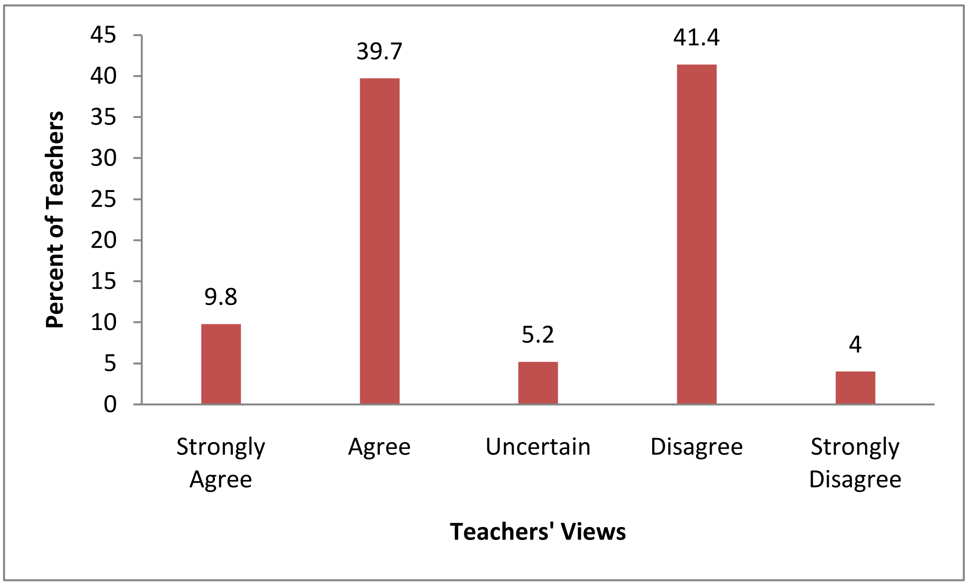

Figure 5.12: Responsibility of the teacher for students’ achievement in science

According to Table 5.6, 49.5% of the participants felt that the teacher was responsible for student achievement, whereas 45.4% expressed a negative opinion regarding this issue (See figure 5.12). In addition, the majority of the participants (83.9%) agreed with the statement that when the teacher exerts extra effort it impacts students’ achievement in science (see Figure 5.13). This ultimately led them to hold beliefs of high expectations in their science teaching outcomes.

Teachers sometimes introduce new teaching strategies in their teaching. According to the data presented in Table 5.6, most but not all teachers, felt comfortable about using new strategies. In response to item 8 in this section, participant teachers expressed their opinions on using new teaching strategies with confidence. 95.4% of them felt confident about trying new strategies for teaching science in their classrooms. The majority of them (69.5%) felt autonomy in their school in implementing new teaching strategies. However, a considerable number of teachers (24.2%) faced problems in implementing new teaching strategies derived from their school administration (Table 5.6). Most of them (90.2%) enjoyed questions from their students during their science classes (Table 5.6).

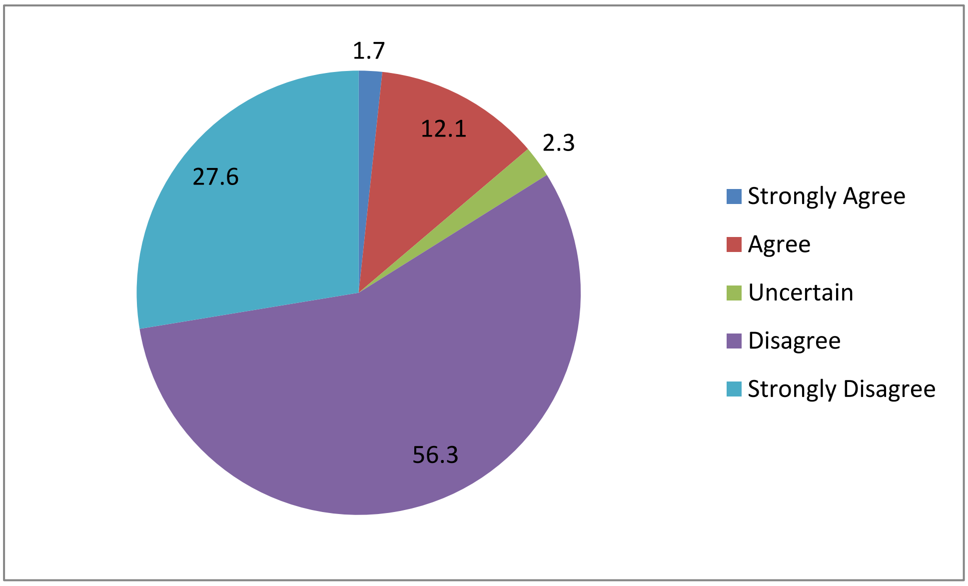

Figure 5.13: Impact of teacher's extra effort on students' achievement

Teachers' view on students' science conceptions

Over more than three decades, a considerable amount of educational research has shown that students develop their own "naïve theories" and beliefs which they use to explain natural phenomena in the world around them (AAAS, 1989; Chou & Tsai, 2002; Driver, 1989; NRC, 1996; Palmer, 2001). Teachers often subscribe to the same alternative conceptions as their students - which can be seen in their explanation of science concepts and the instructional materials they use. In Bangladesh, secondary science teachers are not very familiar with the terminology of "alternative conceptions in science", though some of them had some idea about the concept. Two thirds of the participants (66.7%) stated that they had not heard about the notion of "alternative conceptions" or "misconceptions" in relation to science concepts. On the other hand, other participants provided a positive response regarding this issue; however, most of them did not explain the notion accurately and were unable to provide any examples. Table 5.7 lists some of the areas where teachers experienced alternative conceptions in science, amongst their students or colleagues. The number in the bracket indicates the number of respondents for each area.

Teachers were asked to express their views about students' conceptions in science. In response to item 1 in this section, the majority of the participants (72.2%) remarked that students have their own views regarding science concepts (See table 5.8).

Consistent with this opinion, most of the teachers (94.9%) felt that they need to take into account the prior knowledge that students bring into the class (Figure 5.14).

Table 5.7
Alternative conceptions reported by teachers

A glass with smaller circumference contains more water than a glass with bigger circumference (2)
Concepts about static and dynamic
Concept of acceleration (4)
Darwin's theory
Critical angle in total internal reflection (5)
About protoplasm
Valency in chemistry (4)
Concept and explanation about a mirage (3)
Concept of electricity
Concepts of AIDS (2)
Concepts about human formation/Genetics (2)
The rotation of sun around the earth (4)
Concept for Earth and solar eclipse
The movement of plants Ibrahim
Concept of radioactivity

Table 5.8

Teachers' view on students' conceptions in science

Item **Students' conception in science**	SA	A	UN	D	SD
Students have their own views about science ideas	5.7	66.7	7.7	16.7	3.4
	72.2			20.1	
Teachers should take into account prior knowledge that students carry into the classroom	42.0	52.9	0.0	3.4	1.7
	94.9			5.1	

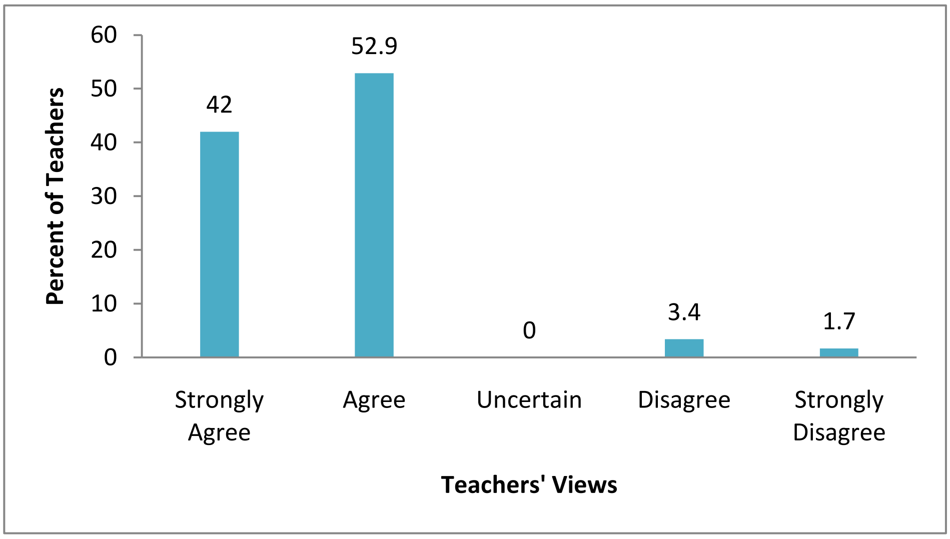

Figure 5.14: Students' prior knowledge

5.2.7 Teachers' knowledge about science teaching.

Teachers' knowledge about subject matter in science

Teachers' subject matter knowledge has an effect on both the content and the processes of their teaching instruction, thus influencing both what and how they teach (Wahyudi & Treagust, 2004). In response to the question as to whether or not teachers felt confident about their subject matter knowledge, the majority (66.7%) indicated that they felt confident though a considerable number of teachers (31.6%) did not feel confident about their subject matter knowledge (see Figure 5.15).

It has been noted that sometimes teachers are not able to explain important substantive concepts to their students (Kennedy, 1990). The pedagogical behaviour of "explaining" cannot succeed if teachers do not adequately understand the content they are supposed to explain and teachers have difficulty in teaching certain areas when they themselves lack sufficient understanding about them (Kennedy, 1990). These areas include explaining the subject matter properly, giving real life examples, applying principles of science to real life examples, providing current ideas about science concepts and differentiating teaching for different topics.

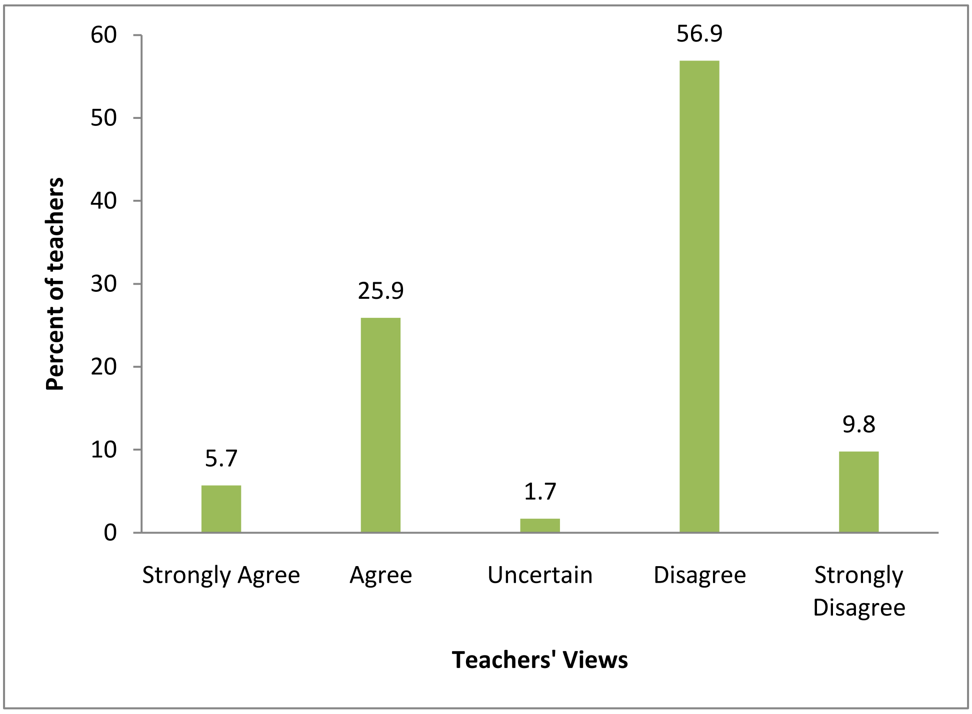

Figure 5.15: Level of confidence in subject matter knowledge

Table 5.9

Teachers' difficulties in different areas in science knowledge

Area in science knowledge	Always	Frequently	Sometimes	Never
Explain the subject matter properly	1.2	6.3	78.7	13.8
		86.2		
Provide real life examples	1.7	14.4	57.5	26.4
		73.6		
Apply principles of science to real life examples	5.2	32.8	51.1	10.9
		89.1		
Provide current ideas about science	1.7	26.5	58.0	13.8
		86.2		
Differentiate teaching for different topics	3.4	29.3	54.6	12.6
		87.4		

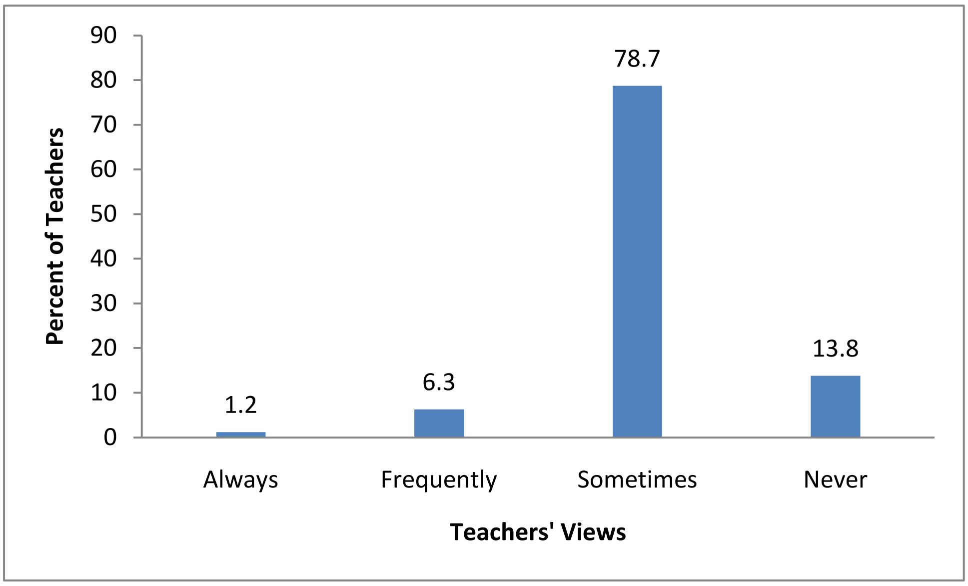

Figure 5.16: Difficulty in explaining subject matter

In response to item 1 on these difficulties, most (86.2%) participant teachers found some degree of difficulty in explaining the subject matter in science (Table 5.9 and Figure 5.16). On the other hand, 13.8% participant teachers never found any difficulty in explaining the subject matter. This indicates that most of them did not feel completely comfortable in their teaching in respect to explaining the subject matter properly.

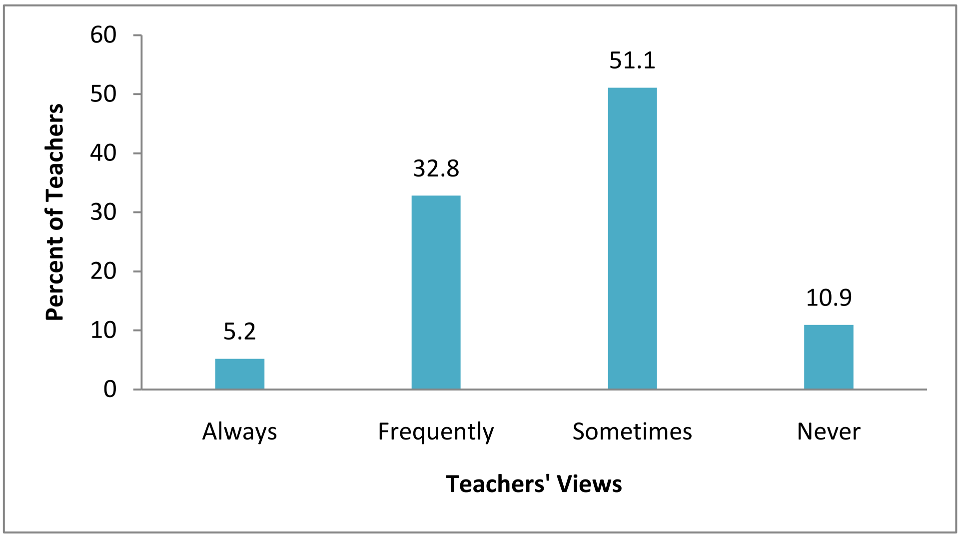

Figure 5.17: Difficulty in applying science principles to real life examples

Teachers must have the ability to critique and apply subject matter knowledge in any new situation (Parker, Wallace, & Fraser, 1993; Ware, 1992b). 26.4% of the participant teachers felt they were always able to provide examples from the world around them. However, a significant number of participant teachers (73.6%) teachers faced difficulty in providing real life examples during their teaching in the classroom (Table 5.9). In all, 89.1% participant science teachers also found it somewhat difficult to link the principles of science with real life examples (Figure 5.17).

Furthermore, 26.5% of participant teachers frequently found it difficult to provide current ideas about science concepts (See Figure 5.18). More than half of them (58.0%) sometimes struggled to provide current ideas to their students. On the other hand only 13.8% of participant teachers reported being confident about doing this.

Only 12.6% of participant teachers did not have a problem varying their teaching according to the topics. However, most (87.4%) of the participant teachers did not feel confident in differentiating their teaching according to the demands of different topics (See Table 5.9). These results reflect that most of the participant teachers did not find their teaching successful all the time because of difficulties in the above-mentioned areas.

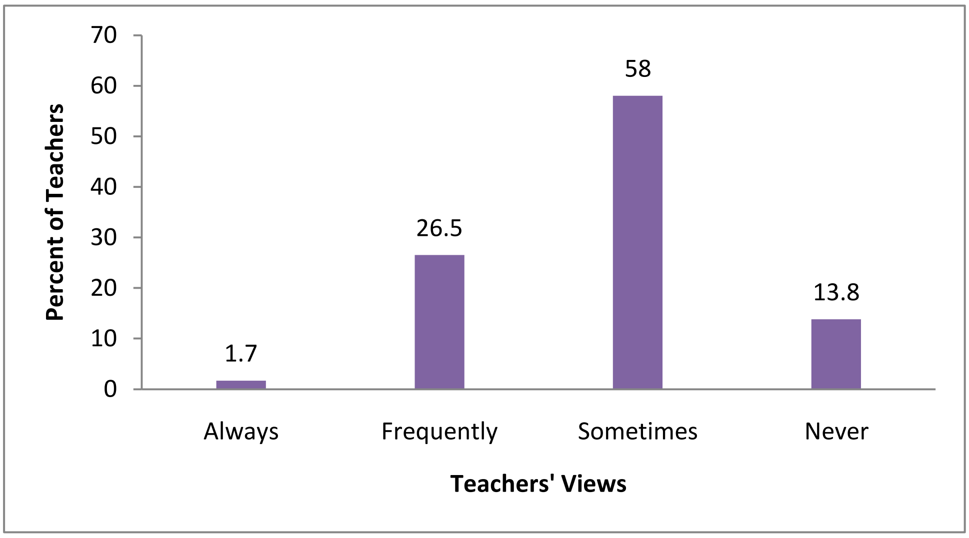

Figure 5.18: Ability to offer current ideas about science

Update of teachers' subject matter knowledge

Teachers' knowledge changes with time and experience (Gess-Newsome, 1999). Resource materials also have an influence on teachers' actions. In addition, when teachers possess inaccurate information or conceive of knowledge in narrow ways, they may pass on these ideas to their students (Kennedy, 1990). In essence, they may fail to challenge their students' alternative/misconceptions. Thus in most cases teachers need to update their teaching knowledge. Table 5.10 illustrates that approximately two-thirds of the participant science teachers sometimes used current science magazines, textbooks from higher levels, reference books and materials from the subject-based in-service training to improve their knowledge. Most participants (62.6% sometimes and 33.9% frequently) also liked to discuss informally with their colleagues to update their subject knowledge (see Figure 5.19).

Table 5.10

Teachers' ways of update their science knowledge

Source of knowledge	Frequently	Sometimes	Never
	(Expressed as percentage)		
Reading current magazine about science knowledge	20.1	67.8	12.1
Reading text book of higher levels	21.8	65.5	12.6
Reading reference books	19.5	58.0	22.5
Subject based in-service training	28.7	62.6	8.6
Searching the internet	5.2	19.0	75.9
Discussions informally with colleagues	33.9	62.6	3.4

In addition, teachers reported that they read daily newspapers (Education section) to update their science knowledge. It is notable that most (75.9%) did not use the internet to update their knowledge - explained largely by the fact that there are problems with internet access. Only very few of them (5.2%) used the internet for this purpose. The above data reflects that teachers use different sources as well as informal discussion with their colleagues to update their teaching knowledge. Internet services still are not available in most Bangladeshi schools.

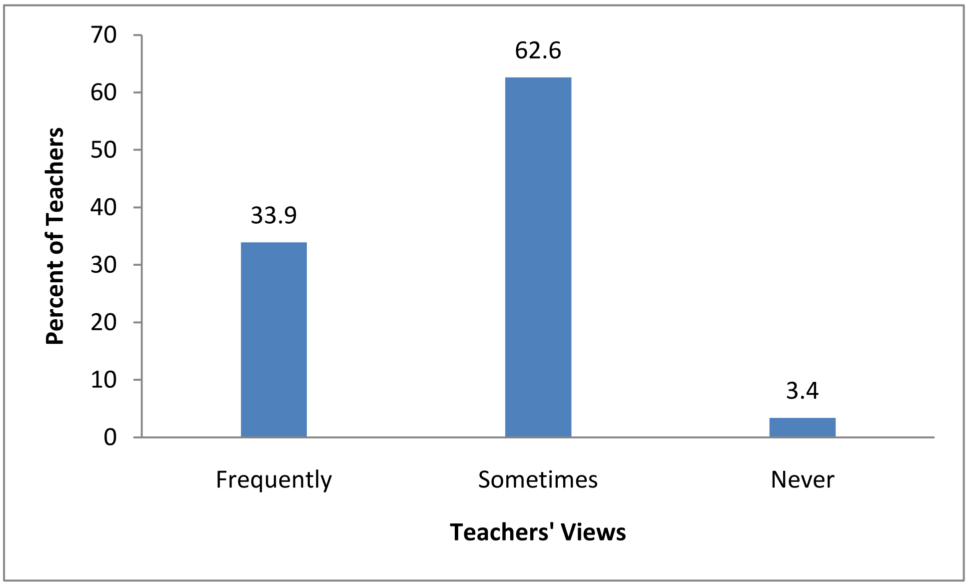

Figure 5.19: Knowledge update through discussion with colleagues

5.2.8 Teaching methods in science.

Methods used in teaching science

To help translate the ideas about learning into classroom action, teachers use different teaching/learning methods (Goodrum, 2004). It is observed from Table 5.11 that 30.5% of the participant science teachers always used the lecture method for their science teaching. In addition, 24.7% and 40.2% of participant teachers used this traditional lecture method frequently and sometimes, respectively (See Figure 5.20). So, altogether 95.6% of the study's science teachers used this traditional method to a greater or lesser extent.

Teachers' use of demonstration as a teaching method seems to be similar to the lecture method. 35.6% of participant teachers stated that they liked to use this as a frequent method in their teaching, and more than half of the participant science teachers (54%) reported using it sometimes (Table 5.11).

Table 5.11
Methods used in science teaching

Methods	Always	Frequently	Sometimes	Never
Lecture	30.5	24.7	40.2	4.6
Demonstration	9.2	35.6	54.0	1.1
Discussion	29.9	37.9	31.0	1.1
Lecture with discussion	23.6	42.5	31.6	2.3
Problem-solving	17.8	39.1	41.4	1.7
Group Discussion	6.9	29.3	56.9	6.9

Discussion method was also popular among these teachers as they reported a preference to using it in their classes. This discussion is basically teacher directed question and answer session. According to Table 5.11, 29.9%, 37.9% and 31.0% of the participant teachers used this method always, frequently and sometimes, respectively.

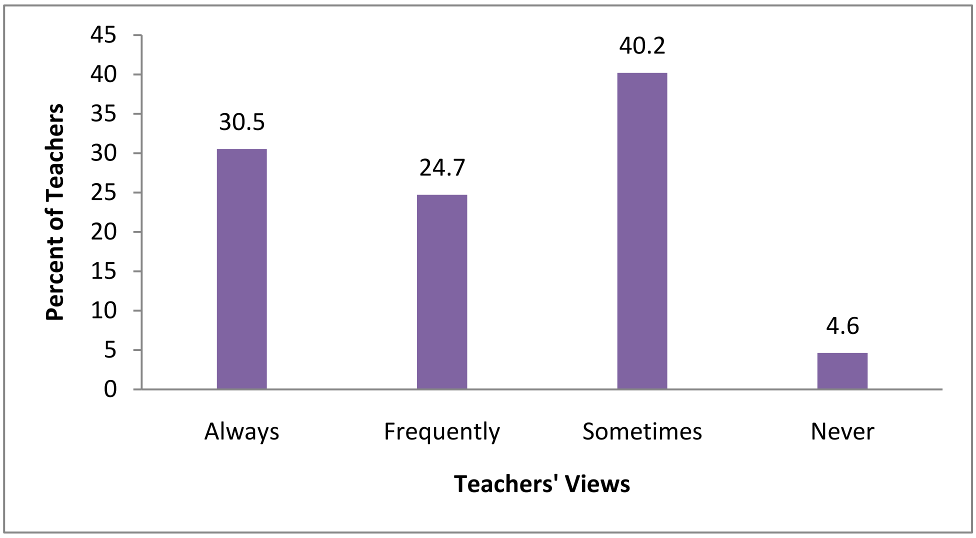

Figure 5.20: Use of lecture method

The same is seen for lecture with discussion. 42.5% participant science teachers claimed to use lecture with discussion frequently. 17.8%, 39.1% and 41.4% participant teachers stated that they liked to use the problem solving method in their science teaching always, frequently and sometimes respectively (Table 5.11).

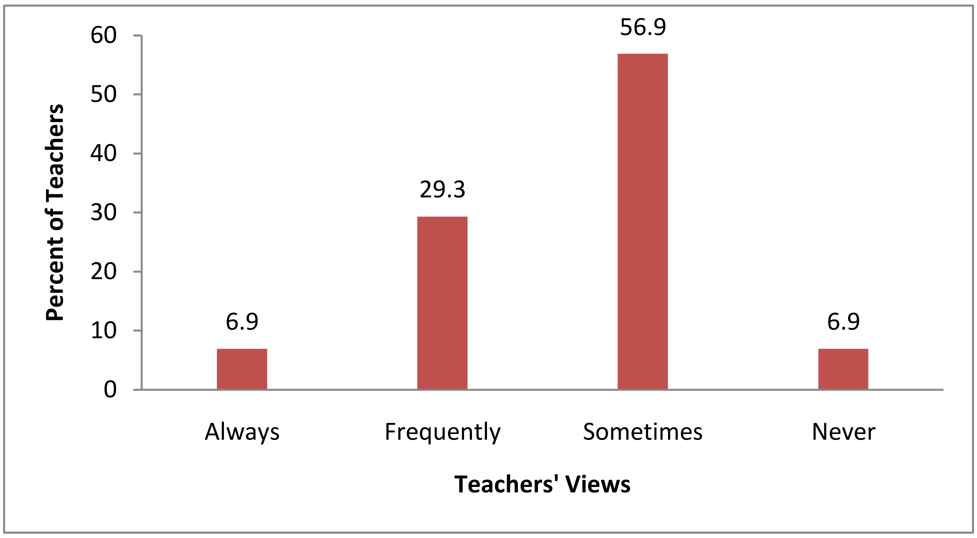

Figure 5.21: Use of group discussion in science class

Teachers also stated a liking for using student-centered methods. In particular, 29.3% and 6.9% of participant science teachers frequently and always used this method, respectively. Only 6.9% participant teachers never used group discussion in their science classroom (Figure 5.21).

The above data reflects that lecture, discussion, and lecture followed by discussion are the most popular teaching approaches among the participant science teachers in Bangladesh as they used these methods most frequently in their teaching. Sometimes they liked to use demonstration, group discussion and problem solving for their science teaching. It is difficult from the above data to identify any particular methods that teachers liked most for their science teaching. Also use all tradition teaching method for their teaching.

5.2.9 Teachers' preparation for science.

Lesson Planning

Different teachers use different planning tools (Donovan, 2004). Some prefer to develop their own, others like to start with an idea from another source and then modify it suit themselves. According to Table 5.12, when participants planned to teach a science lesson 45.4% frequently used a lesson plan that they had prepared and used before. 52.2% of them sometimes used a lesson plan that they had prepared and used before. More than half of them (55.1%) sometimes prepare a lesson plan in collaboration with other colleagues or a science specialist (See Table 5.12). A significant number of participant teachers did not prepare a lesson plan in collaboration with others. In addition, 58.5% of the participating science teachers did not use a lesson plan developed by other teachers who taught the same unit in the previous year. 40.3% of them sometimes used lesson plan developed by other teachers. The above data reflects that most teachers liked to prepare their lessons by themselves rather in collaboration with other colleagues in school.

Concerns in planning a lesson

Knowledge of the conceptions and preconceptions that students of different ages and backgrounds bring to learning are important for science teaching (Appleton, 2006), as are student-centered pedagogies that are constructivist in orientation (Cochran, deRuiter, & King, 1993). Regarding knowledge of students' abilities, learning strategies, age/developmental level, attitude/motivation, and prior knowledge, almost all of the teachers were in some way concerned about their students' interest. Figure 5.22 shows how they felt about this issue.

Table 5.12

Types of lesson plan that teachers develop

No	Item	Not at all	Little	Some	Quite a lot	A great deal
Lesson Plan						
a	A lesson plan that I had prepared and used before	3.4	14.4	36.8	34.5	10.9
			52.2		45.4	
b	A lesson plan I developed in collaboration with other teachers or science specialists	28.2	24.7	30.4	11.5	5.2
			55.1		16.7	
c	A lesson plan developed by other teachers	58.5	28.2	12.1	0.6	0.6
			40.3		1.2	

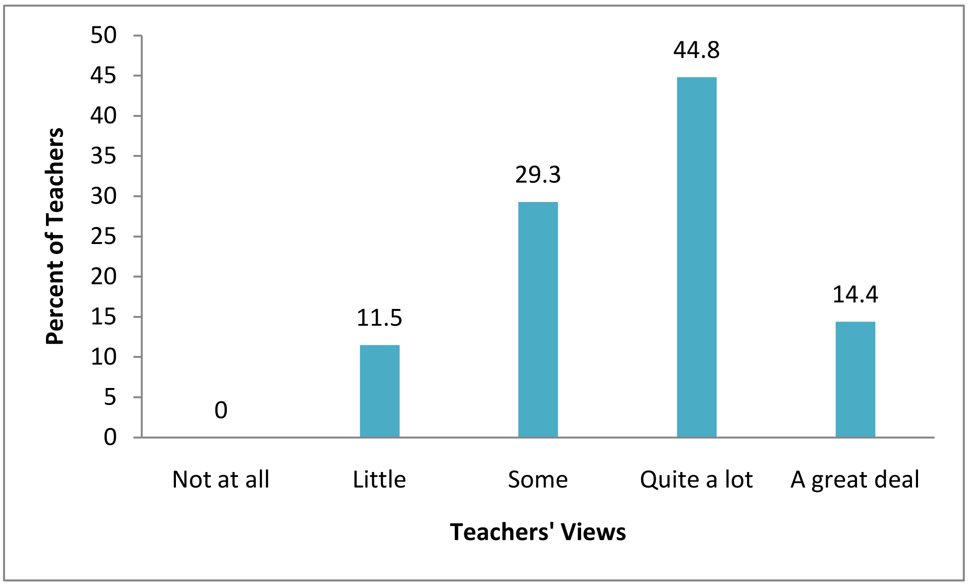

Figure 5.22: Teachers’ concerns about students’ interests

Table 5.13

Knowledge or ideas that teachers expect to use while preparing a lesson

No	Item	Not at all	Little	Some	Quite a lot	A great deal
Knowledge/Ideas						
a	Knowledge about students' interests	0.0	11.5	29.3	44.8	14.4
			40.8		60.2	
b	My understanding about students' level of thinking	0.6	8.1	35.6	40.2	15.5
			43.7		55.7	
c	Knowledge about students' difficulties	2.3	17.8	32.2	35.1	12.6
			50.0		47.7	
d	Ideas from a workshop or in-service training	1.7	6.3	47.2	33.3	11.5
			53.5		44.8	

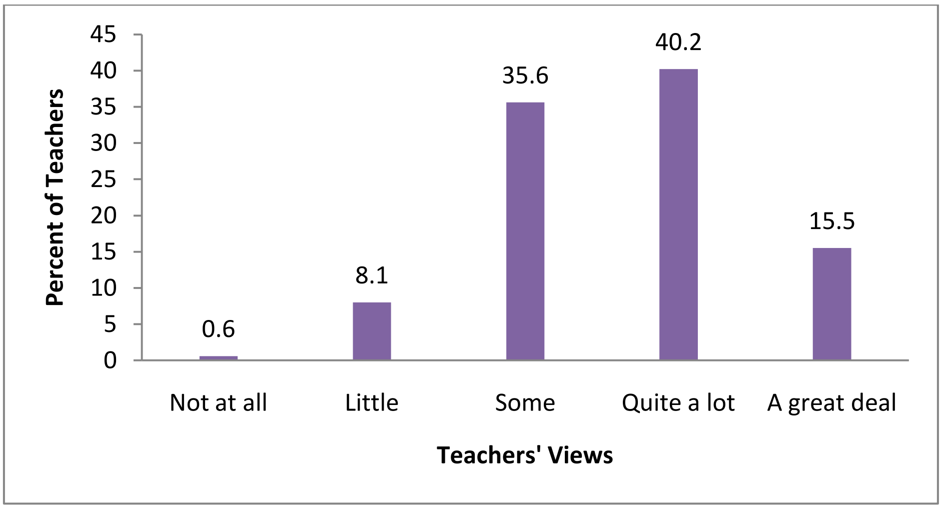

Figure 5.23: Teachers' concerns about students' level of thinking

In addition, teachers were also concerned about the level of their students' thinking. More than half of them (55.7%) used their understandings about students' level of thinking quite a lot in planning for teaching. It is quite interesting that only one participant (0.6%) did not think about this issue (see Figure 5.23 and Table 5.13).

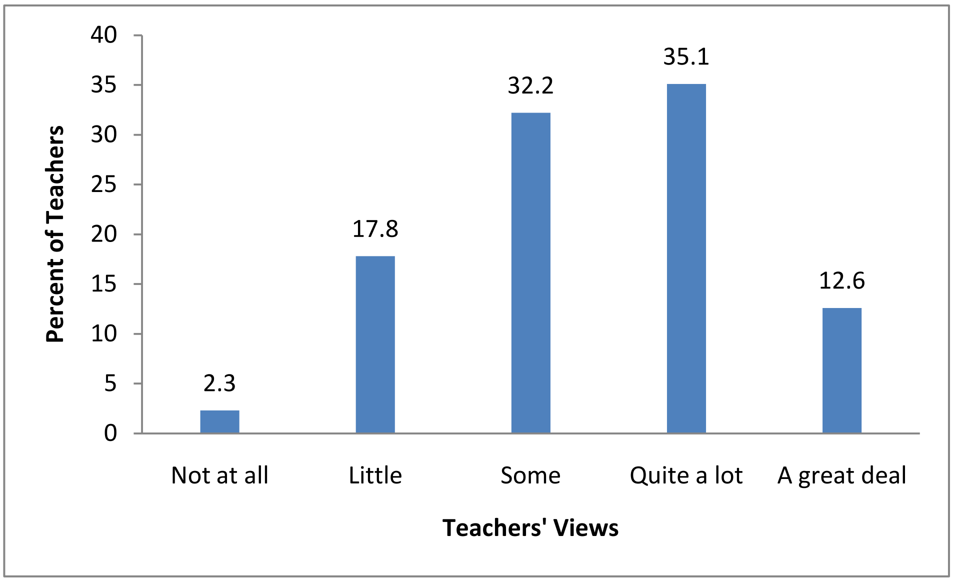

Figure 5.24: Teachers' concerns about students' learning difficulties

Half of the participant teachers reported that they were concerned sometimes about students' learning difficulties in planning their science lessons. In addition, 79.9% participants think quite a lot about students' learning difficulties while planning a science lesson (See Figure 5.24).

More than half of the participant science teachers (53.5%) were concerned sometimes to use their learning from workshops or in-service training in which they had participated (See Figure 5.25). 44.8% participants used quite a lot their learning from different training programs. From the above data, it is easy to conclude that most of them used their understanding about students' interests, level of difficulty and level of thinking in planning their science lessons.

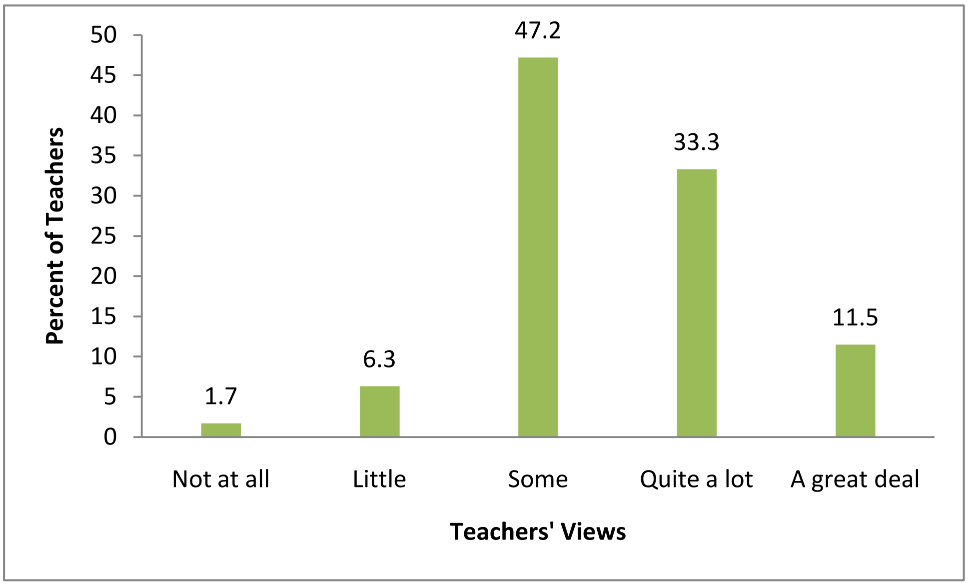

Figure 5.25: Teachers' views about their learning from in-service training

Resource use for planning lessons

Teachers generally, use different types of resources for preparing their science lessons. Among such resources for Bangladeshi teachers is the science student textbook, which is published and approved by the National Curriculum and Textbook Board (NCTB) for individual grade. A teacher's guide is also published by NCTB based on the student text book to help teachers find the most appropriate methods for teaching individual content in the text book. Teachers also use a guidebook published by different publishers (not approved by NCTB) for helping students to prepare for their assessment tasks. (The guidebook is considered to be a shortened version of the text book and includes a question and answer book.) Teachers also receive and use different 'Modules' and 'Activity Manuals' from different professional development programs run by both the Ministry of Education and different Non Government Organizations (NGOs).

It is observed from the collected data that 60.3% participants depended quite a lot on the students' textbook for lesson preparation. The teachers' guide (for text book) was also popular in the same way as 52.3% sometimes and 39.1% quite a lot used this, too. 40.2% of them did not depend much on the guidebook as they did not like to use this for their lesson preparation. Module and activity manuals were also not popular as resources for lesson preparation, as 55.2% of participants sometimes used these resources (See Figure 5.26).

Table 5.14
Types of resources teachers use for their teaching plans

No	Item	Not at all	Little	Some	Quite a lot	A great deal
Resource						
a	Student textbook	9.8	17.8	12.1	33.9	26.4
			29.9		60.3	
b	Teacher's Guide (version of textbook)	8.6	22.4	29.9	25.9	13.2
			52.3		39.1	
c	Guides book	40.2	28.8	20.1	6.3	4.6
			48.9		10.9	
d	Modules, Activity Manuals	17.8	23.6	31.6	21.3	5.7
			55.2		27.0	
e	Multimedia resources (Video, Laser Disc, TV)	76.4	12.7	6.9	2.9	1.1
			19.6		4.0	
f	The Internet	90.8	5.8	3.4	0.0	0.0
			9.2		0.0	

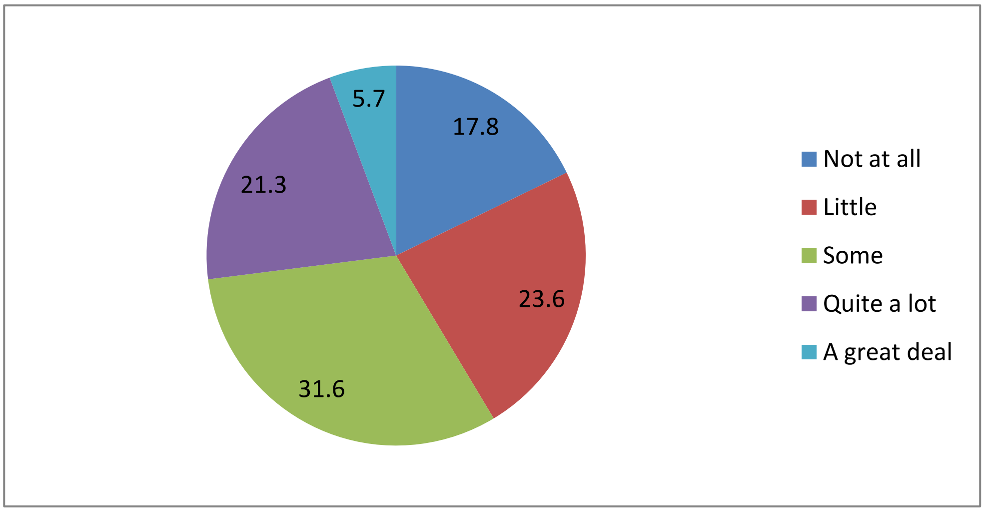

Figure 5.26: Use of module and activity manual as teaching resource

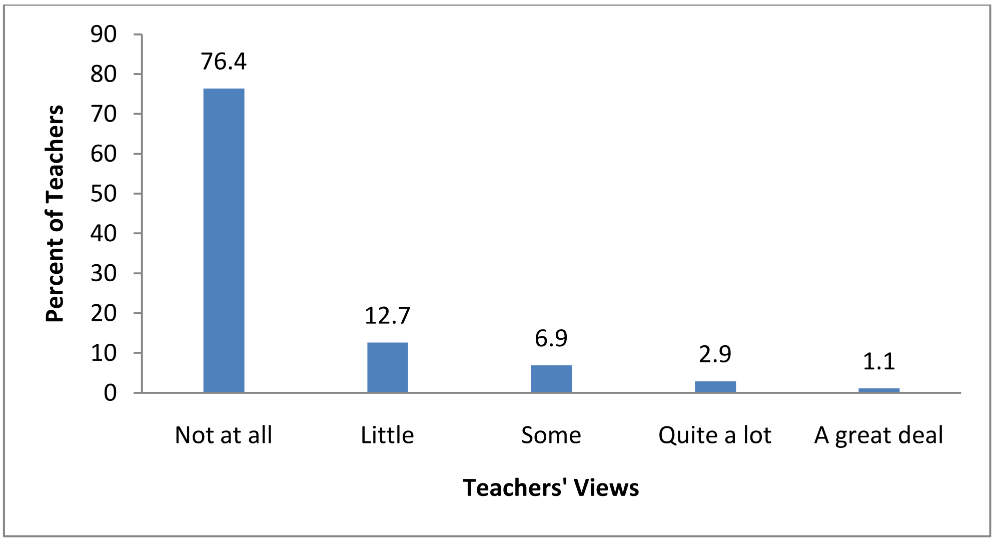

Figure 5.27: Use of multimedia as teaching resource

Multimedia resources and the internet are still not popular resources for science teachers to use in their science classes as mentioned earlier in the knowledge update section. Only in very few cases teachers use these resources during their preparation time, and not in the classroom. Consistent with the reality of limited access, 76.4% and 90.8% participants did not consider using Multimedia or the internet, respectively for preparing their science lesson (See Figures 5.27 & 5.28).

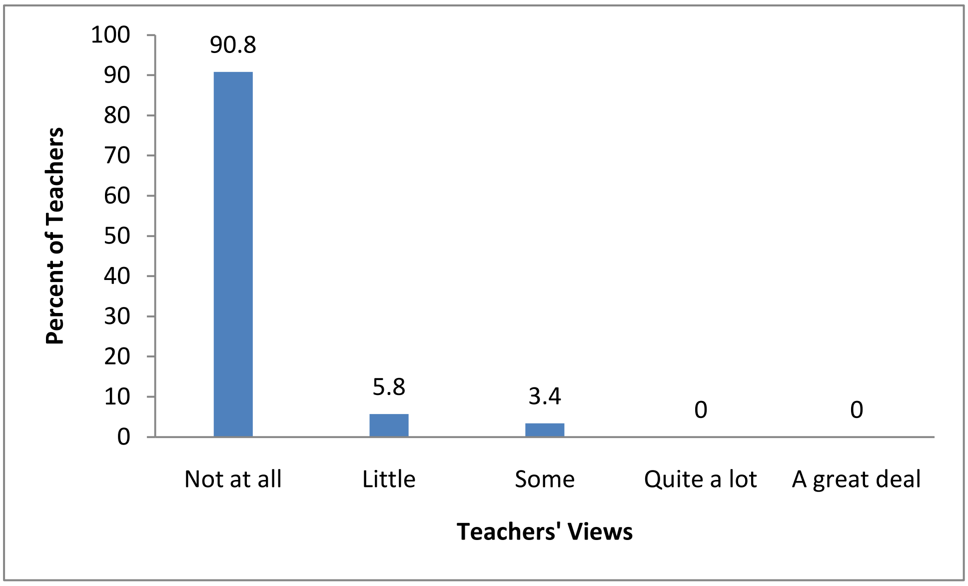

Figure 5.28: Use of the internet as a teaching resource

The above results reflect the fact that participant teachers mostly used the student textbook and teachers' guide for their lesson preparation. Some of them also liked to use guidebooks, modules and activity manuals in some cases. However, most of them did not use modern technology (such as multimedia resources and internet) for their preparation.

5.2.10 Professional development programs.

Professional development is a significant component in science education reform. During the past few decades educators have implemented a variety of programs aimed at increasing teacher knowledge and skills (Loucks-Horsley, et al., 1998). Joining in any kind of in-service training on subject matter knowledge/pedagogy has long been considered to be a part of teachers' professional development. It is observed from the data that 60.3% of the participating science teachers had received in-service training on subject matter knowledge or pedagogy during the two years prior to this study. Among them, 89.2% (who had received training) stated that the training helped them to increase their existing knowledge about subject matter knowledge or pedagogy (See Figure 5.29). The 'missing' section of the pie-chart below shows participants who did not receive any kind of in-service training. In addition to that, 81.6% of them noted that

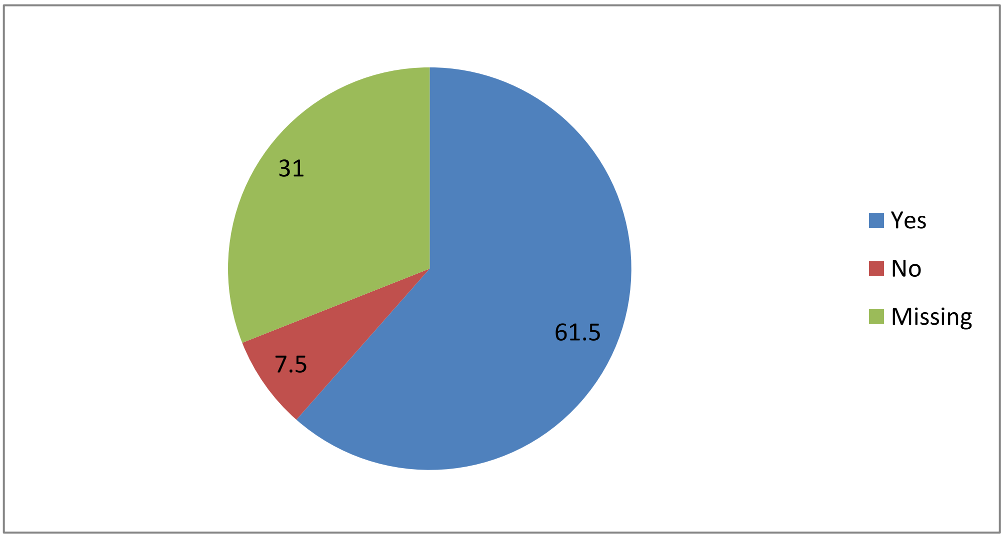

Figure 5.29: Impact of in-service training

their school authority supported them to join into the in-service. So, the above data reflects a positive impact of the kind of professional development programs that the participant teachers received.

5.2.11 Collaboration and learning communities.

Teachers need supportive, collegial communities when inquiring into significant questions about science subject matter as well as into questions concerning learning and pedagogy (Loucks-Horsley, et al., 1998). Professional development activities may include daily structured time for collegial discussion and planning with teaching colleagues from the same school or their peers from other schools. Coherence between professional development activities, school policies and professional experience supports increased teacher learning and improved classroom practice (Biman, et al., 2000). Keeping these issues in mind, it is observed from the data that almost all (97.1%) participants expressed the view that they enjoyed attending science teachers' conferences to learn about new ideas in science teaching (see Figure 5.30 and Table 5.15).

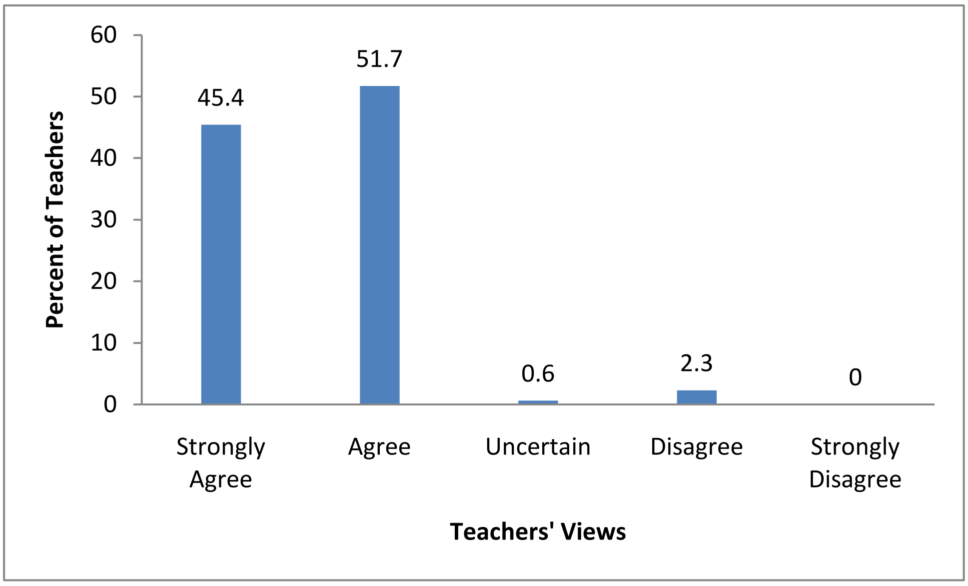

Figure 5.30: Participation in science conferences

Table 5.15

Collaboration and learning communities

Item	**SA**	**A**	**UN**	**D**	**SD**
I enjoy attending science teacher conferences to learn about new ideas in science teaching	45.4	51.7	0.6	2.3	0.0
	97.1			2.3	
My work as a science teacher is appreciated by my science colleagues	6.3	58.0	13.2	18.4	4.0
	64.3			22.4	
Given the choice, I would <u>not</u> invite my science colleagues to observe my science teaching	2.3	9.8	2.3	49.4	36.2
	12.1			85.6	
I enjoy working with colleagues about science curriculum and teaching, even if it means after-school meetings	10.9	74.2	4.0	8.6	2.3
	85.1			10.9	
I have adequate opportunities during the school day to collaborate with my science colleagues about science teaching learning	5.2	35.1	9.8	36.8	13.2
	40.3			50.0	

Almost two-thirds of the teachers (64.3%) stated that their work as science teachers was appreciated by their science colleagues. At the same time, most of them (85.6%) showed interest in inviting their colleagues to observe their science teaching for the purpose of professional development (See Figure 5.31). They also professed enjoying working with colleagues about science curriculum and teaching (85.1%), even if it meant after-school meetings.

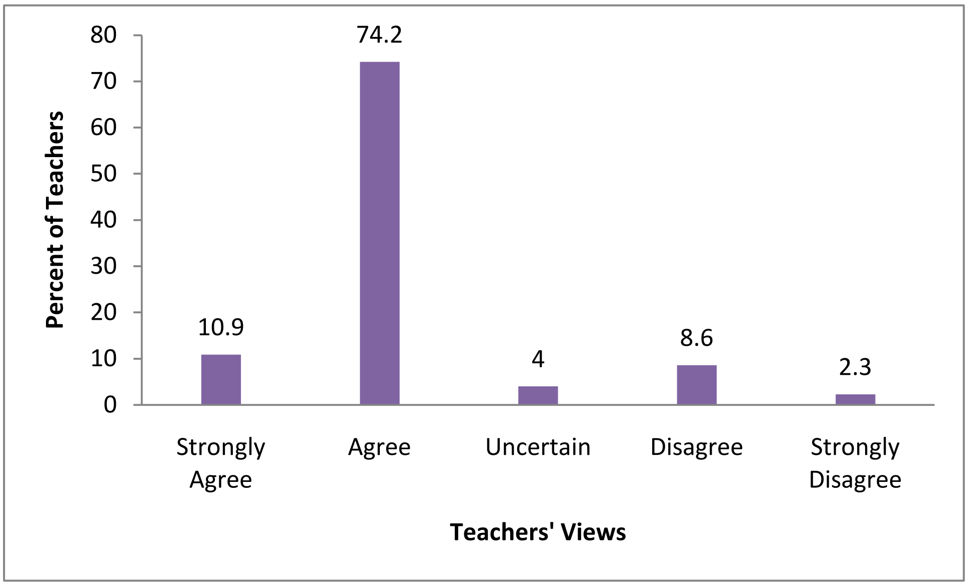

Figure 5.31: Opinions about observation of science class by their colleagues

However, again participants were divided about the possibilities for having adequate opportunities during the school day to collaborate with their science colleagues about science teaching and learning. 40.3% participants felt that they had adequate opportunity to share with their colleagues, whereas 50.0% expressed a negative opinion regarding this issue. In addition, 9.8% of the participants felt uncertain in their opinion regarding this issue (see Figure 5.32 and Table 5.15).

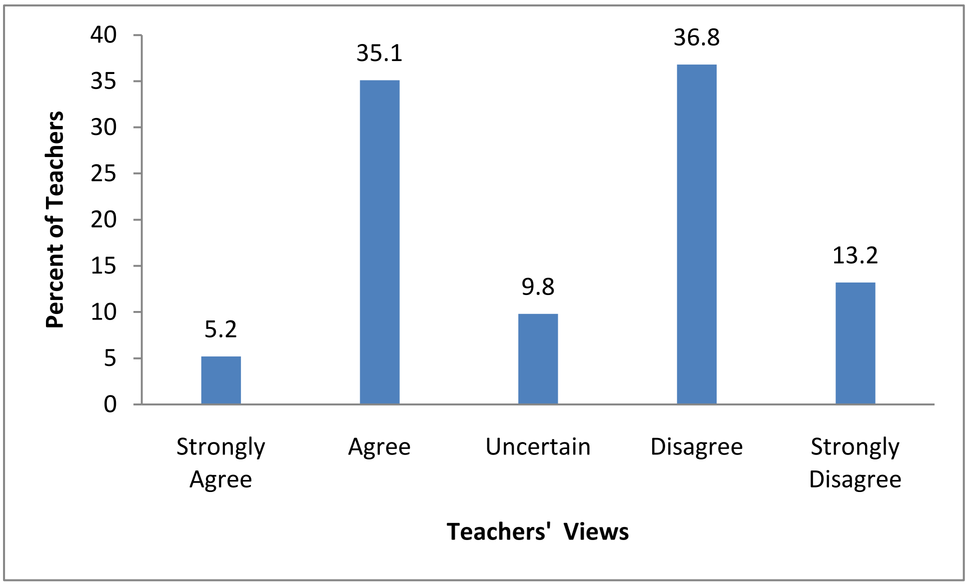

Figure 5.32: Adequate time for sharing with colleagues during school hours

The above data reflects that most of the teachers liked to join in activities which helped them to improve their practice. However, it also reflects an uncertainty regarding their interest in sharing with their colleagues and getting adequate time for these activities.

As part of professional development activities/collegiality, teachers can observe each others' science lessons. More than half of the participants (58%) stated that their science

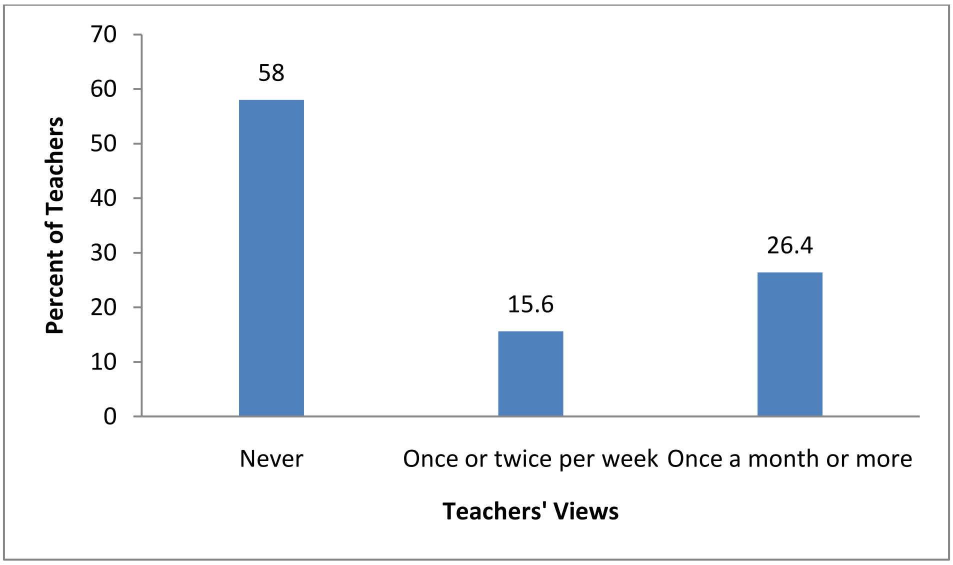

Figure 5.33: Observation of science teaching by science colleagues

teaching had never been observed by their science colleagues. On the other hand, 42% of teachers stated that their science teaching was observed either weekly or monthly by their colleagues (see Figure 5.33). However, in most cases, this observation was undertaken by head teachers who were themselves science teachers, but never for the entire class time.

51.7% of participants also stated that they never observed their colleagues' science teaching, though 48.3% of them sometimes visited their colleagues to observe their science teaching (See Figure 5.34).

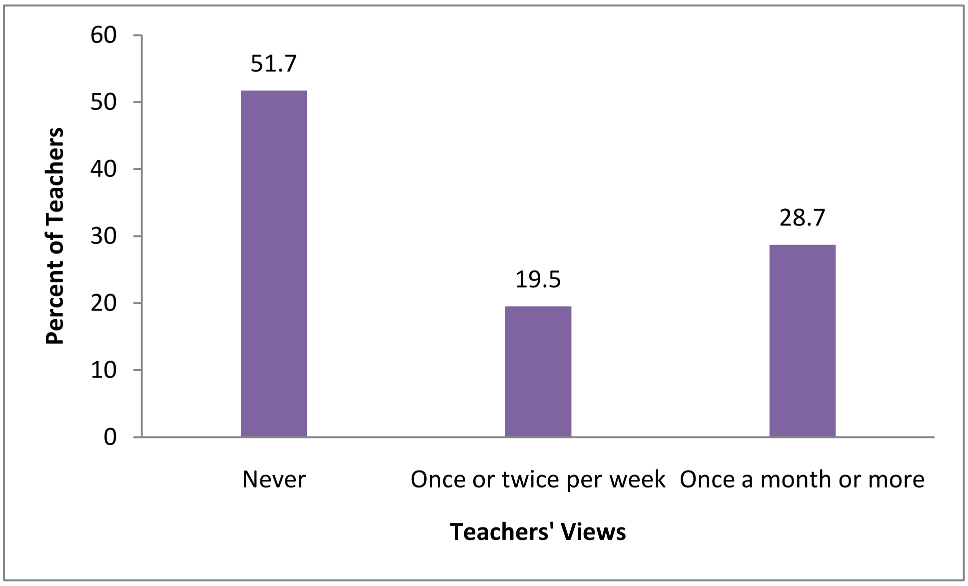

Figure 5.34: Observation of teaching of other science colleagues

All participants (100%) stated they had no learning community to improve their science practice and none of them had any opportunity to participate in any such community. The above data reflects the position that teachers are familiar with classroom observation, whether they use it or not for the improvement of their own practice. At the same it is clear that no community exists for improving their practice.

5.3 Results from Baseline Semi-Structured Interviews

This section looks at the results of collected data through a semi-structured interview concerning the first research question (RQ1). The purpose of this section is to unpack how teachers confronted their current practice. In most cases, the issues follow the format of the baseline questionnaire that was discussed in the previous chapter.

5.3.1 Data sources and analysis.

The baseline interview data in this research was conducted through a semi-structured interview protocol for secondary science teachers. 16 science teachers were selected through 'maximal variation sampling' to be involved in this interview aspect of the study. The interview was conducted in Bangla (First language of Bangladesh) and then translated into English. The main reason being is to ensure a better understanding of the interview questions by all the Bangla speaking science teachers. The English transcripts of all 16 interviews were then analysed using NVIVO 8 software to determine the main themes and issues from participants' perspectives.

Data analysis in this section is mainly aimed at triangulating the responses from the baseline questionnaire in the previous section in order to finalise understandings of the responses to RQ1. The findings are presented under different themes sequentially. The findings from the responses are categorised in the following five themes: subject knowledge in science of teachers; understanding about alternative conceptions in science of science teachers; pedagogical understanding of science teachers; nature of professional development and collaboration among science teachers; and limitations in current practice. The limitations mainly cover the availability of resources and teaching load for science teachers.

5.3.2 Difficulties with subject matter knowledge.

The analysis in the first part of chapter 5 showed that the majority of the participant teachers found difficulty with their subject knowledge in science. The nature of these difficulties included: explaining content; and, linking principles or theories with real life or providing real life examples. In relation to these difficulties and how they might be overcome, teachers responded in different ways. Almost all had concerns about difficulty with the subject knowledge they needed to teach. Seven teachers spoke about the quality of the textbook in terms of information regarding subject matter. For example, according to Mr. Datta, "Firstly we mainly depend on the textbook for the information needed to be taught. In some cases, we do not find a clear understanding from the textbook information, which makes it difficult for us to explain to our students." Further to this, Mr. Karim mentioned that "Total internal reflection in grade eight is very hard to understand from the text book information." They also made it clear that they had concerns providing real life examples. According to Mr. Goni, "In the text book we find relevant real life examples in very few cases. Then we cannot provide adequate examples to students for their better understanding of the science concepts."

Participant teachers also mentioned some of the ways that helped them to overcome their difficulties with subject knowledge. Half of them (8 from 16) liked to check books from higher classes or any reference at the time when it was needed. Three teachers liked to talk with their friends outside the school when considering their problems with subject matter knowledge. Three of them liked to share with their colleagues informally at the time of need or when then they had any difficulty in explaining subject knowledge. Mr. Fakir expressed the view that:

> I never think before for sharing or discussion with our colleagues for the problem of our teaching practice. Nowadays we like to talk with each other for our problems. We mainly share with our colleagues to make the lesson more attractive. We also like to discuss to minimise our confusion.

This result is consistent with the baseline questionnaire where teachers use different sources as well as discussion with their colleagues to clarify their teaching knowledge.

Teachers also expressed reasons about why they liked (or did not like) to teach science. Their responses linked with those of their difficulties in subject matter knowledge. Five of them liked to teach science because of its links with real life. Mr.

Bari and Mrs. Chandana expressed this view almost in the same words, “I prefer to teach science because it is possible to provide more real life examples in science.” Others who liked to teach science mentioned the nature of diversity of science concepts in general science, interest in innovation in science and technology, and more scope to make the class participatory. Mr. Osman expressed the view that:

> I like to teach science. The reason is that this is the time for science; however, we are behind in science in relation to the development of modern technology. Society is not much aware with latest development in modern technology. Knowledge in science is more real life oriented and helps to overcome superstition, so I like to teach science.

On the other hand, some teachers did not like to teach science for other reasons. These included: the abstract nature of science concepts; preparation for teaching aids for better teaching; and, unsuitable school context for an effective science teaching. According to Mr. Mazhar, “For effective or better science teaching, I need to demonstrate in relation to the topics and that is not always possible in the real setting in our schools”. However, Mrs. Parvin expressed in different ways her experience with resources in the school:

> the setting of our local environment is easy for science teaching and we have a lot of resources in our school. Students also can collect different teaching aids as we guide them. The scope for student involvement for participatory teaching is also higher in science teaching.

5.3.3 Alternative conceptions.

The importance of taking into account students’ prior knowledge has been noted earlier in this chapter. The analysis of the responses illustrates that almost all participants found this to be very important. However, different teachers expressed their reasons for this level of importance in different ways including: to understand the level of students’ knowledge; to know whether students have any idea about the topics; to help students to be attentive in the lesson; to make the lesson easy; and, to check whether students still remember the learning about the related topics in their previous class. Mrs Irine expressed the reason as follows:

> It is important to know students' prior knowledge. If students have some prior knowledge about the topic and I know that then it is easy to teach them. At the same time, as a teacher I need to know the prior knowledge because it helps me to understand from where I need to start. Students will also then able to understand the topics quickly.

Teachers use different ways to explore their students' prior knowledge. In most cases, teachers liked to use a question method to explore students' prior knowledge. For example Mr. Ekram said that in teaching about the Natural world, "First I try to find out their knowledge about living thing and matter." Alternatively, some liked to explore students' prior knowledge through different activities that helped students to concentrate more on the lesson. Mr. Jafar said that in the case of teaching Heat, "I usually like to ask students to observe the change after rubbing their hands together for a minute." A few of them, liked to use pictures or any kind of model to explore the students' prior knowledge.

Teachers usually had a plan (may not be in written form) for their lesson. In response to the question, "how do you manage when you find students are not on the right track, or that some students have some alternative conceptions?" most responded that they needed to explain from some basic position. Mr. Habib responded as follows:

> In that case, I need to explain the topics properly. At the same time I try to find out what the basis of their alternation conception in their prior knowledge asking several questions and try to link the topics with real life situation. I need more time to manage this kind of challenge.

It has been also mentioned that teachers are not that familiar with the terminology of alternative conceptions or misconceptions. Analysis also reflects a similar result. Most (12 out of 16) reported that they did not notice any alternative conceptions in their students' prior knowledge. Some responded, "I cannot remember anything about this right at this moment." Some (4 out 16) mentioned one example where they found incorrect information in the concept. These examples were: how pressure differs with depth; the concept of Work; whether a mirage is related to Light refection/refraction; and, the working principle of vacuum flux. However, none were able to explain in detail what they found in relation to alternative conceptions in those examples.

5.3.4 Pedagogical understanding.

It has already been discussed that most science teachers like to prepare their lessons by themselves. However, teachers also talked about their concerns in preparing a lesson. Nine of the 16 teachers were mainly concerned about how they promoted understanding of science concepts for their students. They tried to make the make the lesson simple and understandable. According to Mr. Ahmed:

> Firstly, I have to think for a simple and understandable presentation of the concept. For this I have to understand what the objectives of the lesson are, what the core part of the lesson is, and then what things need to be assessed.

Seven teachers were concerned about the level of their students' understanding in class. According to Mr. Datta, "Some students understand the topics very quickly, whereas others take more time to understand the topics. Teachers need to repeat their presentations for some students." In addition, six teachers liked to think about their students' prior knowledge before initiating a lesson in order to understand where they needed to start from. Five teachers were concerned about the necessary teaching aids to make their classes more interesting. On the other hand, one teacher mentioned that he always liked to use the local language for explaining most examples in the science textbook.

In response to how they selected teaching strategies, seven teachers responded that it depended on the individual topics and the students' level. According to Mr. Karim:

> It depends on the individual topic. Sometimes it depends on the level of students' merit for individual class. I have to choose different strategies for different sections depends on the student condition. So I have to teach choose same topics in different way.

Ten teachers talked about the relationship between their teaching experience and selecting strategies for the lesson. They mentioned that teaching experience helped them a lot in selecting teaching strategies for a particular topic. According to Mrs. Parvin:

> My teaching experience helps me a lot. I find a big difference; at the beginning of my teaching I had a lot of problem in selecting teaching approaches. Now I am facing less trouble. I do not need more time to find appropriate strategies for any of my teaching topics. I feel more comfortable to understand the objectives

> and what I need to assess of the topics. Now I am able to explain more comfortably.

Moreover, Mr. Nayeem mentioned, “as methods depend on the individual topics, sometimes several techniques are needed to make an effective class, so I have to understand which should be better from my own experience.” It was also mentioned that most of the teachers liked to join in activities which helped them to improve their practice. In essence, they were talking about how and why they accepted new teaching strategies. Six teachers mentioned that they liked to use anything which they saw as effective in terms of enhancing their teaching. According to Teacher ‘Bari’, “When I understand any new strategies that might better for student understanding, then I go for it and use it”. Another teacher ‘Ekram’ mentioned, “I learnt the Snowball strategy from a training program I attended last week and I understood that it would be effective for my class”. At the same time, six teachers noted that they always liked to learn something new and felt they needed to bring about a change in their teaching.

Teachers also talked about how their own views shaped the selection of teaching strategies. For instance, according to Mr. Mazhar:

> Teaching will be different if two teachers take the same lesson. This is due to their views about teaching and learning. It depends on how they think to what extent the topics are important. As a result class activities will be different because of different analysis.

Mr. Ekram also talked in the same way , “ The main thing is that class activity differs according to how the teacher views different things. Classroom management should be different for different viewers.”

According to these teachers, efficient teachers will do better in their classroom performance. When a teacher feels that he/she is confident about a topic then he/she can make the topics more interesting and fruitful for students.

5.3.5 Professional development and collaboration.

All 16 teachers talked about their professional development. They felt they needed more study and wanted to attend more in-service training. Eight teachers wanted to extend their sharing with science colleagues even across other schools. According to Mr. Lalit, "We need more commitment for our profession. We need to attend more available training. We have to be more conscious to improve our practice. Besides, we need to increase discussion with our science colleagues."

Four teachers also mentioned that it was important to develop their habit of reading science reference books for their own learning. In response to the use of their science colleagues as a source for their professional development, all 16 teachers gave a positive comment. They claimed that it helped them to know from their colleagues about what they did not know. The ways teachers used their colleagues included: observing each other's teaching practice (12 teachers); discussing their pedagogy (seven teachers); discussing confusion in teachers' and students' subject matter knowledge (nine teachers); discussing problems raised during class (five teachers); and, discussing preparation of teaching aids (three teachers).

However, 10 teachers mentioned that it was difficult to find time to discuss with their colleagues due mainly to the current class load. At the same time, as they were all science teachers anyway, they had to take classes at the same time, so it was also difficult to observe each other's classes. Seven teachers mentioned that they were trying to find times to discuss with each other. According to Mr. Bari, "sometimes we share, however it is very difficult due to class load, however, I try to share my problems in gaps between classes, even at the Tiffin time or after school." At the same time, five teachers said that they felt shy in discussing their teaching with their colleagues. According to Mr. Lalit, "it is a matter of being too shy to ask our colleagues sometimes." In addition Mr. Mazhar proposed some aspects in relation to his thinking for sharing among colleagues:

> Teachers have to be honest before sharing, and have to respect each other and need to feel trust with each other. Then sometimes we can discuss in some free time about our problems, even sometimes we can observe each other's class that will help us to discuss and critique our practice.

5.3.6 Limitations in teaching.

5.3.6.1 Resources for teaching.

In response to the availability of resources in the school, respondents could be categorised into different groups. One group responded that they had sufficient resources for the secondary science teaching. According to Mr. Karim "I think schools have sufficient resources for secondary level, we do not need more things to use for our teaching." On the other hand, another group of teachers thought that they did not find sufficient resources for their teaching – resources which are very important for making the lesson attractive. According to Mr. Bari "It is insufficient for what we need for our teaching. We are facing difficulty to demonstrate anything in real setting. I think, teaching is affected due to shortage of resources." At the same time, Mr. Datta expressed that, "In some case, we are lazy about using teaching aids in our teaching – yet they are very important for clearing up any science concept." According Mr. Ekram, "Actually, we are doing our teaching anyway. I feel bad whenever I understand that I need to use teaching aids, however, I am not using them whether they are available or not".

Almost all of the teachers felt it important to have a collection of resources. Most liked to collect something from the local environment by themselves especially for biology content. In some cases, they liked to involve students in collecting different teaching aids. Mr. Fakir expressed as follows:

> I was teaching the Green house effect. Before the class I guided students to make a model of green house. They asked for my help. Then we make it together before the class. They find it interest and on that day the environment of the class was totally different. There was a big difference with the same class in last year when I did not use any teaching aids.

Another teacher, Mrs. Irine, was talking about her experience for exchanging resources for teaching among colleagues at nearby schools. She found it to be a way of minimising the lack of resources for effective teaching. At the same time, Mr. Habib pointed out that, "if we collect once, we can use it for several times. Posters particularly are one kind of them."

5.3.6.2 Teaching load for science teachers.

It has already been noted that teaching load is a matter of concern for the quality of educational services for teachers. Most of the teachers had a heavy load so in response to how they coped with this teaching load 13 out 16 mentioned that it was not possible to prepare all the classes that they had to take in a day properly. Eleven of them mentioned that it raised questions about quality as they had to take five to six classes per day. According to Mr. Habib:

> It is difficult to take preparation for all classes. It mainly affects maintaining a quality education. If we have three classes every day, then it should be possible to be well prepared and collect all required teaching aids for all three classes and be able to maintain the quality. However, if I have six how can it be possible to maintain the quality of the classes?

Five teachers mentioned that as they had to take class after class it was not possible for them to conduct satisfactory teaching. This situation ultimately led them to experience a great deal of pressure in their teaching. Two teachers also mentioned that extra teaching load did not allow them to concentrate properly on getting and responding to student feedback and it was also difficult to apply different strategies in their teaching.

Most schools in Bangladesh have an insufficient number of science teachers and, in many cases, science teachers do not teach in grades Six and Seven - which is considered an elementary stage for students' learning of science. Ten teachers agreed with this claim. They believed that a shortage of science teachers caused this problem. Three of them mentioned that as science teachers, they were too busy taking classes in the upper levels according to their specialization, while non science background teachers usually took science classes in the junior level.

Most teachers seemed concerned about the impact of non science background teachers taking science classes, with 13 of them talking about this issue. Their main concern was that it decreased student participation in science. According to them, these teachers could not make science classes interesting because of their lack of science pedagogy. According to Mr. Habib:

> It is not possible to conduct a proper science class with the non background science teacher. This is not a right decision. In most cases, the teacher asks students to prepare answers to the questions at the end of the each chapter. Students stay far away from understanding science and grow a concern that science is a hard subject. Ultimately students feel afraid in science and stop science at grades Nine and Ten. As result, participation in science is decreasing day by day. We will find no students for science teaching in the future.

Teachers also felt heavily burdened by the load in their teaching due to large class sizes and duration of the class time. Five teachers mentioned that due to the above reasons, they were not able to assess all students in time. According to Mr. Datta "[it is] difficult to assess all my students. As a result I cannot understand the effectiveness of my teaching. It is difficult to bring about any change in my teaching." Such situations lead them to frustration as they are not aware of the effectiveness of their class. So, it is really difficult to bring any change in their teaching.

5.4 Chapter summary

This chapter presented teachers' views about their teaching practice and students' learning in science. The results indicate that participant teachers are concerned with their teaching context. Most of the participant teachers prefer mathematics rather than science for their teaching. They were also concerned about the abstract nature of science, preparation of teaching aids, and teaching more in higher grades (Grades Nine and Ten) as almost half of these teachers did not take any teaching in grades Six and Seven. In most cases, participant teachers had an excessive teaching load. They found difficulty in preparing for classes and most did not spend a great deal of time preparing their science lessons.

Participant science teachers expressed their views on scientific knowledge, science teaching and students' conceptions in science. The majority of them do not consider science an abstract subject. However, there exist contradictory views amongst these science teachers about the subjectivity and objectivity of the nature of scientific knowledge. The majority of these teachers did not consider science teaching to be harder than other subjects. They also held opposing views regarding the responsibility of the teacher for their students' achievement. Participants held beliefs of high expectations about their science teaching outcomes. Moreover, the majority of participants had not heard about the notion of “alternative conceptions” or “misconceptions” in relation to science concepts. They even did not notice any alternative conceptions in their students’ prior knowledge. Some of them found incorrect information in the concept; however, none of them were able to explain in clear detail what they found in relation to alternative conceptions in those examples. The majority of participants remarked that students had their own views regarding science concepts. Most of these teachers felt that they needed to take into account the prior knowledge that students brought into their classes that helped them to understand from where they need to start the lesson.

Participant teachers also expressed views regarding their knowledge of science content. Almost all of them had concerns about difficulties with the subject knowledge they needed to teach. A significant number of the participant teachers faced difficulties in providing real life examples. Most participants liked to discuss with their colleagues issues about teaching but paradoxically, did not often find time to be able to do so.

Participant teachers mainly used traditional teaching methods based on talk, text and demonstration. The lecture, discussion, and lecture followed by discussion was the most popular method amongst these science teachers. Sometimes they liked to use demonstration, group discussion and problem solving in their science teaching. Most teachers prepared their lessons by themselves. Participant teachers mostly used the student textbook and teachers’ guide for their lesson preparation. Some teachers liked to use guidebooks, modules and in some cases, activity manuals. Furthermore, the results indicate that participant science teachers had limited access to resources and they also used very few resources in their classes.

Participant teachers also expressed their views regarding issues about their professional development and collegiality among science teachers. They were of the view that attending in-service training was valuable as it helped their learning about teaching, and they were looking for more in-service opportunities. They found these opportunities for teachers to enhance their knowledge and skills for teaching. However, in most cases, teachers complained about the training available. Moreover, most of the professional development courses were neither regular nor frequent. They also expressed positive views regarding their interest in sharing with their colleagues but had mixed views regarding getting adequate time for collaborative activities. They showed their interest in inviting their colleagues to observe their science teaching for the purpose of their professional learning but had few opportunities to actually do so.

Chapter 6
Results from the Intervention

6.1 Introduction

This chapter looks at the results of the intervention used in this study. The intervention was designed for participant teachers to observe, critique and use a new teaching approach (Prediction-Observation-Explanation - POE) and engage in professional learning through observing, sharing and challenging each other's teaching practices; in so doing, also work toward forming a professional learning community within and across schools. This section of the study presents findings that identify the changes both in teaching perceptions and the culture of professional practice within the teacher participants and their professional community.

6.2 Data Sources

The central data sources for this chapter are classroom observations, the subsequent post-teaching discussions and the professional workshops. This part of the research design was conducted with 14 volunteer participant science teachers who were formed into seven peer pairs, from seven nearby schools. Each pair of teachers was located at the same school. There were four teaching cycles, each cycle consisting of one teaching session and a subsequent discussion session by each peer pair. It is notable that in each teaching cycle all peers used the same science teaching topic from the junior secondary level. In total, therefore, there were 28 science teaching sessions for four teaching cycles, 28 subsequent discussion sessions and four follow up professional workshops.

In this study, I worked as a participant observer and maintained field notes (during class and discussion time) as well as noting personal reflections after observing each teaching session. Therefore, this chapter deals with four teaching cycles involving 28 classroom observation schedules from observer teachers, 28 classroom observation schedules from conductor teachers (self reflection), 28 participant observer comments from the subsequent post-teaching discussions and notes from four professional workshops.

Both the teacher observer and the teachers reviewed their notes individually after each teaching session using the same classroom observation schedule. These individual reflections formed the basis of a discussion between both teachers in which they shared and challenged each other's observations, which was observed by the researcher. During the teachers' discussion they could critique or challenge each other's reflections. Issues about which they were undecided or were notable for some important reason were recorded by the researcher and then included in a subsequent workshop led by the researcher as issues to be discussed with the whole cohort of teacher participants after each teaching cycle. To facilitate presentation of the findings, the results are offered in three major sections (section 6.3 - results from classroom observation, section 6.4 - results from post teaching discussion and section and 6.5 - results from professional workshop). A summary of results from the intervention are presented at the end of this chapter.

6.3 Results from Classroom Observation

This section presents results from the refection of teachers immediately after the teaching sessions. The participant science teachers planned their teaching based on the use of the POE teaching approach. The lesson was then reflected upon, individually, after each teaching session using a classroom observation schedule. The schedule comprised four sections: (i) resources; (ii) content knowledge and its organization; (iii) pedagogy; and, (iv) classroom learning environment (see Appendix 3). Each individual section contained several items of interest. This schedule provided a choice based on three categories in terms of the extent to which the teacher emphasised each of the four sections: did not emphasize; recommend more emphasis; and, accomplished very well for an individual item. For example, when any reflection was recorded as 'recommend more emphasis' the usual meaning was that teachers needed to provide more emphasis on that particular individual item.

6.3.1 Data analysis.

The data analysis procedure followed the Activity-Reflection-Learning-Action (ARLA, see section 3.11 in method chapter for full description) analysis frame. Activities mainly prescribed what the teacher and students did during the teaching session in using a new teaching approach (e.g., POE). The teacher's activities then served as a basis for the reflection both for the teacher him/herself and the observer using the observation schedule after each teaching session. The analysis procedure mainly required the identification of changes as teachers approached the next teaching cycle. This analysis basically followed two main themes: teacher's self reflection; and, observer's reflection. Firstly, I summarised the reflections of both the teacher and the observer. Results were tallied and reported on the basis of total frequency for individual choice from the observation schedule. This analysis allowed me to identify those items with which teachers provided more emphasis in their attempts to implement teaching based around a POE teaching methodology.

During the research, each voluntary teacher conducted two teaching sessions and observed two teaching sessions. Therefore, secondly, to compare and identify the changes, I put individual teachers' self reflections into two columns that allowed for simple comparison between their first and second sessions. I also developed another table consisting of two columns based on the observer's reflection of the same teaching session. I then calculated the changes (both positive and negative) in terms of frequency across different peer pairs. Any positive changes were then considered as Learning (for the ARLA frame) and were considered as an impact factor in the subsequent discussion after the class. The results again are from total frequency and allow a focus on how the intervention influenced changes in their teaching practices.

After their discussion both teachers were asked to re-check and note whether they wished to change or reconsider any item from the schedule. Therefore, thirdly, I calculated the marked items for all peer pairs and they are reported as 'Learning' from individual teaching sessions later in the chapter. After that, I checked and calculated whether they were concentrating on this particular learning in their subsequent teaching sessions. Whenever teachers approached their teaching using that learning in their following teaching session, it was then identified as 'Action' of their learning. Again, the results are reported as frequency to demonstrate where teachers placed more concentration in using an intervention and also to allow for recognition of how the intervention influenced teachers in changing their teaching perceptions.

6.3.2 Results of changes in the teachers' teaching perceptions.

This section mainly concerns changes in the teaching conceptions of the participant teachers following the intervention. As the analysis follows the ARLA framework, the results are also presented in the same sequence. The general teaching activities therefore for the four teaching sessions are presented as follows:

6.3.2.1 Activities for teaching sessions.

Activities for teaching session one

This teaching topic was from the Physics section of General Science in grade VII. The teachers demonstrated an experiment for understanding the characteristics of the pressure of liquid (See Figure 6.1). The teachers used a plastic bottle with three holes at different heights on the same perpendicular line. The teacher then asked students to predict (in writing) what would happen to water when it was poured into the bottle through its open end. Students observed that jets of water came out of the holes in a position perpendicular to the wall of the bottle. The jets of water fell at different places from nearest to further away from the wall. At the same time, it was observed that jet of water could not flow too far perpendicularly since the gravitational force of the earth "pulled" the jet downwards.

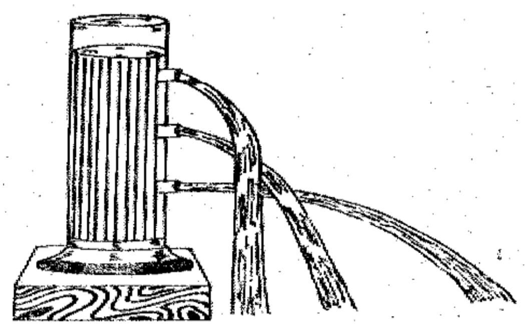

Figure 6.1: Pressure increase with the depth of the liquid

Source: (Shamsudduha, Miah, Wahab, Khan, & Chowdhury, 1997)

Activities for teaching session two

This teaching topic was from the Chemistry section of General Science in grade VII. The teacher demonstrated an experiment by preparing a saturated solution by adding salt/sugar to an unsaturated solution (See figure 6.2). The teacher continued to add spoonfuls of salt into the mixture, stirring it continually. The teacher then asked students to predict whether the salt would continue to dissolve in this way by adding salt/sugar or they tried to change the solution from unsaturated to saturated or vice-versa.

Figure 6.2: Preparation of saturated solution of salt

Source: (Shamsudduha, Miah, Wahab, Khan, & Chowdhury, 1997)

Activities for teaching session three

This teaching topic was from the Physics part of 'General science' in grade VIII. The teacher did an experiment with the refraction of light. The teacher used some water in a cup/glass/beaker and dipped a thin stick/pen obliquely into it (See Figure 6.3). The

Figure 6.3: Refraction of light

Source: http://image.wistatutor.com/content/feed/u80/refractionoencil.jpg teacher then asked students to predict whether they observed any change. It was observed by students that the stick/pen appeared to shift or look broken at the point of separation between the air and water. It looked a bit short and thicker than its original size.

Activities for teaching session four

This teaching topic was from the Biology part of General science in grade VIII. The teacher used a model and a chart of the human brain to explain its different parts (See Figure 6.4). The teacher first asked students to draw a picture of the brain to check their prediction and let them observe and talk about their understanding about the brain. Then the teacher used a big poster and model of the brain to explain the different parts of the human brain.

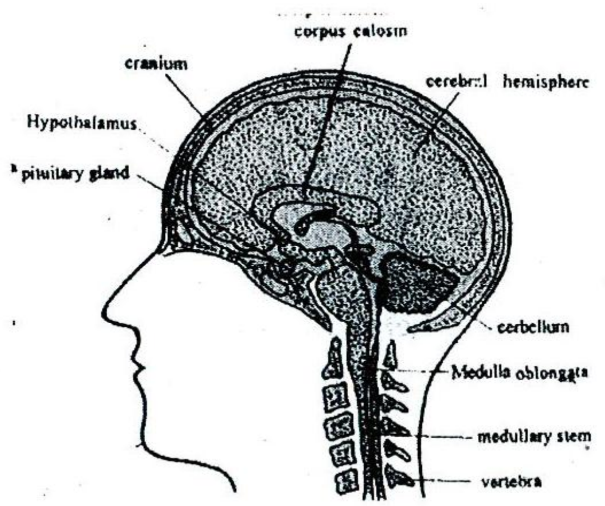

Figure 6.4: Longitudinal section of human brain

Source: (Shamsudduha, Miah, Wahab, Khan, & Morshed, 1997)

6.3.2.2 Summary of responses from teachers' self-reflection.

Following each teaching session both the teacher who taught the lesson and the teacher observer recorded their observations using the aforementioned observation schedule. It has already been noted that each teacher found scope twice for his/her self-reflection after conducting the class from all four teaching cycles. Table 6.1 represents the summary for all peer pairs on their self reflection and accumulated individual pair self reflection rather than individual teachers' reflections. For example, for peer A in

Table 6.1, 3 under ‘RE’ and 1 under ‘WE’ for the item “consider students’ prior knowledge” means for three teaching sessions this item was recommended as requiring more emphasis (RE) while in one teaching session this item was recorded as well emphasized (WE) from all four teaching sessions for peer A. The following section represents a summary of responses from teachers’ self-reflection under the different sub-themes (resources, content organisation, pedagogy and classroom learning environment).

Resources

Teachers reflected on their own teaching regarding their concern for the use of resources. According to teachers’ self reflection, 24 of the 28 teaching sessions were accomplished ‘very well’ (WE) as far as the use of teaching aids in their classes was concerned (See Table 6.1). Also 19 sessions used teaching materials that had a clear purpose, while nine sessions had recommendations for ‘more emphasis’ (RE) to have a clear purpose for the materials. The above data reflect that teaching activities using the POE approach encouraged teachers to use teaching aids as a purposeful tool in their teaching.

Content Knowledge and organization

The items in the schedule also considered content knowledge and organisation from the teaching sessions. According to self reflections, 17 teaching sessions did not follow ‘only the text book information’ in presenting the lecture (See Table 6.1). On the other hand, 13 teaching sessions were recommended for ‘more emphasis’ (RE) and 10 sessions did not as they drew attention to the need to ‘include current ideas or references’. The above data reflects that even though teachers generally did not depend on the textbook information only in presenting their session, they did not include sufficient current ideas in ways or to the extent observers anticipated.

Table 6.1

Summary of responses from teachers' self-reflection

Items	Peer A			Peer B			Peer C			Peer D			Peer E			Peer F			Peer G			Total		
	NE	RE	WE	NE	RE	WE	NE	RE	WE	NE	RE	WE	NE	RE	WE	NE	RE	WE	NE	RE	WE	NE	RE	WE
Use of teaching aids			4			4		1	3		1	3			4		1	3		1	3		4	24
Clear purpose of teaching aids			4		2	2		1	3		1	3		1	3		2	2		2	2		9	19
Follow only student textbook information	2		2	1		3	1		3		2	2		1	3		2	2		2	2	4	7	17
Concern only on recall, recognition of facts		4		1	2	1		2	2		2	2		1	3		3	1	1	3		2	17	9
Explained ideas with clarity		4			3	1		3	1		2	2		2	2		4			1	3		19	9
Application of science concept		2	2	1	1	2		1	3		2	2		3	1	1	3			3	1	2	15	11
Real life examples by teachers		1	3	1	1	2		1	3	1	2	2	2	2		1	2	1		1	3	5	10	13
Real life examples by students	3	1		1	3	1		1	3		2	2	1	1	2	2	2		1	3		8	13	7
Include current ideas or reference	3		1	1	1	2	2	1	1		3	1	1	3		3	1			3	1	10	13	5
Confusion about science idea			4			4		2	2			4			4			4			4			28
Follow only textbook sequence		3	1	1	1	2	2	1	1	1	2	1	1	1	2		4		2	1	1	7	13	8
Clear statement of the purpose of the lesson		2	2	1		3	1		3		2	2		1	3		4			1	3	1	11	16
Consider students' prior knowledge		3	1	1	2	1	1		3		3	1		1	3	1	3			2	2	3	14	11
Encouraged students to discuss		2	2		2	2		1	3		3	1			4		2	2		2	2		12	16
Linkage of teaching strategy with topics		1	3		1	3		2	2			4			4		3	1	1	2	1	1	9	18
Use of Multiple strategies		3	1		2	2		1	3		4			3	1	1	3			3	1	1	19	8
Logical sequence of lectures	1	2	1		2	2			4		3	1		2	2	2	2			2	2	4	13	11

Selected strategies encourage students'		4			2	2	1	2	1		1	3		1	3		3	1		3	1		16	12
Teacher acknowledgement for students		2	2		2	2		3	1		2	2		1	3		3	1		2	2		15	13
Problem of time			4			4			4	1	1	2			4			4			4	1	1	26
Students were reflective		2	2	1	2	1		2	2	1	2	1			4		2	2		1	3	2	11	15
Interested and enthusiastic		2	2	1	1	2		1	3			4			4		1	3			4	1	5	22
Opportunities for students participation		3	1	1	1	2		1	3	2	1	1		2	2	1	2	2	1	3		5	13	10
Lecture stimulated students' thinking		2	2		2	2			4			4			4		2	2			4		6	22

Note: NE- Did not emphasize; RE- Recommended more emphasis; WE- Well Emphasized - accomplished well & 1, 2, 3, & 4 for one, two, three & four teaching session respectively

There were 17 teaching sessions where teachers recommended more emphasis (RE) on understanding rather than only recalling and recognising facts (See Table 6.1). There were also 19 sessions that had recommendations for more emphasis (RE) on ‘explain ideas with more clarity’. However, according to their self reflections no teaching session (apparently) presented any confusion about the underlying scientific ideas. The above data reflect that even though the teachers themselves did not appear to have any confusion in their subject matter knowledge, they perhaps could see that there was a need to find ways to help to make the subject matter clearer for their students.

Teachers also reflected on the extent to which they were able to help their students visualise the science concepts. This was done by relating science concepts with real life either by the teacher themselves or by allowing students to do so. As illustrated in Table 6.1, in 13 teaching sessions teachers themselves used real life examples which were recorded as being done ‘very well’ (WE) whereas 13 teaching sessions achieved a recommendation of more emphasis (RE) on ‘students’ involvement for the same purpose’. These data reflect that the teachers were generally able to relate the science concept being taught to real life, even though, they needed to use more real life examples and particularly to encourage students to identify real life examples of the science concepts.

Pedagogy

The items in the classroom observation schedule also concerned pedagogical aspects of practice. According to teachers’ self reflections, eight sessions were found where teachers did not follow and 13 sessions partially followed the textbook sequence in presenting the lecture (Table 6.1). These results illustrate that in order to maintain the logical sequence, 11 teaching sessions were noted as being done ‘very well’ (WE) while 13 other sessions recommended ‘more emphasis’ (RE). Therefore, the above data reflect that teachers, in most cases, did not follow the text book sequence in presenting the lessons and more or less were concerned about maintaining the logical sequence in presenting the topics.

In 16 teaching sessions teachers noted that they upheld a ‘clear statement for the purpose of the lesson’. These reflections were found to correspond to the ‘linkage between teaching strategies with the selected topics' in 18 teaching sessions. At the same time, 19 teaching sessions recommended using multiple strategies to make the lesson effective as only 12 sessions accomplished 'very well' (WE) in engaging students' participation (See Table 6.1). These above results indicate that in using a new approach (i.e., the POE) teachers were more concerned with upholding the purpose and its link to the topic, however, to make the lesson more effective they saw the need to recommended using multiple strategies.

The POE teaching approach allows teachers to check on students' prior knowledge. In accomplishing that, 11 teaching sessions did very well (WE), whereas 14 others recommended giving 'more emphasis' (RE). A slightly different outcome was observed with regard to this feature where in 16 teaching sessions teachers encouraged students to discuss their different views regarding the concept. Moreover, according to their self reflections, teachers acknowledged the students' contributions whereby they did most of talking which was achieved for 15 teaching sessions (See Table 6.1). That result reflects that their use of the intervention generally permitted them to work with students' prior knowledge and encouraged discussion of their views about the science concept under consideration.

Classroom learning environment

Teachers also reflected on the learning environment in the class. According to their self-reflections using this approach, students were interested and enthusiastic as 22 teaching sessions accomplished this at the level of 'very well' (WE) (See Table 6.1). A similar case was found for stimulating students' thinking, where 22 teaching sessions accomplished 'very well' (WE). Moreover, the teaching approach made students reflective about their learning (15 sessions accomplished this very well). However, only 10 teaching sessions accomplished 'very well' (WE) in providing opportunities for students to mention their problems/concerns in the class. The above data suggests that students were enthusiastic and interested in learning and that their thinking was encouraged too.

6.3.2.3 Summary of responses from observer reflection.

The teacher observer in each class also recorded their responses to the teaching on the same observation schedule. Table 6.2 presents a summary of the observer responses for all pairs.

Resources

In terms of resources, 22 out of a total of 28 teaching sessions were recorded as ‘very well’ (WE) for the use of teaching aids in their classes. Also, 20 sessions used teaching materials that had a clear purpose (See Table 6.2). These findings are similar to the teacher self-reflection and reflect that the POE approach encouraged teachers to use teaching aids while also maintaining a clear purpose for using those materials.

Content knowledge and their organisation

In terms of the content knowledge and their organisation, according to the observer reflections, only 11 teaching sessions did not depend solely on text book information in presenting the session. In Bangladesh, when teachers do not depend only on the text book it usually means that they tend to find information from other reference sources. However, only 13 sessions had recommendations for ‘more emphasis’ (RE) and 9 sessions did ‘not emphasise’ (NE) the inclusion of current ideas or references for their sessions (See Table 6.2). The above data therefore suggests that teachers, in most cases, did not depend only on textbook information for presenting the lesson content, even though, in some cases, they did not seem too inclined to include current ideas or other references as much as they might have. This observer result contradicted the teachers’ views of the sources of information they relied upon.

There were 14 teaching sessions where the observers recommended ‘more emphasis’ (RE) on teaching for understanding rather than only recalling and recognising facts and 18 sessions had recommendations ‘more emphasis’ (RE) on explaining ideas with more clarity (See Table 6.2). However, interestingly, none of the observers noted any teaching session that presented any confusion about the science idea being studied. The above data suggest that even though teachers did not appear to face any obvious confusion in terms of their subject matter, they needed to pay attention to make the subject matter understandable to their students. These findings are similar to the results of the teachers' self reflections for the same teaching.

According to the teacher observers, there were 13 teaching sessions where teachers used real life examples 'very well' (WE) of the concept being studied. However, 14 teaching sessions did not draw or there was 'not emphasis' (NE) on students' involvement for this purpose. That result differs from teachers' self observation.

These data suggest that even though the teachers were conscious of the need to relate science concepts to real life, they did not commonly seem to emphasize it sufficiently to encourage their students to find real life examples for themselves.

Pedagogy

As far as the pedagogical aspect of the sessions were concerned, 13 sessions were found where teachers did not follow the textbook sequence in presenting the lecture while using the POE approach. A similar result was found for maintaining the logical sequence where 13 teaching sessions accomplished 'very well' (WE) and 15 other sessions had recommendations for 'more emphasis' (RE). The above data, therefore, suggest that the intervention helped teachers maintain a logical sequence in presenting the topics.

There were 15 teaching sessions where teachers intimated that they upheld a clear statement for the purpose of the lesson. These reflections were further supported by the result that 19 teaching sessions demonstrated a link between teaching strategies and the selected topics (See Table 6.2). At the same time, 15 teaching sessions recommended 'more emphasis' (RE) in using multiple strategies to make the lesson effective as 15 session accomplished 'very well' (WE) in encouraging student participation. These results are mostly similar to teachers' self reflection, and suggest that in using the new approach teachers were more concerned to uphold the purpose as an important aspect of their pedagogy. However, to make the lesson more effective their reflection recommended using multiple strategies.

The POE teaching approach allows teachers to check on students' prior knowledge. In accomplishing that, 13 teaching sessions did 'very well' (WE), whereas 11 others recommended giving 'more emphasis' (RE). A similar picture was observed when in 15 teaching sessions whereby teachers encouraged students to discuss their different views (See Table 6.2).

Table 6.2

Summary of responses from observer teacher's reflection

Items	Peer A			Peer B			Peer C			Peer D			Peer E			Peer F			Peer G			Total		
	NE	RE	WE	NE	RE	WE	NE	RE	WE	NE	RE	WE	NE	RE	WE	NE	RE	WE	NE	RE	WE	NE	RE	WE
Use of teaching aids		1	3		1	3			4			4		3	1		1	3			4		6	22
Clear purpose of teaching aids		1	3		2	2		1	3			4		1	3		1	3		2	2		8	20
Follow only student textbook information	1	1	2	1		3	2		2	2	1	1	1	1	2	1	3		1	2	1	9	8	11
Concern only on recall, recognition of facts	1	1	2	1	1	2	1	2	1	1	2	1	1	2	1	1	3		1	3		7	14	7
Explained ideas with clarity		3	1		2	2		3	1	1	1	2		4			4		1	1	2	2	18	8
Application of science concept	1	2	1		1	3		3	1		2	2			4	1	3			2	2	2	13	13
Real life examples by teachers	1	1	2		1	3		2	2		1	3	1	2	1	2	1	1		3	1	4	11	13
Real life examples by students	4				3	1	2	1	1	2	1	1	1	3		3	1		2	2		14	11	3
Include current ideas or reference	3	1		1	2	1	2	1	1		2	2		3	1	1	2	1	2	2		9	13	6
Confusion about science idea			4			4			4			4			4			4			4			28
Follow only textbook sequence	1	2	1	1		3	2	1	1	1	1	2	1		3		2	2	2	1	1	8	7	13
Clear statement of the purpose of the lesson		2	2		2	2	1	1	2		1	3		1	3		2	2		3	1	1	12	15
Consider students' prior knowledge	1	1	2		1	3	1	2	1		2	2		2	2	2	2		1	3		4	11	13
Encouraged students to discuss	2		2			4	1		3		3	1		1	3	1	1	2	1	3		5	8	15
Linkage of teaching strategy		3	1		1	3		2	2			4			4		3	1		2	2		9	19

with topics																								
Use of Multiple strategies		2	2		2	2	1	1	2		2	2		2	2		2	2		4		1	15	12
Logical sequence of lectures		2	2		1	3	1	1	2		2	2		2	2		2	2		3	1		15	13
Selected strategies encourage students’		1	3	3	1		2	1	1		2	2		1	3		1	3		2	2	2	11	15
Teacher acknowledgement for students	2		2	3	1		1	2	1			4		2	2	1	2	1	1	1	2	6	10	12
Problem of time			4			4			4			4	2		2			4			4		2	26
Students were reflective		3	1		3	1			4		1	3			4		3	1	1		3	1	8	19
Interested and enthusiastic		1	3		2	2			4		1	3			4		1	3			4		5	23
Opportunities for students participation	1	2	1		2	2		2	2	3	1			2	2		2	2	3	1		7	17	9
Lecture stimulated students’ thinking	1	1	2		2	2		1	3			4			4		1	3		1	3	1	7	20

Note: NE- Did not emphasize; RE- Recommended more emphasis; W E- Well Emphasized -- accomplished well & 1, 2, 3, & 4 for one, two, three & four teaching session respectively

This is slightly different from the results of the self-reflection. The above suggests that the intervention supported teachers in considering students' prior knowledge and discussing their own views about a science concept.

Classroom learning environment

Regarding the learning environment in the class while using the POE approach, students were interested and enthusiastic as 23 teaching sessions were accomplished 'very well' (WE). A similar case was found in terms of stimulating students' thinking whereby 19 teaching sessions accomplished this 'very well' (WE). Moreover, the teaching approach made students reflective about their learning as 19 sessions accomplished it 'very well' (WE) (See Table 6.2). However, in relation to providing opportunities for students to mention their problems/concerns in the class, only nine sessions did 'very well' (WE). The above data suggests that despite providing opportunities for students to raise their problems were not satisfactory; students were actually still enthusiastic and interested in their learning.

6.3.2.4 Changes occurred in reflection.

This section of the chapter deals with changes recorded in the reflection observation schedule. These changes are basically for any specific items in the observation schedule from the first time that the teacher taught a class while being observed. This was then compared with the second time when the same teacher taught a class based on both self and observer reflection schedule. For example, according to self-reflection, teacher X, for item 'Teacher explained ideas with clarity' in the observation schedule recorded his observation as 'recommended more emphasis' (RE) for his first class and accomplished 'very well' (WE) for his second observation. This means Teacher X made a positive change based on his self reflection from RE to WE. If his self-reflection after the second class was recorded as ' not emphasized' (NE) for the same item in the schedule mentioned above, it could has been considered as a negative change. It is interesting that in some cases, a teacher identified a change and the observer did not, or the observer identified a change and the teacher did not. It is also notable that the changes here are reported in terms of individual teachers.

Table 6.3

Looking for change (positive) from self-reflection

Items	Peer A	Peer B	Peer C	Peer D	Peer E	Peer F	Peer G	Total
Use of teaching aids			1	1		1		3
Clear purpose of teaching aids			1	1	1	1		4
Follow only student textbook information	2	2	2	2	2		2	12
Concern only on recall, recognition of facts		1	1	2	1		1	6
Explained ideas with clarity				1	2		1	4
Application of science concept				2	1		1	4
Real life examples by teachers	1					1		2
Real life examples by students						1		1
Include current ideas or reference				1		1		2
Confusion about science idea								
Follow only textbook sequence	1	2	2	2	2		1	10
Clear statement of the purpose of the lesson				1	2			3
Consider students' prior knowledge							1	1
Encouraged students to discuss						1	1	2
Linkage of teaching strategy with topics			1			1	1	3
Use of Multiple strategies		1			1	1	1	4
Logical sequence of lectures				1			1	2
Selected strategies encourage students'				1	1		1	3
Teacher acknowledgement for students				1		1	2	4
Problem of time				1			1	2
Students were reflective						1	1	2
Interested and enthusiastic				1		1	1	3
Opportunities for students participation	1				2	1		4
Lecture stimulated students' thinking						1		1
Total number of changes	5	6	8	18	15	13	16	

Table 6.3 summarises the findings based on the teachers' self-reflections, in which there were 81 positive changes identified in total. Table 6.4 identifies a total of

96 positive changes identified by the observers. The majority of these positive changes were identified for the item ‘not to depend only on the text book information’. According to both observer and self-reflection, 12 out of 14 participating teachers made changes on this issue (Table 6.3 and 6.4). This means in their first class they did ‘not emphasize’ (NE) or recommended ‘more emphasis’ (RE) not to follow only the text book information. Then they demonstrated that they accomplished it ‘very well’ in subsequent teaching sessions - for example, not emphasized (NE) to recommended ‘more emphasis’ (RE) or recommended ‘more emphasis’(RE) to accomplished ‘very well’ (WE).

The second most frequent change that occurred was ‘not to follow the text book sequence’ in presenting the lecture. According to the self and observer reflection 10 and 9 out of 14 participating teachers made changes for this item respectively. The third most frequent change was the item ‘understanding rather than recall and recognition of facts’. 6 and 9 teachers demonstrated their positive change in this issue based on their self and observer reflection respectively. The other cases where teachers made changes were ‘making clear statement of the lesson’, ‘encouraging students to participate using the selected strategies’, ‘teachers’ acknowledgement by students’, ‘opportunity for students’ participation’, and ‘encourage students to discuss their views’ (Table 6.3 and 6.4).

For some items, teachers’ reflection also results a negative change during their second reflection time. These items are: explained ideas with clarity; real life examples by teachers; include current ideas or references; consider students’ prior knowledge; and, make students reflect on their lesson (See Table 6.5). According to observer reflections, six out of 14 teachers demonstrated a negative change for the items ‘explain ideas with clarity’, ‘use of real life examples by teachers’ and ‘consider students prior knowledge’. There were also five teachers who demonstrated a negative change for the item ‘including current ideas and references for their lessons’ (See Table 6.6).

Table 6.4

Looking for change (positive) from observer reflection

Items	**Peer A**	**Peer B**	**Peer C**	**Peer D**	**Peer E**	**Peer F**	**Peer G**	**Total**
Use of teaching aids	1	1			1	1		4
Clear purpose of teaching aids	1					1	1	2
Follow only student textbook information	2	2	2	2	2	1	1	12
Concern only on recall, recognition of facts	1	1	1	2	2	1	1	9
Explained ideas with clarity								
Application of science concept	1					1		2
Real life examples by teachers	1			1	1	1		4
Real life examples by students		1			1	1		3
Include current ideas or reference					1	1		2
Confusion about science idea								
Follow only textbook sequence	2	2	2	1	1		1	9
Clear statement of the purpose of the lesson	2		1		1	2		6
Consider students' prior knowledge	1		1			2		4
Encouraged students to discuss				1	1	2	1	5
Linkage of teaching strategy with topics	1	1				1	2	5
Use of Multiple strategies	2				2	1		5
Logical sequence of lectures	2	1	1			2		6
Selected strategies encourage students'	1				1	1	1	4
Teacher acknowledgement for students				1		1	2	4
Problem of time			1					1
Students were reflective							1	1
Interested and enthusiastic								
Opportunities for students participation	2		1		2			5
Lecture stimulated students' thinking	1			1				2
Total of number of changes	21	9	10	9	16	20	11	

Table: 6.5

Looking for change (negative) from self-reflection

Items	Peer A	Peer B	Peer C	Peer D	Peer E	Peer F	Peer G	Total
Use of teaching aids							1	1
Clear purpose of teaching aids						1		1
Follow only student textbook information								
Concern only on recall, recognition of facts			1			1		2
Explained ideas with clarity		1	1	1				3
Application of science concept	2	1	1					4
Real life examples by teachers		1	1				1	3
Real life examples by students	1	1	1		1			4
Include current ideas or reference	1	2					1	4
Confusion about science idea								
Follow only textbook sequence								
clear statement of the purpose of the lesson		1	1	1			1	4
Consider students' prior knowledge	1	1	2				1	5
Encouraged students to discuss			1	1		1	2	5
Linkage of teaching strategy with topics	1							1
Use of Multiple strategies	1	1					1	3
Logical sequence of lectures	2		1					3
Selected strategies encourage students'						1	1	2
Teacher acknowledgement for students			1	1	1			3
Problem of time								
Students were reflective		2		1		1		4
Interested and enthusiastic		1						1
Opportunities for students participation		1	1	2			1	5
Lecture stimulated students' thinking		2				1		3
Total number of changes	9	15	12	7	2	6	10	

Table 6.6

Looking for change (negative) from observer reflection

Items	**Peer A**	**Peer B**	**Peer C**	**Peer D**	**Peer E**	**Peer F**	**Peer G**	**Total**
Use of teaching aids								
Clear purpose of teaching aids			1		1		1	3
Follow only student textbook information								
Concern only on recall, recognition of facts								
Explained ideas with clarity	1	2	1	1			1	6
Application of science concept		1	1					2
Real life examples by teachers		1	2		1	1	1	6
Real life examples by students	1		2	1				4
Include current ideas or reference	1	1	1				2	5
Confusion about science idea								
Follow only textbook sequence								
Clear statement of the purpose of the lesson				1			1	2
Consider students' prior knowledge	1	1	1	2			1	6
Encouraged students to discuss								
Linkage of teaching strategy with topics								
Use of Multiple strategies			2					2
Logical sequence of lectures			1	1		1	1	4
Selected strategies encourage students'		1	1					2
Teacher acknowledgement for students			1	1				2
Problem of time								
Students were reflective	1	1		1	1	1		5
Interested and enthusiastic	1			1	1	1		4
Opportunities for students participation			1	1			1	3
Lecture stimulated students' thinking	1				1	1	1	3
Total number of changes	7	8	15	10	5	5	10	

6.3.2.5 Learning to change.

This section of the chapter deals with the learning phase of the ARLA analytic frame. As discussed at the beginning of this chapter, both teachers and observers found scope to re-check whether they wished to change or reconsider any item from the schedule as they reflected on the items in the observation schedule after the subsequent post-teaching discussion. The meaning of ‘Learning’, therefore, is basically the understanding of teachers when they realised a need to improve or emphasize any specific items of the schedule for their teaching. At the same time learning also occurred when they found that their colleague did ‘very well’ (WE) in any specific area of teaching (or any item from the schedule), and then they liked to follow that in their own practice.

Ultimately this kind of realisation helped them to see a need for changes in their conception of teaching. For example, teacher 11 and 12 worked in peer F. In the first teaching session, teacher 11 was teaching and teacher 12 was observing the class. The learning of teacher 11 is marked as tick (✓) in front of the individual item on the observation schedule. The observers were not only providing feedback but also found scope to clarify their own thinking about teaching conceptions from the same class. The learning of teacher 12, therefore, is marked as a cross (×) in front of individual item on the check list. Each teacher, therefore, found scope to learn from their colleague through discussion after every session. Table 6.7 reflects the learning of teachers in peer F.

Table 6.8 summarises the learning for teachers of all seven peer groups. It is found from table 6.8 that on 23 occasions teachers’ learning occurred due to their realisation of the need to encourage students to discuss their views. This is followed by: a concern for the understanding of science concepts rather than recall, recognition of facts; not to follow only the students’ text book sequence; and, involve students in finding real life examples. Teachers were concerned for all these three items and mentioned it 20 times for each. Teachers were also concerned not to follow only student textbook information (18 times), and to include current ideas or references for their lectures (11 times). Moreover, they seemed to also be concerned to provide opportunities for students to mention their concerns in the class (17 times). Teachers also considered explaining ideas with clarity, providing real life examples by themselves, considering student prior knowledge and, the logical sequence of lesson.

The above results suggest that the constructivist approach helped teachers to rethink or highlight specific criteria for their teaching conceptions. In terms of teaching content and its organisation, teachers were of the view not to follow the student textbook information, to focus more on science concept understanding rather than recall and recognising facts, the necessity for more focus on real life links with the content and explain ideas with more clarity. In terms of pedagogy, teachers were focused on encouraging students to discuss their views about the content, not to follow the text book sequence in presenting lessons, considering students' prior knowledge for the lesson topics and maintaining the logical sequence of the lesson. In terms of classroom learning environment, teachers seemed focused on providing opportunities for students to mention their concern about their problems in the class.

6.3.2.6 Action accomplished after learning.

Teachers found scope to use their learning in their subsequent teaching cycles. For example, in peer F, teacher 11 had opportunities for learning from the first and second teaching cycles (See Table 6.7). Teacher 11, therefore, found scope to demonstrate his learning during the third teaching cycle in the second class conducted by him. On the other hand, teacher 12 found this scope twice from the overall four teaching cycles. Firstly, teacher 12 found scope to accomplish his learning from the first teaching session in the second teaching cycle during the first class conducted by him. Secondly, Teacher 12 also found scope to accomplish his learning from the first three teaching cycles in the second class conducted by him during the fourth teaching cycle. All participating teachers in other peers found the same opportunities like peer F.

Table 6.8 summarises the actions of all teachers from all seven peers. The results of action have been presented in terms of the number of times teachers accomplished action regarding individual items rather than who accomplished them. It is found from this table that teachers were more focused on 'not to follow the sequence of textbook sequence'. This action had been accomplished 11 times - or put another way, that 11 participating teachers demonstrated that they did not follow only the text book sequence. Seven teachers accomplished their action for learning for maintaining the logical sequence in their presentation. Teachers were also focused on their learning about encouraging students to discuss their views, provide real life examples by teachers and not to depend only on the students' text book information. Six teachers demonstrated the action for each of the above mentioned items. Moreover, they also carried out action for the use of teaching aids, teachers' acknowledgement of students' responses and concern for understanding rather than recall and recognition of facts. Five teachers accomplished action for these items.

On the other hand, a huge gap existed between teachers' learning and their accomplished action. For example, there was no action for including current ideas/references as teachers realised the necessity to improve this item 13 times during their learning. The gap was also noted for items like 'explain idea with clarity', 'encourage students to find real life examples' and 'consider students' prior knowledge' (Table 6.8).

The above results suggest that in terms of resources, the selected teaching strategies encouraged teachers to use teacher aids for their lesson. In terms of content and their organisation, teachers demonstrated their perceptions changed for 'not to follow only the textbook material' and 'use real life examples by teachers'. However, in some cases, they were found not to be interested in including more current ideas or references for explaining ideas with more clarity. In terms of pedagogy, the results suggest that there were changes in teaching conceptions for not to follow only the text book sequence, maintaining the logical sequence and encouraging students to discuss their views. However, teachers did not appear that interested in accomplishing their learning from considering the students' prior knowledge. Moreover, in terms of the learning environment teachers were positive in terms of students' reflection and stimulating their thinking.

Table 6.7

Learning and action for peer pair F

Items	Learning from First Class	Action in second class by teacher 12 from his learning from first class	Learning from Second class	Action at Third class by teacher 11 from his learning from first and second class	Learning from third class	Action at fourth class by teacher 12 from his learning from first, second and third class	Learning from fourth class
Use of teaching aids	✓			Action 11			
Clear purpose of teaching aids			×		×	Action 12	
Follow only student textbook information	×✓		×✓	Action 11			×
Concern only on recall, recognition of facts	×✓		×		×		
Explained ideas with clarity							✓
Application of science concept					✓		
Real life examples by teachers	×	Action 12					
Real life examples by students	✓		✓	Action 11			×
Include current ideas or reference			×		×	Action 12	
Confusion about science idea	×	Action 12					
Follow only textbook sequence	✓					Action 12	
Clear statement of the purpose of the lesson							
Consider students' prior knowledge			×		✓		
Encouraged students to discuss			×		×		
Linkage of teaching strategy with topics							
Use of Multiple strategies							×
Logical sequence of lectures	×		✓	Action 11			
Selected strategies encourage students'	×	Action 12					

Teacher acknowledgement for students			✓	✓
Problem of time				
Students were reflective				
Interested and enthusiastic				
Opportunities for students participation	✓	✓		✓
Lecture stimulated students’ thinking				

✓ Means learning by Teacher 11 and × learning by teacher 12. Action 11 means Action accomplished by teacher 11

Table 6.8

Summary for all peer pairs for their Learning and Action

Items	Learning from first Class (Times)	Action at second class by teacher 2 from his learning from first class as an observer (Times)	Learning from Second class (Times)	Action at Third class by teacher 1 from his first and second class learning both as conductor and observer (Times)	Learning from third class (Times)	Action at fourth class by teacher 2 from his from first, second and third class learning both as conductor and observer (Times)	Learning from fourth class (Times)	Total Learning (Times)	Total Action (Times)
Use of teaching aids	4	1	1	3		1		5	5
Clear purpose of teaching aids			2		1	1	2	5	1
Follow only student textbook information	5	1	5	2	3	3	5	18	6
Concern only on recall, recognition of facts	6	1	7	1	5	2	2	20	4
Explained ideas with clarity	1		4	1	2		4	11	1
Application of science concept	3	1	1	1	3	1		7	3
Real life examples by teachers	5	3		1	3	2	3	11	6

Real life examples by students	6		5	1	5	1	4	20	2
Include current ideas or reference	3		3	1	3		4	13	0
Confusion about science idea	2	1			2	2		4	4
Follow only textbook sequence	7		6	4	4	6	3	20	11
Clear statement of the purpose of the lesson	1	1	2	1			1	4	2
Consider students’ prior knowledge	5	1	5		2		2	14	1
Encouraged students to discuss	5		6	2	7	4	6	23	6
Linkage of teaching strategy with topics			3		1	1		4	1
Use of Multiple strategies	3	2	1	1	2	1	4	10	4
Logical sequence of lectures	3	3	3		4	1	3	13	7
Selected strategies encourage students’	4	1	2	1	2	1	1	9	3
Teacher acknowledgement for students	3		2	3	4	4	2	11	5
Problem of time	1		1	1			1	3	1
Students were reflective	3	1	1	1	3	2	1	8	4
Interested and enthusiastic					1		1	2	0
Opportunities for students participation	4	1	6	421	4	1	3	17	4
Lecture stimulated students’ thinking	2		1	2	2	1		5	3

6.4 Results from Post Teaching Discussions

This section of the chapter discusses the participants' professional practice during the intervention. These practices will then be used as a way of identifying the changes in the culture of professional practice for the science teachers in the secondary schools. This section mainly deals with notes from discussion and participant observer's views.

6.4.1 Data analysis.

Twenty-eight participant observers' comments from the observation and discussion were analysed using NVivo 8 to code themes and issues that contributed to the findings of the intervention using qualitative approaches to data analysis. These analyses are indications of changes in the culture of their professional practice. A summary of results from the overall intervention are presented at the end of this chapter.

6.4.2 Teaching with an observer colleague.

It has already been mentioned that 14 volunteer participant science teachers were involved and formed seven peer pairs, from seven nearby schools. Each pair of teachers was located at the same school. According to the baseline survey, none of them had any experience of observing a full period of their colleagues' teaching or conducted any teaching with an observer colleague before. According to Teacher 3 before the first teaching session cycle:

> I am teaching for the last 23 years. This is the first time I am going to a class in where my science colleague is also ready to observe my full class. It really distracts me a little bit and I feel nervous rather than concentrating on my lesson today. I feel tension whether I am going to make any mistake during my teaching.

It seemed to me that most of the teachers felt nervous during the first teaching session. They were hesitant and were concerned about their colleague's presence rather than concentrating on the lesson. However, that was not the case for the observers in the teaching sessions. According to the Teacher 4, after observing the teaching practice of his colleague:

> It is the first time I observed the teaching practice of my colleagues. I was really excited yesterday. The observation has helped me to see my colleague's teaching method, style of presentation and how he engaged students in the lesson. It also helped me to reflect on and clarify of my own teaching.

It seemed to me that in most cases they were excited about finding scope to observe their colleague's teaching. It is notable that, before and after the first teaching session, all the participant teachers expressed the view that they liked the idea of observation. Most of them responded that this idea would help them to improve their own teaching practice.

6.4.3 Attending the discussion session.

The participant science teachers found scope for discussion after completing the reflection on the observation schedule. The purpose of the discussion was mainly for improving different aspects of their teaching. Individually conducted teaching sessions were used mainly to engage them in discussing different aspects of teaching with a particular focus on individual teaching topics. During the discussion time, teachers found themselves both in agreement and disagreement with their colleagues, challenging each other's reflections or observations and sometimes feeling confused while engaged in debates about some aspects of their peers' teaching issues. In different situations they felt nervous, confident or hesitant in discussing with their colleagues. The following sections present these issues.

6.4.4 Working with others.

Teachers looked and felt different in discussions with their colleagues in different teaching sessions. In most cases, teachers initially felt shy and hesitant and took longer in reflecting as they started the discussion with their colleagues during the first teaching cycle. According to Teacher 6, "I do not know how I can go; I am not used to discussing anything face to face with my colleagues before." In the same way, before starting the discussion during the first teaching cycle, Teacher 12 stated that, "I am hesitating because I am not sure whether I did right or wrong in reflecting from my observation for his (colleague) presentation." These are their worries as they were not used to discussing issues with each other in a prescribed way.

However, I found teachers different even from the second teaching cycle. According to Teacher 5, "Today I feel more relaxed as I know what we have to do." Teacher 9, during the third teaching cycle, said to me that, "I feel more comfortable than the first day; I understood that the discussion helps us a lot to clarify our ideas about teaching, so I like to share my mistakes and failures with my colleagues openly." These quotations reflect that as time goes on the teachers became more comfortable and relaxed in sharing and discussing successes or failures of their teaching with their colleagues.

During the discussion time, teachers found that they agreed with some of the claims of their colleagues. This happened mainly for the teacher who was in charge of teaching and it happened in nearly all the discussions. The agreement between teachers varied in content, pedagogy, resources and learning environment for different discussion sessions. For example, Teacher 6 claimed that the information in the text book for 'class seven' was not sufficient to explain the concept of 'partial pressure' and teachers needed to search references (even from text book of 'Grade Nine') to make the concept clearer. Teacher 5 agreed with him that he needed to search for more references to make the concept of partial pressure clearer for his students.

During the second teaching session, Teacher 14 agreed with Teacher 13 that his emphasis was more on recall or the recognition of the facts rather than understanding of the concept of solution. Their claim also included that students might understand how they can make saturated solutions from an unsaturated solution, but they still were not clear about how different variables (for examples, solvent, solute, temperature) worked to make a saturated from unsaturated solution and vice versa. Teacher 14 then agreed that he needed to focus more on these issues. In the same discussion session, Teacher 13 was also convinced by the claim by Teacher 14 that his way of taking account of students' prior knowledge was not effective for the lesson.

Teacher 12 claimed that Teacher 11 needed to provide more scope for students to mention their problems or any examples they knew for refraction of light during the third teaching cycle. Teacher 12 agreed with him in that they might know real life examples. He also agreed that he had not stimulated his students to reflect their learning regarding this issue. Teacher 11, during the fourth teaching cycle, claimed that it was not possible to say specifically that there are three parts for ‘Cerebrum’. Teacher 12 agreed with him and learnt that it could be better to mention it as “different parts of cerebrum” rather than “there are three parts in cerebrum”. Students would then be focussed on what it was rather than just knowing the number.

The above results for different agreements for the teachers illustrate how some of the discussions prompted participants to clarify different aspects of their teaching through the structure of the discussion. It also helped them to develop a positive attitude to discussing their practice with their colleagues.

Not all discussions were in agreement. Participants disagreed with certain claims or observations of their colleagues during the discussion. This happened with both the teachers who conducted the class and the teachers who observed the class. The disagreement between teachers also varied for content, pedagogy, resources and learning environment for different discussion sessions. For example, Teacher 2 claimed that Teacher 1 fully followed the student textbook sequence during his session at the first teaching cycle. However, Teacher 1 did not agree with the observation. He said that as he tried to use the POE, the sequence of the student’s textbook was automatically broken. As he felt he taught using the POE well, he did not think that he only followed the textbook sequence. Teacher 1 also disagreed with the claim of fully recalling and recognising the facts rather than understanding the concept during the first teaching cycle. He said that he tried to explain the different aspects, for example, why jets of water were coming out of the holes in a position perpendicular to the wall of the bottle; why the jets of water fell at different places near and far away from the wall and that the jet of water did not proceed perpendicularly too far. He even used examples of ‘water barrage or dam’ for a better understanding of the theory.

Teacher 7 disagreed with the claim of Teacher 8 that he did not provide any real life examples during the third teaching session for refraction of light. He reminded Teacher 8 that he was discussing an accident happening during a shower at the pond. He explained that usually people find the stair under the water a little bit higher than its original position in the pond. So when anyone goes to take the next step on the stair under the water, they sometimes fall down because they do not see the position properly because of refraction. Teacher 8 then noted that he had missed that point.

Teacher 6 also disagreed with Teacher 5 regarding the scope of students' opportunities to mention their problems in the class during the fourth teaching sessions. He also disagreed with the observation for not accomplishing the 'observation part of POE' properly. He noted that he allowed students to observe the human model instead of any real brain to reconcile any differences between the prediction and the observation.

As was the case with agreement between colleagues, the above results for different disagreements with different observations or reflections of teachers created scope for clarifying different aspect of teaching. It also helped them to develop a positive attitude to discussing their practice with their colleagues.

6.4.5 Resolving confusion.

Teachers also found the discussion sessions offered a way of resolving their confusion from observations during the class. Teacher 10, when explaining about how partial pressure impacts the jet of water coming out from the bottle during the first teaching cycle was seen by Teacher 9 as offering a confused explanation. Teacher 10 then explained it again during the discussion with additional examples. Similarly, Teacher 3 was confused during the observation about how the temperature for a solution worked as a variable in making saturated solution from an unsaturated solution (during the second teaching cycle). Teacher 4 then explained that, "when we increase the temperature of a saturated solution, its solubility for the solution increases and actually decreases slightly above 60^0C as it becomes an unsaturated solution and temperature works here as a variable to make this change." The above examples reflect how the discussion after the class helped teachers to work through their own questions and confusions from the observation. At the same time, it is notable that teachers received good support from their colleagues at such times.

6.4.6 Challenging others' practice.

The discussion after the class sometimes offered teachers opportunities to challenge their colleague's practice. It was observed several times during all four teaching cycles. For example, Teacher 2 during the first teaching cycle claimed that he did not observe whether Teacher 1 asked students to find any real life examples regarding the variation of pressure with depth. Teacher 1 then said that he used examples. Teacher 2 then challenged him to repeat the example. Teacher 1 was unable to recall any examples that he used in the class. After the session I asked Teacher 1 about this unusual situation. According to Teacher 2, "It's ok, he can ask me, and this type of challenge helps us to clarify more about our teaching." According to Teacher 2, "We have a very good relation, I think he would not mind, we need to reflect on our own practice to understand it properly, so that it works for our students." The above example illustrates that as these teachers challenged one another's practice, it also helped them to clarify more about their own practice.

6.4.7 Use of resources.

Teachers found scope to discuss resources they used during the class time. The discussion included comments about the resources used, problems with these resources and suggestions for improvements. It was noted by 7 observers that teachers used adequate teaching aids for their class. In some cases, observer teachers commented on the level of confidence for accomplishing the experiment. According to teacher 4 during teaching cycle-2, "It seemed to me that teacher 3 did not practice enough to accomplish the experiment properly." Teacher 8 commented similarly during the third teaching session, "It seemed to me that teacher 7 has not enough confidence in doing the experiment for making a saturated solution, he was simply demonstrating rather involving students in participating."

Teachers also discussed the problems associated with resourcing. For example, teacher 2 during the first teaching cycle mentioned that, "It seemed to me that students find difficulty trying to visualise when teacher 1 mentioned only some real life examples like water barrage without any real picture or poster. To me it remained abstract for students." Teacher 5, during the second teaching cycle, discussed the necessity of a spirit lamp and thermometer to demonstrate how temperature worked as a variable in making saturated solutions from an unsaturated solution and vice versa. In some other cases, teachers also mentioned that charts used in the class were not helpful or unclear for students. According to teacher 11 during the third teaching session, “This type of hazy chart kept students in the dark rather than making the concept clearer.” The above mentioned examples reflect that discussion brought teachers together to clarify the use of resources in their practice.

6.4.8 Content knowledge.

Teachers also found scope to clarify their content knowledge during their discussions. The discussion included level of confidence, difficulty and confusion with content knowledge in presenting the lesson. Teachers discussed their confidence in explaining concepts with appropriate examples. For example, teacher 9 in the third teaching cycle for refraction explained refraction with an appropriate drawing using the board. He then explained why we do not see fish under water in its proper position. During the discussion both teachers were talking about their confidence in explaining the concept. Similarly, teacher 12 was confident in explaining different parts of the human brain and their functions during fourth teaching cycle.

On the other hand, teachers also discussed their difficulties in explaining concepts. According to teacher 4 during the first teaching cycle, “I was confident with the concept of today’s lesson, however, I was not able to explain why jets of water do not go too far from the bottle when asked by one student. I tried to explain using the relation of speed and pressure, but I was not satisfied.” Teacher 5, during the third teaching cycle was also unable to explain the reason a stick appears to bend under water. He discussed his difficulty with his colleagues in an attempt to gain clarification. Almost all teachers found difficulty in matching the information in the text book and the diagram for the human brain in the fourth teaching session. According to teacher 13, “It is really frustrating for us when we find something that is a mistake in the textbook; it creates a lot of debate among the teachers.” The above results reflect how teachers were discussing shortcomings regarding the content knowledge.

Teachers also discussed issues of confusion they observed during different teaching sessions. For example, teacher 11, during the first teaching session mentioned that, “It is essential to make the three holes be of equal distance to demonstrate and understand the concept properly." Teacher 12 was confused with the notion and so they discussed the issue further. Teacher 14 presented a reverse concept for saturated and unsaturated solutions during his teaching during the second teaching cycle. Teacher 13 noticed the issues and discussed it further.

Almost all teachers found confusion with the notion that a stick appeared to be "bent" at the point of separation of the air and water due to refraction. According to Teacher 7, "I did not notice it before, this is intersecting, we need to come to a conclusion about which word is best to fit the situation bent or broken." Teachers then discussed this issue during the discussion time. In most of the cases they were confused about whether it is bent or broken. Teachers were then looking forward to this issue in the subsequent professional workshop. Teachers also discussed the confusion they found while teaching the human brain during the fourth teaching session. This was basically due to a mismatch of the diagram and the explanation in the text book. According to teacher 3, "I was struggling in grouping different parts of the human brain into cerebrum, cerebellum and medulla oblongata, the information in the book confused me." In some cases the Bangla name of different parts of the human brain increased the level of confusion for teachers.

6.4.9 Real life examples.

Teachers also found scope to develop or become more familiar with new real life examples of related science content from discussions with colleagues or observing their classes. It is also notable that new examples were also offered by students as well as the teachers. For, example, Teacher 3 explained how sugar melted quicker in hot water than in cold water regarding the understanding of the influence of temperature to make a saturated solution from a unsaturated one. According to Teacher 3, "this example is very easy to understand as we need to use it in our everyday life, however, I never thought of or heard about this example." Teacher 14 mentioned that he came to know about fishing as a real life application of refraction. This was actually mentioned by a student in the class when he was observing his colleague's teaching. According to him, "This is quite common in the rainy season in Bangladesh. People like to use their senses to find and then catch the fish from its proper position. I never thought before that refraction principle works here."

6.4.10 Discussion through POE.

Teachers also discussed about their different concerns and observations about using a POE. Teacher 12, during the first teaching cycle, discussed with teacher 11 about the mismatch of the prediction part of the POE. According to him, teacher 11 explained what would happen before allowing students to predict about the experiment. He also mentioned that teacher 11 did not ask students to write the reasons for their prediction. Teacher 14, during the third teaching cycle, claimed that teacher 13 went very fast when students were making predictions. Moreover, teacher 11, during the fourth teaching cycle, claimed that teacher 12 could ask students to draw pictures of the brain from their perception to elicit their preconception about the brain.

In seven cases, mostly during the first and second teaching cycles, the observers claimed that during the discussion that students did not have enough opportunities to reconcile the difference between their observation and prediction. Teachers themselves tended to do the explanation rather facilitate students' attempts at reconciliation. However, as noted, the discussion helped teachers to make that adjustment during the third and fourth teaching cycles.

These above examples reflect how discussion helped these teachers to develop their teaching using the POE approach. These discussions helped them refine their ideas about POE and how it might be used in their teaching more effectively.

6.5 Results from Professional Workshop

This section of the chapter deals with the activities of, and the outcomes from, the professional workshops. As has been noted earlier, participating teachers from seven different schools attended the workshops after completing each teaching cycle. The purpose of arranging these workshops was to provide scope for the participating teachers to discuss with their colleagues from across the schools their teaching in order to reconsider, reflect upon and become more informed about their practice. Before coming to the workshops, teachers did their teaching incorporating the POE approach and then reflected and discussed their experiences with their peer pair from the same school. By attending the workshops they had the scope of knowing how other peer pairs from different schools conducted the same type of teaching. At the same time, they found the opportunity to discuss their own problems regarding their practice with teacher pairs from the other schools. Therefore, this part of the chapter deals with how these teachers engaged in the activities in the workshops.

6.5.1 Data analysis.

Participant observers' notes from four professional workshops were analysed using NVivo 8 to code themes and issues that contributed to the results of the intervention using qualitative approaches to data analysis. These analyses are indications of changes in the participant teachers' teaching perceptions and culture of their professional practice.

6.5.2 Structure of the workshop.

The four professional workshops mostly maintained a structure based around discussion forums. The agenda were set to focus mainly on teachers' practice during the teaching cycles and their everyday experiences of their work in the project. At the beginning of each professional workshop, I, as facilitator of the professional workshops, offered summaries from my notes (developed through observing their teaching and attending post-teaching discussions) about that which I had come to see and understand as an observer of the process. The content of those discussions included such things as resources, content knowledge, pedagogy, learning environment in the classroom and the nature of collaboration. I also sought their input and response to my overviews which led to many interesting ideas. For example, during the first professional workshop, teacher 6 sought discussion about how to manage the classroom environment for large class sizes. During the second workshop, teacher 11 sought scope to discuss some other concerns from their practice in relation to working in a bigger community. During the third workshop, teacher 5 asked to discuss the advantages and disadvantages of attending the professional workshops. During the fourth workshop, teacher 7 requested a demonstration based on teaching topic four (human brain) by any of volunteer teachers in the group.

6.5.3 Professional workshops.

The participating teachers mainly discussed their teaching for the topics "The pressure of a liquid" at the first professional workshop. The discussions involved content clarification, teaching using a POE approach, experience with new real life examples, use of teaching aids, and the way to improve teaching practice.

The participating teachers discussed their teaching for the topics "Saturated and unsaturated solutions" at the second professional workshop. The discussions included science content or concept clarification, word confusions, advantages and/or disadvantages with POE approaches, resources, sharing new real life examples, confusion in using the observation check list and ways to improve teaching with large class sizes.

The participating teachers mainly discussed their teaching for the topics "Refraction of light" at the third professional workshop. They discussed use of the POE, confusion arising from the observed teaching, concept clarification, word confusion from the textbook, problems with concepts associated with the teaching experience and the possibility of improving their teaching through the POE approach.

The participating teachers mainly discussed their teaching for the topics "Human Brain" at the fourth professional workshop. They were engaged in discussing efficacy in teaching, motivation, concept clarifications, and frustration with the lack information in the text book, real life examples, advantages in exchanging teaching aids across the schools, the nature of collaboration with their colleagues, techniques for assessment, and the development of their learning community.

6.5.4 Understanding experiences from the workshops.

The 14 participating science teachers found the professional workshops to be a new experience. The first professional workshop was very important and exciting for all teachers as they had no clear idea about the discussion agenda. According to teacher 3, "We know a little bit about what we are going to discuss today, it may be for the POE and our faults during first cycle teaching, so we are little worried." According to teacher 6, before starting the workshop:

> We had no experience of this before, usually we find the scope to meet some of us during the public examination time, but there we do not any find time to discuss anything regarding our teaching practice. Today I'm feeling better as I will able learn something from others.

Teacher 12 was a little concerned about the process during the first professional workshop. When asked, he explained, "I made some mismatch during my teaching that I came to know from the discussion, so I am little worried today." The above quotations suggest that participating teachers had mixed views about attending the professional workshops, mostly as this was very new for them.

6.5.5 Resources.

The participating teachers discussed the inadequacy, quality and importance of teaching aids in almost all of the workshops. During the first professional workshop, teachers discussed whether or not they needed any sophisticated teaching aids to make the concepts clearer during their post-teaching discussion in the first teaching cycle. After getting an opportunity to voice their opinion, teacher 6 said, "We need the sophisticated instrument; otherwise students will not learn properly or develop different conceptions." Teacher 4 disagreed with him and stated, "Our schools do not have enough funds to buy all the teaching aids. We need to find resources from our neighbouring local school environments to use in our classes. From example, I think students will able to understand the basic concept of a 'simple pendulum' if we hang a 'stone' or a 'piece of brick' that works as a bob with a thread rather buying sophisticated steel or metal instruments from the scientific shop." Most of the teachers agreed with his statement and teacher 9 stated, "I also believe that this is not a problem, we just need a proper plan. If we collect anything from our local environment and take care to preserve it properly, then we can use it in the following years."

During the first teaching cycle, I observed that five teachers prepared a chart to assist in 'Brainstorming' the characteristics of good teaching aids to use in the classroom during the first professional workshop. Teacher 10 stated that he learnt a mnemonic "CAMPUS' to remember good characteristics of a teaching aid to use from a training session he had previously attended. According to him 'C' stood for clear, 'A' for attractive, ‘M’ for meaningful, ‘P’ for purposeful, ‘U’ for utility and ‘S’ for simple or specific. All of the other teachers were very impressed with this mnemonic.

During the second professional workshop, teachers discussed the importance of adequate practice before conducting an experiment in the actual class. According to Teacher 12, “It is important to demonstrate any experiment with confidence. If we hesitate, students might lose attention in the class.” Teachers also discussed the possibilities of greater participation of students during experiments rather than merely seeing or sitting on the bench all the time.

During the fourth teaching cycle, teachers borrowed the model and chart of the human brain from other schools. According to Teacher 5, “I never think of borrowing teaching materials from other schools. I was really struggling to find a suitable teaching aid to teach the human brain. Then Teacher 8 (from another school) suggested that I borrow the model from their school if I wanted, it was a very good idea and we could keep it to continue to help each other.” Besides this, they also discussed the importance and power of three dimensional models in making concepts easier to understand for their students. Teacher 7 then reminded the group about Edgar Dale’s ‘Cone of Experience’ for active or passive types learning.

The above examples reflect how a professional workshop offers teachers possibilities to share their experience about their practice and support their learning about new ideas in using teaching aids, share their own learning with others, exchange and/or borrow teaching aids, and refine their learning in collaboration with colleagues from other schools.

6.5.6 Improving content knowledge and organisation.

Teachers in different peer pairs experienced difficulty in reaching conclusions regarding content knowledge during their post-teaching discussion. Participating teachers discussed their concerns regarding content knowledge and its organization during all four workshops with their science colleagues. These concerns included concept clarification, confusion arising about observed teaching, alternative conceptions, use of real life examples, and current ideas in relation to the respective concepts. It is notable that different peer pairs experienced different issues from the same teaching cycle, while in other cases, many of the peer pairs were confronted by the same problems. The following paragraphs are evidence from some of these discussions.

During the first professional workshop, teachers discussed the reasons why jets of water do not perpendicularly squirt too far from the bottle. This was an issue that remained unresolved for three of the pair peers during first teaching cycle. Teacher 3 of peer B explained that, “Firstly, the gravitational force of the earth pulls the jets downward. Secondly, the pressure at any point in a liquid depends on the level at that point. The distance of the jets of water depends on the pressure of water on that level.” Teacher 4 then said that he comprehended the points but missed the second point during his teaching that led to his teaching mismatch during the first teaching cycle.

All of the teachers took a glass of water and dipped a stick obliquely into it as a demonstration during the third teaching cycle (illustration of refraction). Most students, as a part of POE approach, replied from their observation that the stick appeared ‘broken’ at the point of separation of air and water. The word ‘break’ confused most teachers while they were more familiar with the word ‘bend’. In their post-teaching discussion they remained undecided about this confusion. During the third professional workshop, participating teachers were interested in discussing further the essence of this confusion. Teacher 12 explained it in detail, “For an object under water, we need to use ‘appear to be bent’ instead of ‘bend’ only, and actually it changes its direction in a different medium.” Most teachers then agreed with him. The use of an explanation to accompany the particular use of language highlighted an important issue about language and discussion for many of the teachers in regard to students’ learning about science concepts that was new for them.

While teachers found difficulty in matching the information and labelling the diagram in the text book in the fourth teaching cycle, they looked frustrated and unhappy at the beginning of the fourth professional workshop. They discussed with their colleagues what they considered to be the proper grouping of different parts of the human brain into three main parts e.g., cerebrum, cerebellum and medulla oblongata.

They also discussed the confusion arising from the Bangla name of these parts of the human brain. After a long discussion Teacher 5 stated, “I feel more comfortable now. The discussion with my colleagues from other schools has helped me to minimise my confusion about this topic. I am sure next time I will be able to teach this topic more comfortably.” All teachers appeared equally satisfied about this type of outcome from their discussions.

Teachers also discussed issues revolving around alternative conceptions among students after their teaching in different cycles. The following offers a summary from all 28 teaching classes where I, as a participant observer, noticed teachers providing alternative perspectives to students:

- three holes need to be in equal distance (Teaching cycle One);
- reverse concept of saturated and unsaturated solution (Teaching cycle Two);
- linkage to real life to understand solution (Teaching cycle Two);
- laws of refraction (make it specific in number) (Teaching cycle Three);
- understanding of how light is bent (Teaching cycle Three); and,
- specific division of human brain (Teaching cycle Four)

Interestingly, teachers did not recognise these issues in their reflections and even at the post teaching discussion. As a participant observer, I noted and placed these issues in the respective workshops for discussion. Most teachers came to the view that they needed to be more careful about these kinds of alternative conceptions. These discussions also helped them realize that they needed to be careful about their conceptions as teachers which were sometimes the same alternative conceptions as their students held.

The workshops also helped teachers become more familiar with real life examples of respective concepts. They also took note when I, as facilitator, read out the summary of real life examples teachers used in their classes in the respective teaching cycles. Teachers also discussed some of the examples that caused them to feel confused. For example, ‘sea water’ and ‘mixing of salt during cooking’, teachers concluded that sea water was not a solution, it was mixture. Mixing salt during cooking curry keeps the solution unsaturated where temperature also works as an influencing variable. However, teacher 10 expressed the view that, “it is better not to use these kinds of contradictory examples for these elementary science classes.”

It appears from the above examples that teachers attending the professional workshops found scope to clarify their science concepts, familiarise themselves with ideas of alternative conceptions and develop new examples and ideas with respect to many science concepts they were teaching. Attending the professional workshops also helped them to become more confident in their teaching.

6.5.7 Pedagogy.

Teachers liked to discuss different aspects of pedagogical understanding during the professional workshops. These discussions included clarification of the nature of a POE, teaching sequences, the use of multiple strategies, strategies for teaching of large class sizes, efficacy in teaching and opportunity for students’ participation.

In all professional workshops teachers discussed the use of the POE teaching procedure. In the discussions, some of the teachers conflated ‘prediction’ and ‘observation’ of the POE during the first teaching cycle. Teacher 9, then, demonstrated the importance of the distinction between the two parts using the same teaching topics of teaching cycle one. Teachers also discussed the use of POE across different experiments to clear up issues about the concept of refraction during the third professional workshop. They also discussed and were happy to know that teacher 11 used a live fish in a bowl of water as a demonstration experiment. According to teacher 11:

> I got the ideas in sharing with science colleagues of my school. One of my students helped me to find a live fish as his father is a fisher man. This made the class very different from usual classroom learning; students were so motivated with a high [level of] attention in the classroom.

Other teachers were very impressed with such thinking and also discussed how to provide more scope to students to reconcile differences between their predictions and observations.

Teachers also discussed effective teaching sequences. For example, during the second professional workshop, I observed that for most of the teaching that the teachers did sufficiently emphasise (WE) progression in a logical sequence. I then asked teacher 8 to explain how he designed his teaching sequence, he responded:

> I tried to find all the variables that are related to change an unsaturated into a saturated solution and vice versa - these are solute, solvent, temperature. I then tried to explain with the help of students how these individual variables control the preparation of saturated and unsaturated solutions. That sequence made my teaching easier; I think students also felt easy to understand all of these changes.

After his explanation, teacher 7 (his peer pair partner) expressed, “It seemed to be logical in presenting the topics. I also found the teaching very interesting as an observer of that teaching where he did not follow the textbook sequence.” All other teachers were also impressed with his logical sequence.

Teachers also discussed students’ prior knowledge and encouraging students to discuss their own views and the use of multiple strategies to make the teaching more effective. Teacher 6 wanted to discuss teaching effectively to a large class. Teacher 1 expressed, “we have the same problem. However, we have to go with this problem.” He then explained two strategies *group work* and *different seating arrangements* that he learnt from a recent training workshop. After that according to teacher 13, “These seem effective, we should try these strategies to make our teaching effective for a large class.” Teachers also discussed different strategies in other workshops to improve their teaching.

The above data reflects how attending the professional workshops offered teachers opportunities to share and learn from their colleagues across the schools regarding their pedagogy. They also came to know how the intervention influenced their learning about effective teaching.

6.5.8 Classroom learning environment.

Teachers also discussed how the POE teaching approach changed the learning environment in the classroom. They shared ideas with their science colleagues from other schools about how to encourage students' reflection in learning, stimulation in thinking and students' interest and enthusiasm for learning in the classroom. According to teacher 2, "During my teaching in the second teaching cycle, the crowd in the classroom at the time of 'prediction and observation' was really exciting, I never found [it] like this [before]. The POE has really changed my classroom learning environment." Teachers also discussed the importance for providing more opportunities for students to ensure their participation in learning.

6.5.9 Developing a culture of professional practice.

Two teachers, at the end of the second professional workshop, wanted to discuss some of their difficulties with content knowledge. I raised the issue in the third professional workshop. After some discussions, we decided that each teacher would write one problem regarding their content difficulties on a sheet of paper and then place it in a box, indicative responses were as follows:

- how to fish keep alive in the ice river in the winter in the polar region;
- N-type and P-type semiconductors;
- periodic table;
- total internal refraction and critical angle; and,
- meiosis and mitosis.

I then asked who would able to explain how fish stay alive in the icy river. Teacher 4 explained it in detail with the help of some of the other teachers. Following the explanation, I asked the participants:

Facilitator:	Have you understood what you wanted to know from this explanation?
Teacher audience:	(No response)
Facilitator	How would we be able to know that you, who placed this issue to discuss, have understood the query?
Teacher 2:	(After silence for one minute, with hesitation) I placed this issue [on the table]. I am clear now.

Facilitator: (After taking another topic from the box) Our next topic to discuss is "N-type and P-type semiconductors".

Teacher 5, then, made specific his problem and teacher 11 explained in detail how to respond to the situation. They continued with the rest of topics more comfortably. The professional workshop also continued this problem solving session.

The above examples illustrate that how the teacher professional workshops helped teachers 'break the ice' in sharing issues about their practice in collaborative ways.

6.5.10 Developing a learning community.

The professional workshops encouraged teachers to be involved in collaborative work. Teachers were also very committed to attending all the workshops. They were very enthusiastic in their learning at the professional workshops and discussed the purposes, advantages and disadvantages in attending the professional workshops during the fourth professional workshop (reported in detail in the next chapter). According to teacher 5, "We all science teachers from this local area met at a workshop on 'assessment' on last Monday. We discussed continuing this professional workshop even after this project." After that all teachers discussed for sometime how, and in what format, they would work better to develop a learning community. This discussion reflected their commitment to learning for effective teaching.

6.6 Chapter Summary

This chapter has explored the results of the intervention used in this study. It demonstrated that teachers found scope to work with a constructivist teaching procedure (POE) in their classes. After their teaching they reflected on their observations which then formed the basis of their post teaching discussions. Participants' reflections were analysed both from the teachers' and observers' perspectives. In general the observations arrived at similar conclusions within pairs but some differences between individual peer pairs clearly existed.

The results suggest that through the process there was a change in teachers' perceptions about teaching as well as their views of the culture of their professional practice. The results also suggest that the intervention encouraged participating teachers to translate their learning from their discussions into action in their following teaching sessions.

The intervention appeared to help teachers to change their teaching perceptions regarding content knowledge and their organisation of their teaching. The results indicated that in following the POE teaching approach they generally did not follow only the textbook information in presenting their session and they provided more emphasis on understanding science concepts rather the simple recall and recognition of facts.

The results also suggested that the use of constructivist teaching approaches led to changes in teachers' perceptions about their pedagogy. In most cases, in using a new approach (i.e., the POE) teachers became more concerned about the need to uphold the pedagogical purpose underpinning their practice and its link to the topic. Their use of the intervention also generally permitted them to work with students' prior knowledge and encouraged discussion of their views about the science concept under consideration. The intervention also generally helped teachers to encourage their students to participate and discuss their views in ways that were not so common prior to their use of the intervention.

The results also indicated that the intervention led to changes in these teachers' perceptions regarding the learning environment in the classroom. In using the POE teaching approach, students were generally enthusiastic and interested in learning and that their thinking was encouraged.

The results explored in this chapter also highlight that there were changes in the culture of professional practice for the participating science teachers. The results reflect how teachers generally felt more comfortable and relaxed in sharing and discussing successes or failures of their teaching with their colleagues. The results also illustrated how some of the discussions prompted participants to clarify different aspects of their teaching to develop a positive attitude to discussing their practice with their colleagues. At the same time any disagreements with different observations or reflections created scope for clarifying different aspects of teaching. These results overall show that the participants were enthusiastic about their learning about their teaching and how that was linked to enhancing their students' learning.

This chapter also dealt with how participating science teachers engaged in the activities regarding their practice with teacher pairs from the other schools at the professional workshops. It appears from the results that participating teachers had a mixed attitude about their involvement before attending the professional workshops - which was very new for them. The results indicate that the professional workshops offered participating teachers opportunities to discuss their problems regarding resources, content knowledge, pedagogy and the learning environment in the classroom. The workshops engaged them in activities in which they found scope to reconsider their thinking both about their teaching and the culture of their teaching practice.

The discussions at the workshops illustrated how introducing the POE teaching approach changed the learning environment in their classrooms. Teachers learnt from the discussions with their science colleagues from other schools about how to make their teaching focus more on 'reflection in learning', 'stimulation in thinking' and encouraging students to be more interested and enthusiastic learners in the classroom. The above results also reflected how the teacher professional workshops encouraged sharing practice in collaborative ways.

Chapter 7
Impact: Developing a Deeper Understanding

7.1 Introduction

This chapter looks at the results from the post intervention questionnaire and focus group discussions (FGDs) used in this study. The open ended and descriptive post intervention questionnaire was designed for participating science teachers to elicit their individual views on the effectiveness of the intervention in helping teachers to change or develop deeper understandings (both in teaching perceptions and culture of professional practice) of their science classroom practice. The focus group discussion was designed to provide participating science teachers with an opportunity to interact and listen to others, perhaps to reach consensus about respective issues or disagree about others and to have an opportunity to reconstruct their meaning about these issues. This chapter, therefore, presents findings that identify teachers' views in order to better understand the impact of the intervention process used in this study on their practice.

7.2 Data Sources

This part of the research design was conducted with all of the peer pairs science teachers who were actively involved in the intervention implementation phase. I invited them to come and join the last professional workshop for this study. I distributed the post questionnaire to them at the beginning of the professional workshop and asked them to read through the questionnaire and to clarify any confusion. The questionnaire was designed to elicit teachers' views for different aspects regarding their experience with: the new teaching strategy (POE); peer classroom observation; post-teaching discussion; professional workshop after the intervention, collaborative activities, and the concept of professional learning communities. The post intervention questionnaire was developed in English and then translated into Bangla to ensure better understanding by participant science teachers.

For the FGDs, the 14 volunteer science teachers were divided into two groups. Each individual teacher from each peer pair (see previous chapters), was then able to be followed up in a particular focus group discussion group. Teacher 2, 3, 6, 7, 9, 12, 14 from pair A to G respectively participated in FGD One, whereas Teacher 1, 4, 5, 8. 10, 11, 13 from pair A to G respectively participated in FGD Two. The basis of their selection was the availability for their time. Both of the FGDs were audio taped with prior permission from the participants and later transcribed for analysis.

7.3 Data Analysis

Participants' responses to the open ended questions were translated and transcribed in English. The basic procedure of analysis was quantifying the qualitative data. For this qualitative data was coded into different themes that informed the research questions. These codes were then assigned numbers and the number of times codes arose were tabulated as numeric data (using NVivo 8). At first, responses from all 14 participants for individual questions were accumulated together and analysed accordingly under different themes to elicit quantitative values. Secondly, the quantitative values for each individual issue from the questionnaire was then crosschecked with the responses from both FGDs to confirm issues around which there was consensus or disagreement in terms of their understandings about any issues of the intervention process. In so doing, I first developed a general sense of the data through reading all the transcriptions. Then I selected text segments under different sub-themes using NVivo 8. Then I merged all the sub-themes into individual themes that captured the major categories of information. The results were then reported as descriptions on the basis of responses both from the post questionnaire and FGDs in response to the respective research questions.

7.4 Results from Impact

7.4.1 Views on new teaching approach.

Participant teachers used the POE teaching strategy for their science teaching at the intervention implementation stage. Teachers expressed their opinion on several aspects such as their feelings about POE, their understanding about the use of POE, aspects after using it, its influence on their teaching practice, problems regarding using the POE strategy, its effectiveness in the Bangladesh context and suggestions for its effective use. They demonstrated consensus as all 14 participating teachers found the

POE to be a very effective strategy in their science teaching. Their major responses are listed in the Table. 7.1.

Table 7.1
Teachers' feelings about the POE strategy

Responses	**Frequency (Number of Teachers)**
Provided scope to these teachers to consider their students' prior knowledge.	4
Related the science content to real life.	3
Involved students in thinking for learning.	5
Clarified the concept with a logical conclusion.	3
Discouraged students from memorising science concepts.	2
Made students attentive in their learning.	4

More specifically, according to Teacher 5:

> The teaching with POE is very good to me. It seems to me that it is a fruitful and effective strategy for science teaching. POE is more effective than any other method I had ever used. It helped to develop students' thinking power. It made a connection of learning with real life that made learning more sustainable. It also helped me to concentrate more on the teaching topics and to make students more attentive. Students were discouraged to memorise the science through direct observation in the classroom.

Teachers were asked what using a POE did in terms of encouraging them to pursue different purposes in their practice. They listed diverse characteristics. Among them seven teachers mentioned that they used it because it created a sense of reality and that it led to students making connections with science and the environment around them. Six of them used it because they thought it helped them to make students attentive in their learning in a way that was very effective for large class size. In Table 7.2 lists the major responses of participant science teachers.

Table 7.2

Objectives of POE according to the participant teachers

Responses	**Frequency (Number of Teachers)**
POE strategy links to reality and makes connecting science with the environment much easier for students.	7
POE strategy helps teachers make students attentive in their learning which is very effective for a large class size.	6
Making students think about their learning.	4
Takes into account students’ prior knowledge.	3
Helps students to acquire accurate knowledge about science concepts.	
Guides the lesson in a logical sequence.	4
Makes students develop a creative attitude.	3
Encourages the exploration of alternative conceptions – brings out prior knowledge.	2
Develops self-confidence for teachers.	3

Teachers made a list for the good aspects of a POE from their experience after using the strategy. Among them, 10 teachers pointed out that a POE is a very good strategy as it allows students to think independently and to express their own opinion. This ultimately helps students to be self-confident and develop a self-directed learning attitude. Eight teachers expressed the view that POE was able to make students attentive in their learning and helped them to teach a large class size effectively; which is very important from a Bangladeshi perspective. Six teachers gave priority to considering students’ prior knowledge through prediction. This also helped students to make a decision about science knowledge through analysing their prior knowledge with the help of direct observation in the classroom. Six teachers also mentioned its power in making a connection with real life through using teaching aids, demonstrations and observation.

Moreover, four of them mentioned its power in helping students understand about their alternative conceptions in their prior knowledge and acquire more accurate science knowledge. More specifically, according to Teacher 2:

> POE is a very good strategy to elicit students' alternative conceptions about science concepts. At first students predict for a science concept based on their prior knowledge. However, when they saw something different during the observation stage, they can easily realise that they have some problem in their own prediction. I found some of them during my two teaching session with POE.

Teachers also experienced influences from using the POE strategy in their usual science teaching practice. Eight teachers mentioned that the strategy helped them to make the lesson interesting, which leads students to be more attentive in their science learning. Six of them were of the view that using this strategy helped them to make sure that they came into class well prepared. This greater preparation included being more confident in their content knowledge, their use of teaching aids and making more links between the science concepts and real life. The major responses are listed in the Table 7.3.

Table 7.3

Influences of POE strategy on teachers' practice

Responses	**Frequency (Number of Teachers)**
Led students to be attentive in their science learning.	8
Made the lesson interesting.	8
Helped them in class preparation.	6
Ensured use of teaching aids.	3
Developed thinking ability.	3
Integrated real life with the text book.	5

Teachers also outlined their problems in using POE within their practice. Eight teachers mentioned straight away that they did not find any difficulty in using POE. Five teachers mentioned that they believed that POE would not work for all topics, especially for topics which required a deep theoretical understanding. For example, one of them doubted that using a POE strategy would be useful for the basic understanding of electricity. Four teachers wondered how they would manage to use a POE with their existing teaching load. During the FGD, they also discussed the issue of class size. However, according to Teacher 13, “I did not find any problem with class size in using POE in my classes. I think it is the strategy that makes students active together.” The other teachers then agreed with him.

Teachers also expressed their opinion on the workability of this strategy in the Bangladesh context. Twelve teachers recommended its use for the Bangladesh secondary school context because they felt it was an effective teaching approach. According to them, the POE strategy would help science teachers find a link between the text book materials and the local environment around the school. This could happen through searching for appropriate teaching aids for their practice because of the use of a POE. Moreover, they discussed at the FGDs that as there is an ongoing problem with large class size and POE is an effective strategy to make attentive a larger number of students, that this method could work well as an effective approach for science teaching in Bangladesh.

However, two teachers were sceptical about the effectiveness of POE in the Bangladeshi context. They were concerned about the need for good preparation for a POE when teachers were usually loaded with classes. They were also concerned about adequate support for using the POE in their practice especially in regard to the lack of school resources. In spite of this, during both FGDs, other teachers disagreed with that view. According to Teacher 10, “Bangladesh is a developing country, we have to look forward rather than waiting to depend on others. We have to work hard to find our resources. I think for the secondary level, we can find all of our resources from our local environment with a minimum effort.” The others agreed with him.

Teachers also offered suggestions for the effective use of POE in the Bangladesh context. Most of them asked for support from schools as much as possible besides teachers’ own initiatives. This mainly included the use of adequate resources for teaching. Teachers also stressed the importance of good preparation before taking any class. According to Teacher 6:

> Teachers need to be well prepared both in content clarification and using the teaching aids. The most important issue here is the chance of rising up alternative conceptions. When students find themselves in [a feeling of] difference between the prediction and observation, they could be lost. They might look for proper facilitation form their teachers that demand a strong command of subject knowledge.

Six other teachers attached importance to changes in the culture of their professional practice and the need to develop an attitude for accepting any new teaching strategies. According to them, teachers needed to change in ways that could benefit their students' learning. Three of them pointed out about the need not to keep teaching in the same way as they had for year after year. They also suggested reducing their pressure regarding teaching load.

7.4.2 Views on peer classroom observation.

Teachers also talked about the peer classroom observation process; their experiences with the presence of their colleague and how they felt it to be essential for their practice. All 14 participating science teachers felt very good about the process of classroom observation. Finding it essential for their teaching practice, different teachers pointed out different benefits regarding the classroom observation process. Ten teachers mentioned its opportunity to reflect both the teachers' and their observer teachers' perspectives and the way of refining their practice through the process of observation of their colleagues. Four of them mentioned how the process helped them to identify problems in their teaching. According to Teacher 9, "The observation process helps me to explore about how I am teaching and what is the problems in my teaching." Moreover, teachers found this process as a good way of integrating two teachers' experiences. According to Teacher 10 during the FGD:

> The classroom observation process seems very essential for us. It is not possible to find out my own problem by myself, if any of my science colleagues help me through observing my class, it is really great ... it also helps to present a class with more logical sequence ... find scope to integrate the two teachers' experiences for enhancement of both the content knowledge and pedagogical understanding.

Teachers also talked about the presence of their colleagues during their teaching practice. Almost all of them hesitated at the beginning. Teachers also mentioned that they found a transition from ‘tension’ to ‘feeling relaxed’ in the classroom observation process. According to Teacher 5:

> I hesitated a little bit at the beginning. I did not feel comfort in the class. However, later I realized that I forget about the presence of my colleague ... it seemed to me that it would be good if I got some feedback that will help me to refine my teaching ... I hope I will not be hesitant with the presence of any colleague anymore.

Some of them even felt scared about the presence of their colleagues. According to Teacher 9, “The reason of my fear [was] if I made any mistake and my colleague reported to others in the school, it would be very bad for my reputation in the school.” In response to how they overcome that fear, Teacher 14 during the FGD said:

> we were not used to observing each other’s classes. When it happened in reality we found the observing process was very effective to clarify our existing knowledge ... I learnt a lot from this observation and the overall situations brought a huge change ... I think all of us really feel that we need to share rather be scared to seek help from each other.

The observation of colleagues’ teaching practice helped participant teachers think about the essentials they wanted to change in their own practice. Most of the teachers stated that the observation process helped them to identify the good, the mistakes and even exemplary aspects of teaching of their colleagues and then use it as a learning tool for their own teaching practice. According to Teacher 4,

> I noted the attractive aspects from my colleague’s presentation and then used it in my teaching ... the process basically developed inspiration for me to do better ... it helped to improve my teaching too, leading to more effective science teaching ... this is the real experience about how to improve my teaching through collaboration.

It is not difficult to see then that their learning from the peer observation process could then bring a change in the culture of professional practice in order to improve their teaching, which impacts on their students’ learning.

7.4.3 Views on post-teaching discussion.

The participating science teachers expressed views about the post-teaching discussion session which they saw as essential for developing their practice. They described their experiences with the post-teaching discussion immediately after they conducted their teaching session, how they found it effective in improving their practice and how they benefited from those discussions. The major responses are listed in Table 7.4.

Almost all participating teachers found the post-teaching discussions to be very interesting and lively. Seven stated that the discussion sessions were exemplary as they received constructive suggestions from their colleagues for improving their teaching practice. Four mentioned how the discussions helped them to overcome their own (previously) rigid views regarding their teaching. According to Teacher 4, “I thought I always taught very well, however, from the discussions I learnt that I have to learn more to make my science teaching effective.” Five of them also found the discussions provided them with new possibilities to exchange their views or ideas regarding their practice with their colleagues.

Table 7.4

Teachers’ feeling about the post teaching discussion

Responses	**Frequency (Number of Teachers)**
Interesting, attractive and lively.	13
Received constructive suggestions to improve their practice.	7
Opportunity to exchange their views.	5
Overcome own strict decision regarding teaching issues.	4
Guide to identify own mistakes.	3
Scope to refine and correct own knowledge.	2

Teachers also found the post-teaching discussion sessions effective in improving their practice. Nine teachers expressed the idea that discussions gave them an opportunity to know about the quality of their own performance. It became possible for them to realise what was good and what was not so good in their teaching in ways that were not possible to identify alone and unassisted. It also helped them to recall all the interesting things that happened during a class.

Four teachers stated that the discussions helped them to refine their understanding of content knowledge, pedagogical aspects, use of resources and how to improve the classroom learning environment. Three teachers also mentioned that the discussions helped them to identify the gap or mismatches in their teaching. Two of them stated that the discussions helped them to identify the alternative conceptions in science concepts. According to Teacher 3:

> I got a suggestion to use the local environment from my colleagues during the post-teaching discussion. I used beakers for demonstration for my refraction topics which we have only in our school science laboratory, however, my colleague suggested to use any glass which serves the same purpose and we can get them easily – I hadn't thought about that before.

Five teachers stated that the discussion process helped them to improve their confidence in teaching. They described how the discussions helped in overcoming hesitation in sharing and developed more conscious awareness of science concepts, selecting pedagogy and using resources that contributed to making a science lessons more effective. According to Teacher 12:

> The discussions provide us a scope to think for the change in the culture of professional practice. Before I have a belief that colleagues could report to others about my fault, However I found that every science teacher is cooperative in nature in this situation. Everything seems beyond my previous thinking and I am happy now with this situation.

The other teachers have agreed with his opinion during the FGD. The above results overall reflect that they found post-teaching discussion to be effective for changing their teaching practice.

7.4.4 Views on professional workshop post intervention.

Teachers expressed their views about why they felt it essential to attend the professional workshops after every teaching cycle. All teachers found it excellent to meet together to discuss their everyday problems with their practice. Their responses are listed in Table 7.5. Twelve found these professional workshops reasonably different from previous workshops they had attended. According to teacher 11, “The concept of this workshop is different from the traditional teacher training I attended before. The reason is that the teacher training sessions are concerned with particular preset issues; however we can discuss our current problems in this workshop.” Ten teachers expressed the view that the workshops developed a collaborative attitude among themselves in exchanging their experiences. Five mentioned that the process helped them to overcome the inertia or rigidity from sharing that guided them to better address complicated issues in their practice and to find a common decision. According to teacher 7, “The whole process led us to be more confident for our teaching practice.”

Table 7.5

Teachers’ views on professional workshop

Responses	**Frequency (Number of Teachers)**
Developed a collaborative attitude among themselves to exchange their experience.	10
Found these professional workshops reasonably different from the previous workshops they had attended.	12
The process helped them to overcome the inertia or rigidity of sharing.	5
Provided scope to share experiences from other schools.	3
Able to discuss complicated issues.	2
Found it informative.	2

Teachers also found it very important to discuss current issues and get updated knowledge on science concepts and pedagogy. All of them mentioned that they became more aware of current ideas through sharing with their colleagues from schools at the professional workshops. According to Teacher 3, “I had not a clear conception about the difference between LP gas and CNG in attending the workshop now I have clear knowledge about it.” During the FGDs, according to Teacher 6, “This will be particularly important when we find new chapters regarding adding it to the text book every year, we then really feel help from some who are able to solve our problems with new issues.” The other teachers agreed.

Teachers also emphasised the need for professional workshops to increase the areas of their subject knowledge. The major responses are listed in Table 7.6. Seven teachers mentioned that the workshops helped them to clarify science concepts from their every day practice on which they had confusion. Five stated that the workshops provided scope to refine their understanding about subject knowledge. Two also focused on the essential nature of the workshops for getting the latest information through sharing from their colleagues. According to Teacher 10 during the FGD, “When we are used to sharing with our colleagues, I think we will be in the habit of collecting and sharing the latest information regarding science concepts.”

Table 7.6

Teachers’ responses on subject knowledge

Responses	**Frequency (Number of Teachers)**
Helped to clarify the science concept.	7
Refined their understanding about subject knowledge.	5
Enhanced subject knowledge.	4
More learning experience.	2
Gathers latest information.	2

Teachers also discussed their limitations regarding the subject knowledge in science necessary to conduct an effective science class for junior secondary sections. According to Teacher 14 during the FGD:

> I am a physical science teacher; however, [because of] the shortage of teachers, I have to teach Biology. At the same time, I have to also teach biological part of integrated science for junior secondary … I have no problem to give the general idea; however, find difficulty to provide details and in depth information. I understood that I am teaching from the surface level. The idea of professional workshop should help me to share my problems with other science colleagues around our local schools.

Teachers also discussed how professional workshops helped them to address and overcome their own alternative conceptions. According to Teacher 8,

> I felt confused in deciding whether pressure increased or decreased as we move up from the surface of the earth. I always thought that we have to measure the height from the surface. Now I have the clear idea that we have to measure from space.

Teacher 12 also stated that his alternative conceptions on how an onion causes tears. He also gained a clearer idea from colleagues from another school. According to him, “Sometimes I might not know about something, but my colleagues from other schools might know that. So the professional workshops could be a place where we can address our incomplete knowledge and possible ways of clarifying”. These examples reflect how collaboration through attending the professional workshops addressed teachers’ everyday issues through discussions with their colleagues as a result of changing the culture of their professional practice.

7.4.5 Views on collaborative activities.

Teachers also expressed their views regarding the collaborative practice that was fostered by the intervention process. They expressed their opinions as to why they were enthusiastic about collaboration, how it ensured improvement in their practice, and how it influenced other colleagues and led to school change.

Teachers described their experiences of sharing with their colleagues at school in terms of their teaching preparation. Ten teachers discussed clarifying science concepts with their colleagues regarding the teaching topics. Nine teachers were looking for their colleagues in order to collaborate in developing the effective use of teaching aids and how to make it more real world oriented. Seven teachers mentioned that they talked with their colleagues about how to make the presentations easier and more effective was and to ensure the proper use of POE.

Teachers also expressed their opinions about how these collaborative activities helped them to ensure improvement in their teaching practice. Five teachers mentioned that the collaborative activities helped them to be confident in their teaching. According to Teacher 3:

> I overcome my difficulty in teaching when my colleagues noticed my faults and discussed with me; we were discussing about the teaching aids and its better way of use, it helps us to make the teaching effective. The sharing process has developed a better friendly relationship among colleagues...find new path of solution for any problem after discussing with colleagues ... cordial relation with colleagues bring a nice learning environment at the school.

Teachers also discussed any negative impact from the sharing with their colleagues. Almost all of them stated that they did not notice any negative influence from this sharing. According to Teacher 2:

> Before we were not used to sharing as we taught if we expressed our unknown things regarding our practice it might damage or influence our image or reputation ... we were always careful about it ... but in reality we found it different ... we now realise that it is helpful and essential for our practice.

Five teachers mentioned that they liked to meet and discuss in their free time, where four of them mentioned rescheduling the class routine to provide them with an opportunity for regular collaborative meetings. They also mentioned that the rescheduling of the class routine even reduced class load and provided more opportunities for space and time for sharing and observing each other’s teaching practice.

The collaborative processes were seen as having influenced other colleagues in their schools. All of them said that the collaborative process inspired other colleagues from other subjects. According to Teacher 9, “When we discuss science teaching problems, other teachers are inspired and acknowledge the importance of this process. They also started with their practice before and after the school." This is a reflection of how this collaborative process ultimately helped to change the culture of the school.

7.4.6 Views on the concept of PLC.

Participant teachers expressed their views regarding their membership of their professional learning community (PLC). They expressed how they felt, how it helped to enhance the teaching profession, whether they found any difficulties in membership and how they liked to maintain their membership in their learning community. All participant teachers found the concept of PLCs very good for enhancing their practice. According to them, it offered them possibilities for maintaining regular communication and a forum for the exchange of views regarding their every day practice. They also thought it was a way to be more conscious about professional responsibilities.

Six stated that they would be able to overcome their shortcomings in subject knowledge and clarify their confusion in terms of science concepts. Five expressed the view that discussions in the learning community helped them to explore what we they did not know. According to teacher 10, "When I go to a bigger community, then it is easier for me to realise and identify what is my problem rather than me." Three teachers also emphasised the importance of membership in addressing their alternative conceptions.

Thirteen teachers did not think they would have problems with membership in the learning community and doing the activities for it. However, one teacher brought up the question of time management due to his extreme teaching load. The question of how to continue or sustain the learning community was also discussed during the FGDs. According to Teacher 11, "we have to ensure our presence for all of its activities; need commitments to make it effective; have to take care to make the discussion successful; have to work hard to make it as a model." All of them expressed their strong commitment to sustaining a learning community as they considered it essential for improving their practice.

7.5 Chapter Summary

Participant teachers viewed the POE as a very good teaching strategy for their practice. The strategy had several aspects that influenced their teaching practice. Participant teachers also listed different good aspects of POE including its power to make students interested in their own learning processes. The POE strategy also guided these teachers in better preparing before taking their classes, which made them more confident in their content knowledge and their use of teaching aids to make links between the text book material and the local environment around them. Most of them did not find any problem regarding their use of the POE teaching strategy in their practice and expressed their positive concerns for its workability in the Bangladesh context, in particular for making students more attentive in larger classes.

Teachers also found the peer observation process effective for identifying their problems in teaching. The process guided them in a transition from hesitation to feeling relaxed about the presence of their colleagues in their classroom. Moreover, they considered post-teaching discussions as a way of gaining constructive suggestions for improving their practice; it allowed them to identify gaps or mismatches in their teaching. Furthermore, participant teachers experienced the professional workshop as a valuable way of exchanging views with colleagues from other schools. This opportunity helped them to increase their knowledge of subject matter and pedagogy as well as discuss limitations with their teaching practice. In general, teachers were very positive about the intervention process and found that it influenced their thinking in ways that led to change for the better in relation to their practice and their students' learning.

Chapter 8
Discussion

This chapter discusses how the findings of the previous three chapters have created an informed response to the two main research purposes, i.e.,: (1) to guide participant teachers in changing their existing traditional teaching approach; and, (2) to assist participant science teachers to change the culture of their existing professional practice. Through this examination, the four research questions outlined for this study will then have been fully addressed.

The following sections in this chapter focus on a discussion of the teachers' views and how they are linked to, and influence the nature of, the learning of science teaching in secondary schools in Bangladesh. The discussion that follows considers how the issues that have emerged in the data impact understandings of, and approaches to, teachers' thinking about change when linked to constructivist views of teaching and learning and how developing a culture of professional practice supports those changes.

8.1 Science Teachers' Views about their Practice and Students' Learning of Science

This section of the chapter discusses teachers' views regarding their practices and their students' learning of science. The section focuses on the teaching context, teachers' perceptions about teaching and learning, their knowledge of subject matter and pedagogy, and issues related to professional development and collaboration.

8.1.1 The context for science teaching and learning.

From the results of the baseline survey, participant teachers were of the view that the teacher-student ratio was problematic in relation to their ability to deliver quality science education in secondary schools. According to the baseline survey findings, on average, participants' schools were reported to have two or three science teachers and the number of students in the junior secondary classes was always more than 60 and in many cases, it reported as being around 100 (see chapter 5). This situation can be seen as imposing two types of excessive workload. The first is that of topic overload and the second is an overload in relation to the number of classes to be taught.

It was noted in chapter two that, in most cases, a science teacher is responsible for teaching both science and mathematics from grade Six to Ten. Moreover, in most cases, schools split each junior secondary grade level into a number of sections (with the expectation that it might lead to better management of the teaching-learning situation). The increase in sections for individual grades then increases the numbers of classes for science teachers to teach in a school. To manage this number of classes (for both science and mathematics), science teachers may have to take around 30 different classes (average duration of 40 minutes) - these are similar findings to those of Hossain (2000) and Haque (1976). Not surprisingly, teachers viewed this teaching load as extreme.

It was also evident from teachers' interviews that science teachers typically felt under pressure from a teaching routine that had them moving from general science classes to mathematics and then to chemistry then on to higher maths and then back again to a general science class in the course of a day. Through that process, they suffered under what might be described as topic overload, also named as cognitive load (Ferry, 2010), which has implications for how well they could concentrate on diverse issues regarding the teaching of science and mathematics concepts and how those would be challenged across different grade levels. There are two consequences for the above mentioned teaching and topic load in this context. One is teachers' time for preparing their lessons and the second is the way in which they come to manage their teaching load.

Teachers consistently complained (through the baseline interview) that they did not have sufficient time to appropriately prepare for all these different classes in one day and, as was evident from the data (see chapter 5) a consequence was that most of the participant teachers did not spend a great deal of time preparing their science lessons.

The participant teachers argued (see chapter 5) that they were so busy with the consecutive nature of their class allocations in a day that it was difficult to prepare well for all the different classes. Ultimately then, that situation leads to teachers taking classes without adequate preparation. Obviously that has implications for students' learning.

The teaching load also creates a forced choice between subject areas and many science teachers had to give up some classes in order to manage their overall load. In most cases, they preferred to take maths classes across different grades (as noted in chapter 5) as most preferred to teach maths rather than science. Moreover, they tended to prepare more for their higher science classes (Grades Nine and Ten) where they felt as though they had a chance to teach science for specialised courses (i.e., Physics, Chemistry and Biology) rather than general science at the junior secondary level. As these teachers then 'gave up' these general science classes, the roll on effect was that these classes were taken by non-science background teachers who studied science as a student in school but not as part of their tertiary level studies.

These issues (above) create major issues in terms of science teaching and learning at the junior secondary level. These issues then may well impact curriculum implementation, science instruction, students' participation and interest in science. Considering these issues, it may well be that the lack of preparation time directly impacts implementation of an integrated science course. This outcome has previously been recognized by Caillods, et al. (1996) and Lewin (1992) - they argued that science teachers needed sufficient preparation for any general or integrated science course if it was to be appropriately implemented. The impact of this insufficient preparation may well result in poor science teaching. As a consequence, it is not difficult to see how teachers may then depend only on the textbook for their knowledge and have a superficial focus on professional development activities that help them to gather knowledge about subject matter to the detriment of pedagogical development and insights. The outcome being that the subsequent science instruction might simply encourage students to memorise elements of the text book rather than to see the value in working toward developing an understanding of the science concept(s) (See chapter 5 where extra teaching load did not allow participants to concentrate properly on getting and responding to student feedback, but encouraged a transmissive approach to delivery propositional knowledge.)

Participant teachers found it to be quite a challenge to cover the general science curriculum (see chapter 5). They were of the view that the textbook was overloaded with ‘must learn’ content - in ways similar to Tapan’s (2010) findings. Teachers were therefore faced with a dilemma. On the one hand they did not have enough time to prepare for their classes because of teaching overload and on the other hand they had to cover a large amount of content due to a ‘fact overloaded’ curriculum. For the general science classes in particular, this dilemma directly impacts the quality of teaching and students’ learning and detracts from the purpose of science teaching outlined in the Bangladesh education policy.

Teachers therefore struggled to make science classrooms lively and creative (as continually noted in the teachers’ interviews in chapter 5) as they placed more emphasis on theoretical, abstract topics to be taught, rather making it meaningful to the students’ experiences and interests. As a consequence, students would find themselves memorising basic principles, concepts, theories and laws, but were rarely encouraged to investigate the environment around them, or to solve daily life problems with the knowledge and skills they had already gained.

Junior secondary level is part of the compulsory grades of schooling in Bangladesh. The expectation being that such schooling should help students develop an understanding of the nature of science as a key element for achieving scientific literacy so that they are able to identify and investigate questions and draw evidence-based conclusions. Teaching at this level then should demand more emphasis on guiding students in active and extended student inquiry. However, when students are taught by non-science background teachers, it is hard to imagine how such teachers might develop general science activities in which students can draw evidence based conclusions from their learning (teachers’ interviews supported the view that there was a major lack of activity oriented classes). This was also evident (see chapter 5) where participants were of the view that the quality of general science teaching dropped when it was taught by a non-science background teacher. Participants’ views were that such teaching mainly covered the content that needed to be taught rather than focusing on the development of cognitive skills for better understanding of science. Ultimately then students do not particularly enjoy their science experiences and tend to give up science so that in the higher classes there is a decrease in participation in science.

8.1.2 Teachers' perceptions about teaching and learning.

This section of the chapter deals with issues related to how participating teachers viewed scientific knowledge and science teaching.

Scientific knowledge

The participant science teachers had mixed views about the nature and place of scientific knowledge. For example, most were of the view that science was about finding the right answer and that science itself is a logical and ordered subject (see chapter 5). On the other hand, most of the teachers did not view scientific knowledge as abstract. Their view about scientific knowledge was mixed and they seemed hesitant to take a position about their personal opinion on scientific knowledge when considered as a discipline. This mixed nature of their views regarding scientific knowledge is similar to the finding of Sarkar and Gomes (2010) and Buaraphan and Sung-Ong (2009).

These mixed views of participant teachers about scientific knowledge have the potential to influence science education in Bangladesh. It is important in science education to appreciate that scientific knowledge is both symbolic in nature and socially negotiated. Moreover, the objects of science are not the phenomena of nature but constructs that are advanced by the scientific community to interpret nature. In this particular situation teachers may find it difficult to be involved in introducing students to a scientific way of knowing if they do not personally appreciate that perspective. It may therefore be difficult for teachers to mediate scientific knowledge for their learners and to help them make personal sense of the ways in which knowledge claims are generated and validated if they lack a core commitment associated with scientific practice and knowledge claims as suggested by Driver et al., (1994).

Secondly, it could well be argued that a successful science curriculum feeds an interest in science that underlines lifelong learning. It then leads to the valuing of this kind of scientific knowledge through a process of careful experimentation and argument. Moreover, it is the responsibility of science teachers to involve their students in the explicit process of doing science and to cultivate these interests, values and attitudes. However, when teachers carry uniformed views about scientific knowledge it may be difficult for them to involve their students in the explicit process of doing science. This may also mean that students are not explicitly confronted by teaching and learning situations designed to foster conceptual change; which is also related to the nature and intention of a science curriculum.

Thirdly, there is an inevitable impact on teachers' instructional behaviours and decisions. According to Lederman (1992), teachers' instructional behaviours, activities and decisions are significantly influenced by their own views of the nature of scientific knowledge. As participant teachers had mixed understandings about the nature of scientific knowledge, they may well similarly have difficulty in converting their understanding into classroom practice in any sophisticated manner. Thus, they may not necessarily teach in ways that result in instructional activities designed to enhance students' scientific conceptions beyond propositional knowledge alone.

Science as a subject to teach

Participant teachers had mixed views as to whether or not science was a hard subject to teach in comparison to other subject areas. The majority of participant teachers were not of that view. However, a considerable number of teachers found it harder and that may well link to the finding that most did not consider science to be an abstract subject. These differences again may be due to their different exposure or experience from their own teaching or the different courses they completed in their own schooling. Teachers who considered science teaching to be harder than other subjects may present science as a rigid body of facts, theories and rules to be memorized and practised, rather than as a way of knowing about natural phenomenon (Caillods, et al., 1996).

Half of the participant teachers were of the view that they were responsible for their students' learning which is somewhat in contrast to the constructivist notion of learning as suggested by Tytler (2004) whereby learners have the final responsibility for their own learning and that teachers can only support their students' learning. This differentiation in terms of these somewhat opposing views may influence participating teachers' understandings of their needs for in-service training especially with regard to moving from a teacher-centred to a student-centered approach to teaching (MacDonald & Morgan, 1990).

The baseline survey also explored teachers' views regarding their efficacy for their science teaching. The findings revealed that these teachers had a high level of both outcome expectancy and self-efficacy. Teachers with a high sense of their own efficacy have the ability to affect their students' learning outcomes. This was reflected in those that seemed confident about organising science content in an appropriate teaching sequence and felt that effective teaching can change students' learning outcomes (see chapter 5). However, according to the interview findings, teachers did not appear sufficiently confident to be explicit about how their beliefs impacted their decision making about their teaching and their students' learning and were unable to provide a concrete example regarding this issue. For example, in response to the influence of beliefs on decision making, activity or performance in the classroom, teacher 6 responded, "I have a belief that if I do some hard work, then at least 40% of students will be able to understand the topics. At the same time, students will not respond as long as I force [that] on them. This belief leads me to make pressure on students in different ways (sometime using sticks)". On the other hand teacher 5 stated that, "The main thing is that class activities differ according to how a teacher believes in different things ... [it] should be different for different believers."

Beliefs then influence views about instruction and how to adapt teaching practices to meet students' needs (Minke, Bear, Deemer, & Griffin, 1996; Saklofske, Michayluk, & Randhawa, 1988). Teachers who believe they are effective set more challenging goals for themselves, are more likely to use hands-on teaching methods (Riggs & Enochs, 1990) and are more involved in collaborative activities with others (Gibson & Dembo, 1984; Minke, et al., 1996).

8.1.3 Teachers' knowledge of subject matter.

This section deals with issues that impact on teaching and learning regarding teachers' subject matter knowledge and alternative conceptions in science. It is immediately evident in both the baseline survey and teacher interviews (see chapter 5) that most of the participating teachers faced difficulties with regard to their subject matter knowledge. These difficulties included: explaining the science content; providing real life examples; linking the principles of science with real life examples; and, providing current ideas regarding science content. This situation has a clear link to pedagogical behaviour in relation to explaining subject matter.

It has already been noted (see chapter 5) that most (86.1%) participating teachers found some degree of difficulty in explaining science subject matter. This result is consistent with the findings of Malek et al. (2004) and is partly explained by the fact that most teachers in their interview mentioned (see chapter 5) that the difficulties were mainly due to an insufficient understanding of certain subject matter. Science teaching must then surely be challenging if a teacher is unable to explain substantive concepts to their students. This situation has the potential to impact a teacher's pedagogical behaviour because any difficulty in understanding the content of the subject may make it difficult to organise and structure content appropriately and impact ways of thinking about how to design inquiry into that content. Again, and a common theme emerging in the data, is that these difficulties may also lead to transmissive modes of teaching which may lead students to adopt a surface approach to learning. The likelihood of that being the case stands out in stark contrast to the view that teachers need higher levels of subject matter knowledge in order to be 'fluent' in a subject; it requires a great deal of content specific knowledge (Kennedy, 1990), because that enables a variety of complex relationships among different pieces of content to be formed.

When teachers have difficulty in explaining subject matter knowledge it may well be because they are may not be sufficiently 'fluent' in their subject. Their teaching then may be dominated by transmitting content knowledge for passive memorisation. This ultimately encourages students toward surface level learning which may further support them to consider simply trying to memorise many unrelated facts (Loughran, 2010).

Finally, the difficulties in explaining subject matter knowledge may also impact teachers' sharing with other colleagues within and across the school. This may also be evident (see chapter 6) by the fact that when teachers feel they have limited knowledge they do not like to expose that situation to their other colleagues thus maintaining a teaching community that can appear to be in a state of isolation and lacking in collegiality (Hossain, 2000).

Science education demands students' understanding of everyday science. However, it is evident that many of these teachers faced difficulties in providing real life examples or linking science principles with real life situations in their teaching. It is also evident from the teacher interviews (see chapter 6) that in some cases these difficulties are due to the lack of familiarity with real life examples and/or the lack of availability of appropriate resources. This may due to lack of teachers' deep subject matter knowledge needed to connect their conceptual knowledge to real life examples. In addition they teachers may threaten if they make a mistake; therefore they stick to the textbook. The outcome being that students may not have their interest in science sparked, and consequently find it difficult to make decisions about such things as the environment, their own health and wellbeing and their role as future citizens in understanding science issues; thus limiting their ability to be scientifically literate (Goodrum, et al., 2001). As a result, science teachers, in most cases, seem to merely deliver what the curriculum or text book provides rather than finding utility and relevance of the subject to everyday life.

Alternative conceptions

The issue of alternative conceptions in science has also been considered in this study. It is evident both from the baseline survey and teachers' interviews that most participating teachers in this study were not familiar with the terminology of alternative conceptions in science. In some cases, they had heard of alternative conceptions but were not able to provide a concrete example of confronting them in their teaching (either from a teacher or student perspective). As noted (see chapter 5), some teachers suggested that they had experienced alternative conceptions with students, namely 'how pressure differs with depth'; 'concept of work'; 'whether a mirage is related to light refection or refraction'; and, 'working principles of vacuum flux'. However, none of these teachers was able to explain in clear detail what they found in relation to these alternative conceptions or how they worked with them through their practice. These results clearly suggest that alternative conceptions offer an aspect of science teaching and learning that has not really gained much traction with these teachers in Bangladesh to date.

This situation suggests that these teachers may not be likely to determine whether or not students have parallel explanations of natural phenomenon or whether they used their alternative conceptions in different contexts. At the same time, as the majority of teachers were not concerned about alternative conceptions, it carries implications for the development and use of instructional materials. Moreover, it raises questions about to the extent to which they might be able to bring learners' prior knowledge to the surface in their teaching and respond to that knowledge in meaningful ways.

8.1.4 Teachers' knowledge of pedagogy.

The baseline survey data clearly illustrates that these science teachers like to use traditional teaching methods in their teaching of science. Their teaching methods appear to be dominated by teacher-centred approaches (see Table 5.11) mainly based on talk, text and demonstration. This result is consistent with Tapan's (2010) findings and draws attention to the fact that these teachers usually try to make lessons simple and uncomplicated thus encouraging students to approach learning as recitation of acquired knowledge – which is similarly reflected in the approach to assessment. More often than not, as has been reported elsewhere, teachers relied on rote learning and theoretical exercises (Caillods, et al., 1996) to transmit science as information.

The use of these traditional methods inevitably leads to a lack of challenge to students' existing ideas and reinforces the well acknowledged aspect of learning as school science – to be used in school but rarely applied in out of school contexts. Moreover, such traditional approaches may well be seen as discouraging students from developing a sense of purpose and motivation for learning science topics as students do have pedagogically sound approaches to clarifying their ideas or resolving conceptual conflict.

The baseline data also highlights that these science teachers were concerned with different aspects of students' learning (see chapter 5). Their concerns included: understanding about students' interests; level of difficulty; and, level of thinking in planning science lessons. These results offer an opportunity to consider more deeply why it might be that these teachers were enthusiastic about new possibilities for their professional learning and working with new teaching strategies that they could see impacted in positive ways, the learning of their students.

Although many teachers felt confident with their teaching approach and ability to organise science content in an appropriate sequence – which is slightly different from the results of Malek et al. (2004) – 32.7% of these teachers still reported feeling troubled about differentiating their teaching based on individual science topics. These levels of confidence are important in helping teachers to forge links and connections between different science concepts (French, 2003) and may well be the basis for an openness to seeing alternative ways of looking at the same idea which is so essential for effective science teaching. Hence, within the data there are some inherent contradictions. However, these contradictions are able to be explained through the differences between the nature of the context and the concerns about ways of coping with the demands of heavy teaching loads and lack of content knowledge and the obvious concern for student learning and possibilities for development and pedagogical enhancement that is linked to teachers' professional learning and their hopes and expectations for student outcomes. This is particularly apparent when resources are considered.

8.1.5 Resources for science teaching.

The availability of resources and their use is also a concern of this study. The availability of resources is important as it relates to maintaining quality science teaching (Gray, 1999). According to the baseline data, secondary teachers in Bangladesh have limited access to resources for their teaching (see chapter 5). They mainly depend on the textbook in supporting their practice which is consistent with previous research in the

Bangladesh context (Siddique, 2008; Tapan, 2010). It is also evident from the interviews that teachers feel less comfortable about their teaching when they have to depend only on a few resources (see chapter 6). This situation may make it difficult for these teachers to place more emphasis on learning science actively when they do not have opportunities to develop understanding from multiple resources i.e., books, internet, media reports, and hands-on investigations (Caillods, et al., 1996; Goodrum, 2004).

It is also evident from the baseline interview that teachers held different views regarding the availability of resources. One group of teachers reported that they had sufficient resources for their teaching, whereas the other group were not satisfied with the available resources. This situation is similarly reflected in other developing countries where availability of resources impacts teachers differently. This is also evident from the baseline interview whereby many of the participant teachers felt disappointed that they did not have access to the desired teaching aids but, at the same time, somewhat paradoxically, they tended not to use them when they were available. In some cases teachers illustrated a preponderance to collect teaching aids, however, again in most cases they were in fact reluctant to use them (see chapter 5) - a result that is consistent with the claim of Tapan (2010) where in most cases teachers are not motivated to use teaching aids for their teaching.

According to the baseline interview in this study, some teachers reported that that they tried to make some improvised materials for their science classes. For example, one teacher provided an example of how a green house model motivated his students in their learning (see section 6.3.5.1). Overall, the findings of this study indicate that participant science teachers have limited access to resources and they also use very few resources in their classes. When they are available, they are perhaps underutilized through a lack of genuine understanding of how to incorporate them into their practice.

This ‘resource poor’ situation may lead to science teaching for these teachers being more text-book oriented, and theory-based, based on transmissive teaching and rote learning rather than drawing on everyday problems (Gray, 1999). Also, lack of equipment may lead these teachers to teach science with less emphasis on practical activities which may act as a barrier to achieving the aims of the curriculum such as developing students' interest in doing hands-on activities (NCTB, 1996). As there are well established connections between the availability of resources and student achievement in schools (Gray, 1999; Lewin, 2000), lack of appropriate resources may also affect the quality of science teaching, in the secondary school. Given the reality of a weak economy such as that in Bangladesh, these science teachers may remain poorly prepared to deliver lessons, and due to a lack of resources, students may continue to struggle to develop the desired science process skills.

8.1.6 Professional development and collaboration.

This section is concerned with issues regarding teachers' professional development and collegiality among science teachers. Teachers were of the view that attending in-service training was valuable as it helped their learning about teaching, and they were looking for more in-service opportunities (see chapter 5). It is also evident from the teachers' interview that in-service training provided opportunities for teachers to enhance their knowledge and skills for teaching. However, it is also evident that in most cases, teachers complained about the available training, as they were of the view that they were not getting the content they needed (see chapter 5). Therefore, while teachers placed importance on attending professional development programs, in most cases they were not satisfied with what was on offer since it did not match their current needs regarding the complex nature of teaching and learning; a finding that is consistent with Caillods et al. (1996). This situation is exacerbated by programs that are didactic in nature, hence inadequate for the purpose of changing teachers' practice (Stowitschek, et al., 2000).

The findings from this study show that most of the professional development courses are neither regular nor frequent so the likelihood of any long-term impact on teacher participants is diminished (see chapter 5). These programs may also have little effect on teachers' actual practice because they do not take into account the contextual realities of many schools and students in Bangladesh – as is similarly reflected in many developing countries (Caillods, et al., 1996).

In this study, the baseline survey and interview were also concerned with issues related to collegiality among teachers to support their professional development. Teachers expressed positive views regarding their interest in sharing with their colleagues but had mixed views regarding getting adequate time for collaborative activities. This result is consistent with earlier findings also common to developing countries that science teachers rarely observe the teaching practice of their colleagues (Wahyudi & Treagust, 2004). However, teachers' positive attitudes toward in-service training and their interest in inviting their colleagues to observe their science teaching for the purpose of professional development reflects their enthusiasm for their professional learning.

Lack of collegiality amongst teachers can impact teaching practices in several ways. Firstly, this situation may prevent science teachers from accessing supportive, collegial communities when inquiring into significant questions about science subject matter as well as into questions concerning learning and pedagogy (Loucks-Horsley, et al., 1998). Secondly, this situation may make it difficult to carry out professional development activities that include structured time for collegial discussion and planning with teaching colleagues from the same school or peers from other schools. Thirdly, this may lead to a situation whereby members of the teaching community work in a state of isolation (Hossain, 2000). These factors ultimately impact teachers' professional development regarding their subject knowledge and pedagogy which then negatively impacts student learning.

8.2 Learning About Constructivist Teaching Approaches

This section of the chapter discusses teachers' learning from the constructivist teaching approach they used in their practice as part of the intervention and how teachers' learning influences their thinking about their practice, the way they go about their practice and their students' learning of science. More specifically, these discussions consider participant teachers' learning regarding the use of resources, their thinking about specific content knowledge and its organisation, articulation of their pedagogy and the classroom as a learning environment. This section also discusses how such learning influenced participant teachers in re-thinking their current practice with regard to improving student learning.

8.2.1 Influence on use of resources.

The participant teachers implemented a constructivist teaching approach (POE) in their practice, which served as the intervention in this study. These teachers worked over four teaching cycles and all of the teaching sessions were designed so that students found opportunities to see different teaching (through the use of the POE teaching procedure). It is evident from the reflection from both teachers and observers using the classroom observation schedule that the teaching activities using the POE approach encouraged these teachers to use teachings aids as a purposeful tool in their teaching. These science teachers also seemed very committed to using the resources for their teaching during these teaching sessions which is not found in their normal practice (see section 8.1.5 for that discussion). It was also observed that they had already concentrated on collecting and using resources to demonstrate a good POE (see Tables 6.1 and 6.2). This was also evident when these teachers transformed their ‘Learning’ into ‘Action’ in their subsequent sessions regarding the use of teaching aids (see Table 6.8). These results are positively aligned with Goodrum’s (2004) claim that a constructivist teaching approach may provide opportunities for teachers to seek understanding from multiple sources. The use of different teaching aids through this constructivist teaching approach (POE) then may have helped students to develop a sense of purpose and motivation for learning the topic (evident when the use of the POE was described as assisting students interest in their learning - see Tables 6.1 and 6.2).

The POE teaching approach also assisted these teachers in recognising the power of local materials rather necessarily being seduced by the use of more sophisticated materials for their science teaching classes. This is evident from the post-intervention questionnaire (see chapter 7) and the findings from the professional workshop where participants talked about how they were encouraged to collect teaching aids for the general science classes from the local environment around the school. The data suggests that the use of these local teaching aids helped to bring students to a state of conscious awareness of the concept to be learned (Driver & Oldham, 1986). It may well be that it also helped these teachers to realise that local non-sophisticated teaching materials can be enough to make explicit the science concepts under consideration for their students in ways that made a difference for their learning. This realisation may also have helped these teachers to plan more purposefully for their resource budget which matters within the limited economic conditions of their schools as highlighted in the Focus Group Discussions (FGDs) after the intervention (see chapter 7).

The use of resources within the constructivist teaching process also helped these science teachers to concentrate more on better preparation before any actual practice in the classroom. Teachers reported that they found themselves to be well prepared before taking their teaching sessions (see chapter 7). It has already been mentioned (see chapter 2) that in most cases science teachers in Bangladesh do not prepare for their classes well in terms of their use of teaching aids. However, this POE approach guided and helped these teachers to realise how good preparation (that includes the careful selection of appropriate teaching aids) improves the effectiveness of their science teaching. The effectiveness of their teaching was also evident to them when students were found to be reflective in their classes as reported in the observation schedule (see Tables 6.1 and 6.2). The data then suggests that this ultimately informed these teachers about their practice in ways that helped them to feel more confident about their teaching (see chapter 7).

The intervention process also worked to motivate these teachers to use more teaching aids. It was evident from the baseline interview data that the availability of resources impacts teachers differently. However, after using the POE approach and reflecting on their experiences during post teaching discussions and professional workshops there was consensus of the need to consider their teaching in new ways as their sense of effective teaching linked more closely with that of meaningful student learning. Tapan (2010) claimed that in most cases science teachers are not motivated about collecting teaching aids. However, the results from this study show that the POE strategy worked as an agent to motivate teachers to collect teaching aids. The POE strategy stimulated their enthusiasm to make use of the local environment, even though they were lacking more sophisticated resources. The opportunity to use the POE teaching procedure may have helped these teachers to realise that if they wished to use teaching aids for their teaching they were in fact more than capable of developing and collecting their own teaching materials.

8.2.2 Understanding of content knowledge and its organisation.

This section discusses how the constructivist teaching approach (POE) guided participant science teachers to re-think their content knowledge understanding and its organisation. Teachers in Bangladesh mainly depend on the student textbook as the dominant source of information to be taught (see chapter 2 and 5). However, the constructivist teaching approach (through use of POE) guided participant teachers not to depend only on the text book material for their required teaching information. It is also evident from the data (see chapter 6) that for almost half of the teaching sessions, teachers received a recommendation from their peer observer to concentrate more on gathering current ideas regarding the science concept. This recommendation for concentrating more on updating their content knowledge worked as 'Learning' from the intervention process particularly the impact of use of POE (see Table 6.8 and chapter 7).

These learnings that they experienced during the intervention process may have helped these teachers to overcome their tendency to conceive of science knowledge in narrow ways (i.e., the way of the text book). Moreover, this teaching approach (the POE as an example of a constructivist learning approach to practice) may have helped these teachers to update their content knowledge by gathering current ideas from different sources rather than depending only on the text book materials. The change in attitude towards finding information from different sources for current ideas may also have encouraged these teachers to be more fluent with their content knowledge. Moreover, it could well be that, in the future, as these teachers seek information from different sources, their teaching is then designed to provide more emphasis on students being more scientifically literate (Goodrum, 2004).

The POE teaching approach also influenced participant teachers in terms of developing understanding of science content for their students rather than recall and recognition of facts. This is also evident from the observation schedule when the observer teachers reported that most of the teaching sessions demonstrated well that these teachers concentrated more on understanding rather than recall. The peer observer teachers were also found in some cases to transform their learning into action in their subsequent teaching session as the use of the POE approach impacted their practice (i.e., they also focused more on understanding).

In some cases, teachers received recommendations from their peers to concentrate more on the clarity of the science concept under consideration. This is evident from the majority of the teaching sessions where teachers received recommendations from their peers for more clarity regarding their content knowledge (see Tables 6.1 and 6.2). One of the possible reasons for this recommendation may be that teachers found themselves confronted by ‘harder’ content over the teaching sessions according its design (see chapter 3), as most of these teachers found their content more challenging. They considered the recommendation from their peer observer regarding content clarity as their learning. The data suggests that these results of learning (through the peer exchange) made them more aware of the need to organise and structure content appropriately as they designed their content and pedagogy more around an inquiry approach. These influences on understanding science concepts with clarity also helped them to decrease a transmission of content knowledge approach that supports passive memorisation. Through this shift, it is likely that their students might also then be more encouraged to take a deep approach rather than a surface approach to learning and overcome the simplistic approach to memorising unrelated facts and considering more seriously the essence of their learning (Loughran, 2010).

The POE teaching approach also motivated participant teachers to find ways to look for the relevance of science within real life situations. In so doing, students may also come to see the relevance of science to everyday life. This POE teaching approach helped these teachers move from providing examples themselves to encouraging students to identify examples relevant to themselves. This is indicated by a negative change in the number of ‘real life examples provided by the teacher’ compared to the positive change in ‘encourages students to identify real example’ over the teaching sessions (see Tables 6.3, 6.4, 6.5, and 6.6). Though these teachers did not make as much improvement regarding this issue as expected by their observers, the learning from using this POE strategy ensured these teachers and their students linked science concepts with real life in a way that enabled them to make decisions about the environment, and their own health and wellbeing and the utility and relevance of the subject to everyday life (thus supporting a similar view proposed by Goodrum, et al. (2001).

8.2.3 Influence on articulation of teachers' pedagogical knowledge.

This section discusses how the POE teaching approach guided participant teachers to think about their current pedagogical behaviour and to make it more effective in terms of encouraging students to adopt deep learning processes. The POE teaching approach challenged these teachers not to follow the same sequence as the student text book. This was most evident when participant teachers received recommendations in most of their teaching sessions regarding following the sequence of the textbook. They considered these recommendations of not following the same sequence of textbook in presenting the lesson as their learning and in most cases they also transformed that learning into action in their subsequent teaching sessions (see Table 6.8). It is also evident from teachers' post teaching discussion that they maintained the prediction, observation and explanation sequence, which further diminished their previous need to follow the text book sequence. The data suggests that this approach guided these teachers in finding a theme to present the overall concept with its relevance to the environment (see chapter 7). This also helped these teachers overcome a reliance on rote learning and theoretical exercises to transmit science as information - which is a very common practice in Bangladesh (see chapter 2).

The POE approach also guided participant teachers in how to uphold the purpose of a lesson by maintaining an appropriate sequence through the use of prediction, observation and then explanation. This is evident from reflection of both teachers' themselves and peer observer reflection that in using this teaching approach most of these teachers were able to uphold the clear purpose of the lesson (see chapter 6). At the same time whenever they received any recommendation for improvement, they took it as an opportunity for learning and in most cases they took their learning into action in their subsequent teaching session (see Table 6.8).

In a similar way, the POE teaching approach helped teachers to maintain a logical sequence within their teaching. Continuing in this way may help these teachers to develop confidence to make links and connections with different science concepts in their lessons. This confidence may also guide these teachers to integrate and even extend different science aspects of the content in order to maintain good science learning for their students (Gunstone, 1995). Moreover, in maintaining the purpose and logical sequence, these teachers may overcome their difficulty in mediating scientific knowledge for their students and help them to make personal sense of the ways in which knowledge claims are generated and validated (Driver, et al., 1994).

In most cases the POE teaching approach encouraged participant teachers to take account of their students' prior knowledge during the intervention process. Doing so also allowed them to provide students with an opportunity to express their views about what they already knew regarding a particular concept. This is evident both from teachers' reflections on the observation schedule (see chapter 6) where in the majority of cases participant teachers had accomplished this aspect during their teaching sessions (see Tables 6.1 and 6.2). However, it is also noted (see Table 6.8) that in some cases teachers did not transform their learning from the post-teaching discussion or professional workshop discussions into action in their subsequent teaching session. Thus, while it is clear that these teachers tried to consider their students' alternative conceptions; their own or observer expectations indicate that they may not have improved in doing that as they may have expected or anticipated. This then brought a negative change of the result for change or accomplished learning (see Tables 6.3 - 6.6). Ultimately this POE approach guided these teachers to develop an awareness of the need to work with students' prior knowledge in order to identify alternative conceptions. It may also have helped these teachers to realise that students may well have personal explanations of events that make sense but does not necessarily mean that they are in accord with the explanations of others (Loughran, 2010).

8.2.4 Influence on classroom learning environment.

This section discusses the influence of the POE approach on the learning environment in the class. The POE teaching approach may guide participant science teachers to bring about a change in the classroom learning environment. This claim is evident when almost all teaching sessions using the POE approach encouraged students' interest and enthusiasm towards the learning process. Moreover, these teachers reflected that this approach helped students to reflect on their learning as well as stimulating students' thinking. In both cases, these teachers did very well according to their observers' expectation. It is also evident (see Tables 6.3 - 6.6) that in only a few cases teachers did not improve from their previous session, even after getting a recommendation to improve. Therefore, in most cases, the teachers demonstrated their ability to encourage their students in the learning process.

In most teaching sessions, teachers received recommendations to provide opportunities for their students to mention their problems during the teaching sessions. This is evident (see Tables 6.1 and 6.2) where in the majority of cases they were recommended to improve this practice and provide more opportunities for students to mention problems regarding their understanding of science concepts. These teachers considered this issue as their learning though they did not necessarily transform their learning into action in their subsequent teaching session as expected. The data suggests that such learning may help these teachers to provide more scope for students to mention their own problems regarding their understanding during the class and therefore could help these teachers review their teacher centred approach.

8.3 Professional Learning Community and Teachers' Practice

This section of the chapter discusses the influence of establishing a professional learning community among the participant science teachers. It has already been mentioned that through the intervention these teachers were supported in attempting to develop PLCs to encourage and help to improve their practice and therefore enhance their students' learning of science. The discussions also sought to find out influences on the ways in which these teachers learnt about, and developed, their practice. These discussions ultimately led to a change in the culture of their professional practice. The following sub-sections discuss how the establishment of a PLC offered these teachers the opportunity to develop their leadership capacities, share their mission, vision and goals in relation to improving their practice and focus on collective learning through shared personal practice, all of which supports their commitment to continuous improvement under different physical and human conditions.

8.3.1 Supportive and shared leadership capacity.

This section discusses how the intervention process empowered participant teachers to share their power, authority and decision making. It then explores the structure/s that enabled deeper considerations and investigations regarding their teaching practice. The intervention process guided participant teachers to develop the capacity for building shared leadership through sharing their teaching practices which empowered them to share. Participant teachers engaged voluntarily in the learning process in order to enhance the quality of their teaching practice. The intervention process allowed them to observe a full period of classroom teaching, discuss their observations with their colleagues and attend the professional workshops. These various opportunities helped teachers feel more comfortable to share their feedback with their colleagues. These teachers enjoyed opportunities to share and critique their colleagues' practice and also to reflect on their own practice in relation to identifying positive and negative aspects of their teaching (see chapter 6 and 7). It is evident that initially these teachers felt shy or hesitant in sharing; however, gradually they realised that it helped them to improve their teaching and they felt more comfortable in so doing in the latter part of the intervention implementation stage (see chapter 6 and 7). Teachers' increased confidence may be due to collaborative activities where they found good supports and ways to improve their teaching practices. The collaborative process allowed them to expand their capacity in developing a personal vision for their own teaching practice for enhancing student learning (Senge, 2000). As a consequence of their experiences, these teachers may well find in the future that they have now developed ways of working together as a teaching community based on collaborative approaches rather than a state of isolation.

The intervention process offered participant teachers the opportunity to join together in a structure where they were encouraged to question, investigate and seek solutions concerning aspects of their practice. This was evident when these teachers received constructive suggestions from their colleagues about how to improve their teaching (see chapter 7). The discussions between colleagues allowed them to agree or disagree with the observations, even challenge each other's observations whenever they felt confused. These questions about their practice helped them to not only clarify their observations with their colleagues, but also to clarify their content knowledge, pedagogy and the learning environment in their classrooms (see chapter 6 and 7). As a consequence, it appears as though participants also felt more comfortable (see chapter 6) in exploring their own problems regarding their own practice. Discussing and addressing their problems together, appears to have helped these teachers to develop a positive attitude towards establishing a professional learning community. The structure or frame used for discussions with their colleagues helped them to learn more from their colleagues and to raise their issues about their needs through this process of job-embedded learning (DuFour, et al., 2008).

8.3.2 Fostering shared mission.

This section discusses participant teachers' commitment to their students' learning and explores their decision making as a part of a shared mission. The collaborative work with their colleagues guided participant teachers to establish their commitment to their students' learning. They became committed to finding the gaps or mismatches between their teaching and their students' learning in their own and their colleagues' practice (see chapter 7). In so doing, they worked together and used their discussions and attendance at the professional workshops as the motivator for their thinking about what to change in their own practice (see chapter 7). These processes helped them to explore how they taught and the problems inherent in their teaching. For example, they identified the positive and negative aspects from the teaching of their colleagues and in many cases they reflected on these issues in their own teaching (see chapter 6). These opportunities provided scope for them to reflect upon and know more about their own performance.

The participant teachers used post-teaching discussions and professional workshops to guide their decision making about the challenges they faced regarding their practice. They found post teaching discussions to be interesting, lively and necessary for improving their practice (see chapter 7). In most cases they received constructive suggestions about their challenges from their practice and found an opportunity to exchange their views with other colleagues in their schools that allowed them to take the opportunity to know more about their own performance.

At the same time they also expressed the view that they found it excellent to meet together with colleagues from other schools and to discuss their everyday problems through the professional workshops. It is also evident that the process helped them to develop a positive attitude toward sharing and exchanging their views and reaching common decisions (see chapter 7). For example, the discussion at the workshop helped these teachers to come to consensus regarding a mismatch about issues regarding understanding of parts of human brain. The collaborative PLC approaches developed through these workshops enabled teachers to engage in a process of clarifying understanding in ways similar to that of their students. The discussions helped them to make more informed decisions about teaching practice. In this process all of these teachers found themselves to be accountable for identifying issue to discuss with their colleagues. The process also motivated and created a result-oriented approach that gave them direction in terms of building a collective commitment to a shared vision which in turn fostered their shared mission (Senge, 2000).

Participant science teachers also showed respect, trust and wisdom in order to build their professional commitments. This trust and respect helped them to overcome the hesitation and inertia in sharing with each others. With this trust and respect, an environment was created whereby teachers found opportunities to challenge each other in order to clarify aspects of their teaching (see chapter 6). Moreover based on this trust and respect for their colleagues, participant teachers explored their difficulties openly with their colleagues (see chapter 6). Trust and respect therefore may have helped them to move from feeling shy to open sharing and is important in developing a collective commitment to their students' learning rather privatisation of their practice (Kruse, et al., 1994).

Participant teachers therefore engaged in the collaborative activities to improve both their practice and their students' learning. These activities assisted them in identifying and overcoming their perceived difficulties with their teaching. The intervention process engaged them in the process where their commitment to improving their practice helped them to envision enhancing their students' learning. Moreover, their professional commitment through continuing their collaborative activities worked to ensure the promotion of a shared mission with a meaningful focus (Patterson & Rolhiehieser, 2004).

8.3.3 Focusing on collective learning and its application.

This section discusses how participant teachers became involved in a continuous learning process and applied what they learnt to their practice. Participants engaged in, and received opportunities to, be involve learning processes through observing classroom teaching, discussing these experiences with their peers and attending the professional workshops. They engaged in reflecting on and clarifying their own teaching. The processes include agreement, disagreement and even challenging each others' observations. Their collective learning brought results that aligned with their expectations. For example, participant teachers found difficulty in matching the information and labelling the diagram in the text book in the fourth teaching cycle (see chapter 6). Most of the post teaching discussion within individual peer pairs did not bring fruitful outcomes regarding this issue. They discussed with their colleagues what they considered to be the proper grouping of different parts of the human brain e.g., cerebrum, cerebellum and medulla oblongata during the professional workshop. They also discussed the confusion arising from the Bangla name of these parts of the human brain. After a long discussion all participant teachers appeared equally satisfied about the outcome from their discussions. This instance illustrated the value of collective efforts for all participants as it mobilised each individual's energy (Senge, 2000). These processes encouraged collective learning through working together to overcome difficulties in explaining subject matter through organising and structuring content appropriately. This process also developed an expectation among them that learning is ongoing and occurs as an integral part of routine practice.

The collegial effort through learning and reflection also guided these teachers to be devoted to using a new teaching strategy (POE). For example, using the POE guided them to see that they might also have alternative conceptions regarding science concepts, just as their students do (see chapter 6). This realisation was important to them as the majority of these teachers were not familiar with alternative conceptions in science (see chapter 5) before they became involved in this research project.

It is evident from the data that initially some participants found the POE approach hard to use as they had difficulty maintaining the right sequence. However, these teachers overcame their difficulties by seeking and receiving suggestions from their peers and more generally from the workshops they attended during the intervention process. Their commitment to incorporate the POE strategy into their practice was most evident (see chapter 7) in which they realised these collaborative processes helped them to refine, strengthen and rethink the use of the strategy for future practice. Their learning about their teaching therefore occurred through collaboration with their colleagues.

Their collective learning also encouraged participants to develop a shared understanding about approaching improving their practice. It is evident (see chapter 7) that the post-teaching discussion process guided these teachers to overcome the view that their colleagues could report to others about aspects of their practice that may have an influence on their reputation in the schools. However, opportunities for discussing with their colleagues supported these teachers to openly share their problems from their own teaching. After the intervention process these teachers suggested that it was not such a problem as they had anticipated and realised that it was helpful and essential for their practice to identify and discuss problems of practice. The data illustrates how they came to see that building shared knowledge and understandings about learning were more helpful to them than individual and isolated approaches to attempting to clarify what and how students need to learn.

The collective learning process also provided opportunities to improve socialisation among the participant teachers. It is evident (see chapter 7) that the sharing process had developed a more friendly sense of relationship among colleagues within and across the schools. According to participants this improved relationship created a nice learning environment at the school. This socialisation may have guided these teachers to communicate a sense that all members were part of a meaningful collective, which in turn guided them in learn about developing the wellbeing of a learning community (Kruse, et al., 1994).

8.3.4 Developing shared personal practice.

The intervention process guided participant science teachers to share their personal practice with their colleagues. They found opportunities to support each other's practice through observing each other's classrooms, discussing observed practice with colleagues within and across the schools. It is evident from teachers' comments that the scope of the intervention process provided them with an opportunity to integrate the experiences of other teachers (see chapter 7) into their thinking and practice. The process helped them to explore several challenges they faced in their regular practice. For example, confusion with science content understanding (variation of liquid pressure), language issues in science (bent or broken) and, lack of quality resources (labelling issues within a diagram) that were collectively explored during the intervention process.

Teachers had problems with these issues, but most of them were not even aware that they were facing problems with these issues during their teaching. This 'peers helping peers' process guided these teachers in developing enough trust in their colleagues to share their shortcomings in constructive ways. According to the data, the shared personal practices may also have helped these teachers to identify their needs and seek support from their colleagues. It is evident that most of them identified that they still needed to learn more to clarify their content and even in using teaching aids (see chapter 7). The processes also helped them to realise they should look toward themselves for their own professional enhancement rather waiting for, or depending on, others (see chapter 6 and 7). They also found it easier to identify their problems and needs when they belonged to a bigger community (see chapter 7). Moreover, these teachers found the discussions among colleagues a support in addressing their incomplete knowledge, seeking clarification and fostering a culture of collaboration, learning from one another and constructing shared pedagogical beliefs (Roberts & Pruitt, 2003, 2009). They exposed their thinking and made that thinking open to the influence of their other colleagues from different subjects in their school (see chapter 7).

The process of shared personal practice also guided teachers to act as 'change facilitators' for individual and school improvement. This basically helped them to encourage and support each other. It is evident (see chapter 6) that teachers borrowed teaching materials from other schools and received support from their colleagues to ensure better teaching. Participant teachers also supported each other to adopt a new teaching strategy (POE) during the intervention process. They discussed failures and successes in implementing this teaching strategy and discussion helped them to facilitate students' involvement in their learning during the third and fourth teaching cycles. These discussions also supported the enhancement of subject and pedagogical knowledge through examining and questioning their existing practice.

8.3.5 Developing a commitment to continuous improvement.

Participant teachers in this study supported each other as a part of their commitment to professional development during the intervention process. It is clear (see chapter 6) that participant teachers received support from other colleagues and even from their students in planning for their teaching. In most cases they received support from their colleagues regarding the teaching aids before the class. In some cases they also discussed the sequence of a new teaching strategy and how they could make it more effective. The participant teachers also found that documenting their evidence of changed practice as a part of their commitment to continuous improvement was important. It is evident (see chapter 6) that in many cases these teachers turned their learning from discussion with their colleagues into action in their subsequent teaching sessions as a consequence of sharing their difficulties regarding their content knowledge from their regular practice. This sharing was not a part of the intervention process and it was not usual for these teachers to share such problems.

The intervention may have developed a trust among these teachers regarding their colleagues that encouraged them to share openly. They participated in subject area meetings and it is also evident (see chapter 6) that they improved in several cases regarding content knowledge and pedagogical issues. This evidence may have helped them to engage more in the learning process and encourage them to form a formal learning group designed (see chapter 7) to improve their learning experiences. These learning processes also encouraged these participants in terms of systematic responses to improve their practices that ensured better support for their students' learning.

8.3.6 Establishing supportive conditions.

This section discusses how the intervention process helped participant science teachers to establish supportive conditions in building professional learning communities. It has already been mentioned that the intervention process offered these teachers the opportunity to observe each other's classes. After that, individual peer pairs within a school joined a post-teaching discussion. After completing each teaching cycle (see chapter 3) all of the teachers attended a professional workshop. These opportunities allowed them to spend some time to meet with their colleagues and talk about their teaching practice.

The schedule and structure offered by this intervention also helped to reduce the state of isolation among these teachers that is a very common complaint for teachers in Bangladesh (see chapter 2). Participant teachers wanted to maintain this collaborative approach to their practice and suggested rescheduling their class routines to provide scope for regular collaborative meetings. They also suggested reducing their existing teaching load to provide more scope for sharing and observing each other's teaching practice (see chapter 7). The intervention process also encouraged these teachers to find new approaches toward communication structures with their colleagues. It is evident (see chapter 6 and 7) that they agreed to develop a learning community among themselves that helped them to find a communication structure to collaborate with each other on regular basis. This structure may have helped these teachers to come together as a unit to do the learning, and support decision making, problem solving, and creative work in ways that characterise a professional learning community (Hord, 2004). These processes also highlight the importance of time and support for learning as variables for school improvement.

It has already been noted (see section 8.3.2) that the intervention process guided participant teachers in showing respect and developing trust in each other. Section 8.3.5 showed how these teachers supported each other in order to use a new constructivist teaching approach. In some cases, teachers among the individual peers helped each other regarding content knowledge. For example, chapter 6 illustrated how Biological science teachers on suggestions from their Physical science colleagues assisted one another. Moreover, the intervention process helped these teachers to know each other regarding their knowledge and pedagogical aspects from a very personal level and facilitated allowed face to face professional interaction within a learning community. These practices helped them to develop a collegial attitude and relationship. The intervention also supported these teachers to change their culture of professional practice.

Overall this process helped them work towards achieving the school mission by providing a caring and productive environment and, improving the quality of the school program (Boyd & Hord, 1994).

8.4 Chapter Summary

This chapter has discussed participant teachers' views regarding teaching context, teachers' view about teaching and learning, teachers' knowledge of subject matter and pedagogy, resources for science teaching, and their professional development and collegiality. In most cases teachers struggled to make the science classroom lively and creative and students were seen to be memorising basic principles, theories and laws in science without any evidence based conclusions from their own learning.

Participant teachers also found it difficult to be involved with their students in introducing them to a scientific way of knowing or in developing an explicit process of doing science. Their views led them to present science as a rigid body of facts rather than as a way of exploring natural phenomenon. Moreover, students therefore, found it difficult to see the relevance of textbook materials and the use of traditional teaching methods inevitably led to a lack of challenge to students' existing ideas.

The use of the POE approached influenced participant teachers' thinking about science teaching and learning. The POE teaching approach encouraged these teachers to use teaching aids as a purposeful tool in their teaching and also stimulated their enthusiasm to find teaching materials from the local environment around them. The POE teaching approach also influenced participant teachers in terms of developing understanding of science content for their students rather than recall and recognition of facts and motivated them to find ways to look for the relevance of science within real life situations. Moreover, the use of this approach also helped these teachers overcome a reliance on rote learning and theoretical exercises to transmit science as information and maintain a logical sequence within their teaching to make personal sense of the ways in which knowledge claims are generated and validated. The POE teaching approach also encouraged students' interest and enthusiasm towards the learning process to bring about a change in the classroom learning environment. This approach could help these teachers respond positively to a teacher centred approach by providing opportunities for their students to raise their problems during in their classes.

The collaborative activities through the intervention process influenced participant teachers learning about constructivist teaching approaches. The intervention process guided participant teachers to develop the capacity for building shared leadership through sharing their teaching practices which empowered them to share. They became committed to finding gaps or mismatches between their teaching and their students' learning and making decisions about the challenges they faced regarding their practice through this process of job-embedded learning. The process also motivated and created a result-oriented approach that gave them direction in terms of building a collective commitment to a shared vision which in turn fostered their shared mission.

It appeared that they came to see the value in supporting one another to openly share problems from their own teaching. The participant teachers also found that documenting their evidence of changed practice as a part of their commitment to continuous improvement was important. They found the intervention to be an agent to reduce their state of professional isolation. The structure of collaboration helped these teachers to come together as a group to develop a collegial attitude and relationship that translated into professional learning, support for decision making, problem solving, and creative work in ways of functioning akin to those that characterise a professional learning community.

Chapter 9
Implications of the Research Findings

This chapter discusses the implications of the research findings from this study. It has been found from the findings that the new constructivist teaching approach (as per the intervention used in this study) positively affected participant teacher's thinking about their practices. Moreover, the collaborative activities through the intervention process influenced these teachers to think in terms of supporting change in their culture of professional practice. These results then ultimately carry implications for science teachers' practice in secondary schools in Bangladesh, their own professional learning, curriculum developers and pre and in-service education for secondary science teachers, and school administrators.

9.1 Implications for Teaching Practice

The research findings have an implication for science teachers in terms of the use of resources in their teaching. The situation of resources in schools in Bangladesh makes it a difficult job for science teachers to place more emphasis on learning science actively. In most cases participant teachers were reluctant to use teaching aids in their teaching. This situation therefore supported the status quo of transmissive teaching that was textbook oriented and theory based with less emphasis on practical activities. However, the intervention in this study influenced participant teachers a great deal with regard to the use of teaching aids. Participant teachers conducted their teaching using teaching aids as purposeful tools due to the demands of implementing the POE teaching strategy.

They had opportunities to seek understanding regarding the use of resources from multiple sources in order to implement the POE strategy. In most cases, they used local materials rather than any sophisticated teaching aids in order to develop a conscious awareness of the science concepts to be learnt for their students. The intervention process worked as a motivating agent to use more teaching aids in their practice. Moreover they shared their teaching aids and suggested ways to find and use teaching aids through collaborative activities. This means that it could be helpful to think about using more teaching aids to develop a sense of purpose of their students and it would obviously be more worthwhile if they concentrated on collecting more from the local environment rather than rely on sophisticated aids as one way of counteracting the weak financial situation of their schools. Moreover, it could also be helpful to think about how to create a more collaborative culture in supporting the development of practice.

The research findings carry implications about science teachers' views on scientific knowledge. They indicated that the participant teachers had superficial views about scientific knowledge and that they found it difficult to be involved in introducing their students to a scientific way of knowing and any explicit process of doing science. Moreover, students also found it difficult to make personal sense of the ways in which knowledge claims in science might be generated or validated. Further to this, they were not explicitly confronted by teaching designed to foster conceptual change. However, when using the POE teaching approach these teachers were assisted in overcoming their difficulty in mediating scientific knowledge by maintaining the purpose and logical sequence of a lesson in a more thoughtful manner. Moreover, participant teachers discussed and openly share their problems with their colleagues regarding their practice in ways not common before the intervention. The participant teachers were involved in a collective learning process to develop a shared understanding about ways of approaching improving their practice.

Participant teachers to some extent found difficulty in explaining substantive concepts of some science subjects to their students. Teachers then faced the challenge of having to form a variety of complex relationships among different pieces of content. This made it difficult for some to organise and structure the science content appropriately. Teaching in most cases then followed the transmissive approach to the delivery of content knowledge which in turn supported passive learning and memorisation by students. Moreover, in most cases, the non-collegial cultures in schools led these teachers to not being comfortable about exposing their limitations in content knowledge to their science colleagues. However, the POE teaching approach and post-teaching discussions within the intervention process guided teachers to find ways to clarify their content knowledge. Teachers found their colleagues to be resources with whom they could share and clarify their content knowledge and share views about their personal practices. This means that it could be helpful for teachers to think about continuing to use a constructivist teaching approach in future and across more content areas in science. Moreover, their commitment to sharing could bring about a change in their practice, enabling them to explain their subject matter more confidently and overcome the tendency to conceive of science knowledge in narrow ways. Their students may then be encouraged to transform their approaches from surface to deep learning.

The research findings of this study revealed that most of the participant teachers were not familiar with the terminology ‘alternative conceptions’ or ‘misconceptions’ regarding science concepts. None provided any concrete examples of alternative conceptions in science. This situation raises questions as to the extent to which these teachers were able to consider learners’ prior knowledge and deal with it accordingly. However, the POE teaching approach, through the intervention in this study, encouraged participant teachers to take into account their students’ prior knowledge. Moreover, the discussions among these teachers helped them to find and even resolve several issues regarding alternative conceptions. It also developed their consciousness of the situation through their collective learning approach in using teaching materials that could mediate alternative conceptions.

These findings therefore suggest that it could be helpful to think about taking into account a constructivist teaching approach that helps to develop awareness about alternative conceptions both for teachers and students. At the same time, it could be helpful to think about a framework for discussion within and across the schools that could help teachers to explore issues about alternative conceptions and how they impact teaching and student learning.

The findings of this research also reveal participant teachers’ lack of familiarity with real life examples regarding the relevance of science concepts to their students’ everyday lives. The leads to students not being interested in science and consequently finding it difficult to make decisions about their role in understanding science issues in the environment around them. However, the intervention process motivated participating teachers to find ways of looking for the relevance to real life situations.

Students were then encouraged to make decisions about the utility and relevance of the subject to their everyday life. Moreover the collaborative practice during the intervention process helped these teachers to know learn about more examples from their colleagues. This means that it could be helpful for science teachers to actively search for relevance of science to the environment around them and to continue collaborative activities that foster these efforts through sharing among their colleagues within and across schools.

It is evident from the research findings that these teachers like to use traditional teaching methods based on talk, test and demonstrations. These simple and uncomplicated methods basically encourage students to adopt a surface approach to their learning and discourage them from developing a sense of purpose and motivation for learning science. Moreover, such teaching lacks challenge in terms of students' existing ideas and application of science knowledge outside the context of school. However, in using the POE teaching approach participant science teachers found a change in certain areas of their pedagogical knowledge. These included finding a theme to present the overall concept within, upholding the purpose of the lesson by maintaining an appropriate and logical teaching sequence, and considering students' prior knowledge, all which helped to change the learning environment in the classrooms. Through sharing activities with colleagues within and across the schools these teachers found it helpful in making more informed decisions about teaching design. It could therefore be helpful for science teachers to think about how to continue a constructivist teaching approach and structures for continuing the sharing culture them made them more confident about their pedagogical decision making in their practice.

The findings of this research also revealed that these teachers found it difficult to set challenging goals and to use hands-on teaching methods that involved collaborative activities with others. However, through using the POE and collaborating with colleagues they found themselves much more confident in developing and using hands on activities. The collaborative activities empowered them to share, which expanded their capacity to develop a personal vision for their own teaching practice.

The research findings also revealed that participant teachers were not satisfied with existing didactic professional development programs. First of all, in most cases they were not getting the content they needed. They were not satisfied with what was offered and found that it did not match their current needs regarding the complex nature of teaching and learning and had little impact on their practice because of the lack of account of the contextual realities of schools and their students. However, though they did not find time and were not used to sharing their practice, they showed positive views regarding their interest in sharing. The intervention process mainly encouraged these teachers to share with their colleagues to deal with ongoing problems in classroom practice. They found opportunities to share their current needs with their colleagues. These opportunities helped these teachers feel more comfortable about sharing their feedback with their colleagues. They learnt more from colleagues and raised their issues about their needs through this process of job-embedded training. This means it could be helpful for science teachers to think about incorporating a sharing culture rather than staying in isolation.

The findings of this study revealed that participant science teachers did not spend adequate time on class preparation. They liked to present a lecture in a simple and uncomplicated way and mainly deliver a rigid body of facts. However, in using the POE teaching approach participant teachers found themselves preparing their classes better and at the same time they realised how a well prepared class can encourage students to reflect differently on their learning. The use of a constructivist teaching approach helped these teachers to realise that they needed better preparation before taking any class. Moreover, the collaborative activities helped them be better prepared through getting constructive suggestions from their colleagues. This means it could be helpful for these science teachers to think about how they could continue to use a constructivist teaching approach to guide them in their preparation for the classes.

The teaching load and topic load were also challenging issues for these teachers. These findings have implications for the way teaching is organised in schools in Bangladesh. Increasing the number of science teachers in schools, as well as rescheduling their class routine, would leave some space for sharing activities with their peers within their school and even in nearby schools in their local area. This would allow them to devote some of their time to their own professional learning.

The findings of this research revealed that general science classes are frequently taught by some non-science background science teachers. It also revealed that the intervention outcomes created new opportunities for participants to clarify their ideas, and design lessons with an appropriate teaching sequence that allowed them to change the learning environment of their classes. Moreover, they developed a positive attitude in learning through sharing. This means that it could helpful for non-science background teachers to join in discussions with their science colleagues, to observe their classes and discuss the agenda for teaching with a focus on the development of cognitive skills for better understanding of science.

The quality of the textbook came up as an issue in the findings of the research. It could therefore be helpful for the NCTB authority to take the necessary initiatives to overcome the perceived ambiguities in the text books to make it a more useful guide for both students and teachers and therefore better support science teaching and learning.

Participant science teachers found the collaborative ways of the intervention process as positive for enhancing their practice. They also expressed their commitment to continue these activities. So it could be helpful to think about professional development programs that could support these activities in schools in terms of resources rather developing didactic professional development programs that have little impact on teachers' practice and are poorly regarded by participants.

9.2 Implications for Research

The implications of the findings from this study also have something to say about the research design and the manner in which it was conducted. These are discussed below.

9.2.1 Limitations of the study.

Firstly, the representativeness of the participants was a limitation. One hundred and seventy four secondary science teachers were involved in the base line questionnaire and 16 science teachers were included in the baseline interview. This could not be described as developing a broad picture regarding teaching and student learning in science in Bangladesh as a whole. A further study therefore with a larger sample may further enhance answers to the research questions. Moreover, it is not possible to interpret the findings in light of gender, age, or experience as these variables were clearly not set as selection criteria.

Secondly, the diversity of schools was not fully represented in this study. The study mainly focused on teachers, perception about teaching and their culture of their professional practice. Further research would be needed to address diversity of schools to develop a more complete picture of the situation across Bangladesh as a whole.

Another limitation of the study was in the implementation process of the intervention and impact due to time. The intervention was conducted for only 12 weeks and teachers views about impact were collected within next four weeks. A further study over a greater time period would be valuable for better understanding lasting impact from the intervention process. Moreover, a further research is needed to find out constraints to sustain this project. This research could also be included a comparison between rural and urban setting for this kind of project.

Lastly, this study did not consider student involvement regarding their learning for teaching due to the scope of the study as Ph.D. Student involvement would clearly be important in better informing an intervention process in order to develop a better sense of impact on student learning.

Chapter 10
Conclusion

This chapter revisits the research purposes, research questions, methods, and findings before making some concluding remarks.

10.1 Revisiting the Research Purpose and Questions.

This research set out to explore two basic aspects of secondary science teaching in Bangladesh. One was to guide participant teachers in changing their traditional teaching approach through the use of a concrete example of a new teaching approach. The intention being that through that process they might re-think their understandings of practice and make a shift from their traditional ways of science teaching. The second was to assist participant science teachers to change the culture of their existing professional practice.

The intention for this change in the culture of professional practice was based on a desire for teachers to have more conversations with their colleagues within and across the school in order to develop a learning community with the hope that through their professional learning their science teaching might improve. This research therefore focused on four research questions in addressing the above mentioned aspects. The first one was concerned with teachers' views about their practice and their students' learning of science. The second question concerned the issues that appear to impact teachers' views about teaching and learning practice in science. The third research question basically considered how learning about a constructivist teaching approach influenced teachers' thinking in order to address those issues and concerns related to existing practice. The fourth research question looked at how a professional learning community approach might influence the ways in which these teachers might learn about, and develop their practice.

In responding to these questions, the research used a mixed method approach. I chose the social constructivist stance for this research where constructed knowledge of participant teachers from the intervention was continually tested and modified in light of new experiences and interaction with other colleagues within and across schools. To address and explore the research purposes, I selected a constructivist teaching approach (POE) to use as an intervention with participant teachers in an attempt to ascertain if it could influence their thinking and lead to a change in their traditional teaching of science content. Simultaneously, I allowed all participant teachers to be involved in conversations regarding critique and challenge of theirs and their colleague's lessons in ways that were also not a part of their regular culture of professional practice. The explicit intention being that through these collaborative ways a professional learning community might be developed through which their own professional learning might lead to improvements in their science teaching practice.

10.2 Answers to the Research Questions

Research question 1: What are secondary science teachers' views about their practice and their students' learning of science?

In addressing the first research question, I explored participant teachers' views regarding teaching context, teaching and learning, teachers' knowledge of subject matter, teachers' knowledge of pedagogy, resources for science teaching, and their professional development and collegiality among colleagues. Participant teachers' views were that the teacher-student ratio is problematic in relation to their ability to deliver quality science education. They had mixed views about the nature and place of scientific knowledge as well as science as a subject to teach. Most of these teachers faced difficulties in regard to their subject matter knowledge and there was a clear link between that and their pedagogical behaviour. Most were not familiar with the notion of alternative conceptions in science and were not able to provide concrete examples of such from their practice. Furthermore, teachers liked to use traditional methods based on the talk, text and few demonstrations and consistency noted limited access to resources for their teaching; hence an over-reliance on the textbook. Moreover, teachers had limited opportunities for professional development and had mixed views regarding getting adequate time for collaborative activities.

Research question 2: What issues appear to impact these views?

In response to second research question, I identified the following issues as impacting the above mentioned teachers' views. Firstly, teachers could be seen as both topic and teaching overloaded. That created a situation where many chose to give up science teaching at the junior secondary level or to take classes without adequate preparation which resulted in teachers struggling to make science classes lively or creative – rather they concentrated more on theoretical and abstract topics. As a consequence, students tended to memorise basic principles, theories and laws in science without any evidence based conclusions as influencing their learning. Secondly, the teachers found difficulty in introducing students to a scientific way of knowing or any explicit process of doing science. Moreover, their views led them to present science as a rigid body of facts rather than as a way of exploring natural phenomena.

Thirdly, teachers' difficulties in explaining substantive concepts made it difficult for them to organise and structure content appropriately and so further led to transmissive modes of teaching (which may encourage students to adopt a surface approach to learning). Fourthly, the use traditional teaching methods inevitably led to lack of challenge to students' existing ideas.

Lastly, the situation of professional programs as didactic in nature meant they had little effect on teachers' actual practice. Moreover, the lack of collegiality tended to prevent science teachers from accessing supportive, collegial communities when inquiring into significant questions about science subject matter as well as into questions concerning learning and pedagogy.

Research question 3: How does learning about constructivist teaching approaches influence teachers' thinking about their practice and their students' learning of science?

In addressing the third research questions I found the use of the POE teaching approach influenced participant teachers' thinking about how to address the above issues (from research questions 1 and 2). Firstly, the POE teaching approach encouraged these teachers to use teachings aids as purposeful tools in their teaching and created a sense of purpose and motivation for learning the topic. Moreover, the POE strategy stimulated their enthusiasm to make use of the local environment and helped these teachers to realise that if they wished to use teaching aids for their teaching they were in fact more than capable of developing and collecting their own teaching materials. Secondly, the constructivist teaching approach (through use of POE) guided participant teachers not to depend only on the text book material and helped these teachers to overcome their tendency to conceive of science knowledge in narrow ways. The POE teaching approach also influenced participant teachers in terms of developing understanding of science content with their students rather than the simple recall and recognition of facts. The POE teaching approach also motivated participant teachers to find ways to look for the relevance of science within real life situations.

Thirdly, the use of this approach also helped these teachers overcome a reliance on rote learning and theoretical exercises to transmit science as information - which is a very common practice in Bangladesh. In a similar way, the POE teaching approach may have helped these teachers to maintain a logical sequence in their teaching and to make personal sense of the ways in which knowledge claims are generated and validated. The POE teaching approach developed their awareness of the need to work with students' prior knowledge in order to identify alternative conceptions in science. Lastly, the POE teaching approach encouraged students' interest and enthusiasm towards the learning process and led to a change in the classroom learning environment.

Research question 4: How can establishing a Professional Learning Community influence the ways in which these teachers learn about, and develop, their practice?

In addressing the fourth research question I found that the establishment of professional learning communities influenced these teachers learning about a constructivist teaching approach. The intervention process guided participant teachers to develop the capacity for building shared leadership through sharing their teaching practices. The process increased these teachers' confidence with collaborative activities which they found created supportive ways for addressing improvements in their teaching practices. Moreover, it appears as though participants also felt more comfortable in exploring their own problems regarding their own practice and needs through this process of job-embedded learning.

Through collaborative work with their colleagues they felt supported in establishing their commitment to their students' learning. They became committed to finding the gaps or mismatches between their teaching and their students' learning and making decisions about the challenges they faced regarding their practice.

Participant teachers also found themselves accountable for identifying issue to discuss with their colleagues. The process also motivated and created a results-oriented approach that gave them direction in terms of building a collective commitment to a shared vision which in turn fostered their shared mission. These processes encouraged collective learning through working together to overcome difficulties in explaining subject matter through organising and structuring content appropriately through examining and questioning their existing practice. The intervention then helped them to realise that they could look toward themselves for their own professional enhancement rather than waiting for, or depending on, others.

The participant teachers also found that documenting their evidence of changed practice as a part of their commitment to continuous improvement was important. The learning processes also encouraged these participants in terms of systematic responses to improving their practices that ensured better support for their students' learning. They found the intervention to act as an agent to reduce the state of isolation among them (which is a common complaint for teachers in Bangladesh). The structure of collaboration appeared to help these teachers come together as a unit to develop a collegial attitude and relationship in their learning, to support decision making, problem solving, and creative work in ways that characterises a professional learning community.

10.3 Concluding Remarks

The findings of this research show that the use of a constructivist teaching approach (POE) encouraged participant teachers to change their teaching perceptions which had been based on a traditional (didactic) approach. These teachers experiences of using the POE approach guided them in changing their views about collecting and using teaching aids in their practice. Moreover, the POE approach also helped them come to see account the importance of students' prior knowledge and the value of exploring students' alternative conceptions. The teachers also came to develop logical teaching sequences using the POE approach that may have helped them to build effective learning environments in their classrooms in ways different to that which they had previously experienced. In addition, the collaborative activities amongst their colleagues within and across the schools helped them to re-examine and reconstruct their understandings of teaching and its relationship to student learning. Moreover, the findings also show that the development of the idea of a PLC reinforced the value of professional learning through job-embedded learning.

From the outcomes of this research, my thinking has been influenced in several different ways. Firstly, this research developed my confidence about my thinking that a constructivist teaching approach will work in the Bangladesh context. Regardless of the teaching load and limited resources, this approach can be an effective way of engaging a large number of students, as is particularly the case in junior science classes, in Bangladesh. Secondly, teachers' engagement in collaborative teams rather than working in isolation helps to build shared knowledge and understanding regarding effective learning. Working in teams also helps teachers to make decisions collectively through shared knowledge of best practice rather than individual preference. Thirdly, the idea of open sharing of practice rather than privatisation influenced my thinking a great deal. I can see that this way of working helps to focus more on learning rather than teaching; including what students learn. Such sharing is essential if teachers' practice is to become learner-focussed (where the teachers are also learners), rather than teacher or textbook-focussed. Finally, my thinking has also been influenced in terms of teachers' engagement in personally relevant, job-embedded learning rather than depending only on external training to improve their practice. This also helps teachers to become more independent and to accept greater responsibility for their own professional learning.

I see the quest for science educators as helping students come to better understand the complex nature of science learning. Many approaches have been tried to achieve this vision. Improving teachers' practice through engaging them in their professional learning is one approach championed through this research. The findings demonstrate positive outcomes regarding improving science teachers' practice.

My hope is that if more secondary science teachers in Bangladesh come to follow a constructivist based approach, it will bring a tremendous change in the teaching and learning situation in secondary science in Bangladesh. Such an approach could therefore guide teachers in terms of changing their teaching perceptions and ultimately positively influence students' science learning. Moreover, the idea of Professional Learning Communities offers a breakthrough for the culture of professional practice in schools in Bangladesh. The PLC idea supports teachers in the development of their professional learning in ways that enables and empowers them to understand their own practice and deliver effective lessons for better student learning. In so doing, the results of this research offers ways of empowering science teachers to take more control of their teaching and to more seriously focus on their students' learning.

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Appendices

Appendix 1

General Questionnaire for Science Teachers

A. General questions related to teaching

1. What are the two main subjects that you are teaching in this year?

   (*Please write in order of your preference)*

   A………………………. B.………………………….

2. Including this school year, how many years in total have you been teaching? (include part-time teaching, but not substitute teaching or practice teaching)

   - ☐ Less than 2 Years
   - ☐ 2-5 years
   - ☐ 5-10 years
   - ☐ 10-15 years
   - ☐ More than 15 years

3. In the last 2 years, which levels have you taught?

   - ☐ Grade Six
   - ☐ Grade Seven
   - ☐ Grade Eight
   - ☐ Grade Nine
   - ☐ Grade Ten

4. On average, how many students are there in your grade Six to Eight Science classes?

   - ☐ Less than 30
   - ☐ 30 – 40

- ☐ 40 -50
- ☐ 50 -60
- ☐ More than 60

5. How many science teachers are there in your school this year? ☐

B. Teaching Load of a science teacher

1. What is your overall teaching load per week in this year?

☐ Class/es of ☐ minutes

☐ Class/es of ☐ minutes

☐ Class/es of ☐ minutes

Science Teaching

2. What is the length of your science class in Minutes?
3. In a typical week, approximately how many hours do you spend at school teaching science classes?
   - ☐ Less than 3 hours
   - ☐ 3-6 hours
   - ☐ 7-10 hours
   - ☐ More than 10 hours
4. In a typical week, approximately how many hours do you spend at school doing work related to teaching science? (e.g., lesson planning, grading papers, developing teaching aids etc.).
   - ☐ Less than 1 hour
   - ☐ 1-2 hours

□ 3 - 5 hours

□ More than 5 hours

5. In a typical week, approximately how many hours do you spend at home doing work related to teaching science (e.g., lesson planning, grading papers, developing teaching aids etc.).

□ Less than 2 hours

□ 2 - 4 hours

□ 5-7 hours

□ More than 8 hours

Other Matters in School

9. In a typical week, approximately how many hours do you spend at school meeting with other teachers to work on curriculum and planning issues?

□ Never

□ Less than 1 hour

□ 1-2 hours

□ 2-3 hours

10. In a typical week, approximately how many hours do you spend at school and home doing other school-related activities? (e.g., administrative work, counselling students etc.).

□ Less than 1 hour

□ 1-2 hours

□ 2-3 hours □ more than 3 hours

C. Teacher's view about science and teaching and learning of science

Please indicate the degree to which you agree or disagree with each statement below by putting tick in the appropriate box to the right of each statement

SA = Strongly Agree

A = Agree

UN = Uncertain

D = Disagree

SD = Strongly Disagree

No.	Item	SA	A	UN	D	SD
Science Concept						
1	Science is an abstract subject					
2	Science is about the right answers					
3	Science is a logical and ordered subject					
4	Science is a strict discipline in which there is no place for personal opinion					
5	I feel confident about my subject matter knowledge in science					
Science teaching						
6	I feel confident about organising science content in an appropriate teaching sequence					
7	Teaching science is harder than teaching other subjects					
8	It is important to develop children's understanding of the processes of science					
9	It is important to develop children's skills in science					
10	The Teacher is responsible for students' achievement in science					
11	Students' achievement in science does not change even when the teacher exerts extra effort					
12	I am confident about trying new strategies for teaching science in my classroom					

13	In implementing new teaching strategies, I enjoy autonomy in my school					
14	When teaching science, I welcome student questions					
Students' conception in science (Alternative conception)						
15	Students have their own views about science ideas					
16	Teachers should take into account prior knowledge that students carry into the classroom					

2 a. Have you heard of the notion of "alternative conceptions" or "misconceptions" in relation to science concepts? ☐ Yes ☐ No

b. If Yes, Please write down one or two examples of alternative conceptions you know.

D. Teachers' knowledge about subject matter in science

1. *Please put tick in the box to the appropriate right in response to the following:*

I find it difficult to....

Area in science knowledge	**Always**	**Frequently**	**Sometimes**	**Never**
Explain the subject matter properly				
Provide real life examples				
Apply principles of science on real life examples				
Provide current ideas about science				
Differentiate my teaching based on individual topic				

Other (Please specify)				

2. *Please put tick in the appropriate box to the right in response to the following:*

I update my science knowledge through:

Name of Way	**Frequently**	**Sometimes**	**Never**
reading current magazine about science knowledge			
reading text book of higher levels			
reading reference books			
subject based in-service training			
Searching the internet			
discussions with colleagues			
Others (please list)			

E. Teaching strategies and Resources

1. *Please put tick in the appropriate box to the right (for as many as apply to you) in response to:*

I use the following methods in teaching science

Methods	**Always**	**Frequently**	**Sometimes**	**Never**

Lecture				
Demonstration				
Discussion				
Lecture with discussion				
Problem-solving				
Group Discussion				
Others (Please list)				

2. How does the number of students in your science class have any influence in your teaching plan?

3. Does the topic make a difference to how you teach science?

□ Yes □ sometimes □ 7-10 hours

4. To what extent does teaching load affect your planning for science teaching? Explain.

5. *Please put tick in the appropriate box to the right (for as many as apply to you) in response to:*

When I am planning to teach a lesson in science I use …

No	Item	Not at all	Little	Some	Quite a lot	A great deal
Lesson Plan						
a	A lesson plan that I had prepared and used before					
b	A lesson plan I developed in collaboration with other teachers or science specialists					
c	A lesson plan developed by other teachers					
Knowledge/Ideas						
d	Ideas from a workshop or in-service training					
e	Knowledge about students' interests					
f	My understanding about students' level of thinking					
g	Knowledge about students' difficulties					
Resources						
h	Student textbook					
i	Teacher's Guide (version of textbook)					
j	Guides book (kits, modules, activity manuals)					
k	Multimedia resources (video, laser disc, TV, etc)					
l	The Internet					
m	Others (Please list)					

F. Professional Development

1. a. Have you received any kind of in-service training on subject knowledge/pedagogy in last two years? ☐ Yes ☐ No

   b. If yes, did it help you to increase your existing subject matter knowledge?

   ☐ Yes ☐ No

2. a. Does your school support teachers for their professional development?

   ☐ Yes ☐ No

   b. If Yes, please mention briefly how school supports teachers?

3. Are there any professional development opportunities available for science teachers within your school community? If so, how does it work?

G. Collaboration and Learning community

1. *Please indicate the degree to which you agree or disagree with each statement below by putting tick in the appropriate box to the right of each statement*

SA = Strongly Agree

A = Agree

UN = Uncertain

D = Disagree

SD = Strongly Disagree

Item	**SA**	**A**	**UN**	**D**	**SD**
I enjoy attending science teacher conferences to learn about new ideas in science teaching					
My work as a science teacher is appreciated by my science colleagues					
Given the choice, I would **not** invite my science colleagues to observe my science teaching					
I enjoy working with colleagues about science curriculum and teaching, even if it means after-school meetings					
I have adequate opportunities during the school day to collaborate with my science colleagues about science teaching learning					

2. As part of professional development activities/**collegiality**, how often in the last year has a science teacher colleague observed you teaching an entire science lesson?

- ☐ Never
- ☐ Once or twice per week
- ☐ Once a month or more
- ☐ Always

Continue…..

3. As part of professional development activities/**collegiality**, how often in the last year have you observed a teacher colleague teaching an entire science lesson?

- ☐ Never
- ☐ Once or twice per week
- ☐ Once a month or more
- ☐ Always

4. Do you have any association/learning community of science teachers in your local area?

☐ Yes ☐ No ☐ I don’t know

a. If Yes, Do you know of any activities related to update/clarify of science teachers’ subject knowledge? Please list.

b. Do you participate in this association/learning community?

☐ Yes ☐ No

c. If Yes, Please briefly mention your role as a member of the community

End

Thanks for responding to this questionnaire.

Appendix 2

Guidelines for Interview with Teachers

The following will be discussed with teachers:

Could you describe for me your views about:

- Teaching load of science teachers and how it works for quality teaching
- Availabilities of resources for teaching science and implications for effective science teaching
- Beliefs about science teaching and ability to articulate these
- How teachers confront their problems about subject matter in science?
- How teachers consider the prior knowledge of students in science?
- How teachers think about alternative conceptions of science idea?
- How teachers choose teaching strategy for effective science learning of students?
- How teachers overcome problems with resources for science teaching?
- Teachers' attitude towards adapting new teaching method/strategy to enhance their science teaching
- How collaboration works among science teachers is in a school/local area (Problems and hopes)?
- How teachers learn from other science colleagues in their school?
- How teachers think about their professional development?
- How teachers think about 'professional learning community'?
- How the community works in this school and connections with other schools in local area?

Appendix 3

Classroom Observation Schedule

Directions: *Please put tick in the appropriate box to the right of each key indicator. Use the comments space below each section to provide more feedback or suggestions.*

No	Key indicator	Not observed	More emphasis recommended	Accomplished very well
Resources				
	Use of teaching aids			
	Teaching materials have a clear purpose			
Comments:				
Content knowledge and relevant organisation				
	Lecture depends on only student textbook information			
	Emphasis on recall, recognition of facts			
	Explained ideas with clarity			
	Use practical application of science concept			
	Use of real life examples by teachers			
	Use of real life examples by students			
	Presented topics include current ideas or reference			
	Presented topics with a confusion about science idea			
Comments:				

No	Key indicator	Not observed	More emphasis recommended	Accomplished very well
Pedagogy				
	Following of student textbook sequence			
	Made clear statement of the purpose of the lesson			
	Consider students' prior knowledge			
	Encouraged students to discuss their views			
	Learning activities are linked with lesson purpose			
	Link of the selected teaching strategy with presented topics			
	Multiple strategies are used to make effective the lesson			
	Presented topics with a logical sequence			
	Selected strategy encourage students' participation			
	Teacher acknowledge student's contribution who did most of talking			
	Problem of time in presenting the topic			
Comments:				

Classroom Environment				
	Students were reflective about their learning			
	Students are interested and enthusiastic			
	Opportunities for students to mention their problems/concerns in the class			
	The lecture has stimulated students' thinking			
Comments:				

Appendix 4

Professional Work Guidelines

Agenda for Professional Workshop 4

- Discussion on different part of POE (may be need a demonstration)
- Discussion on different parts of human brain
- Discussion on problems for only following the book information
- Discussion for not relating to any specific examples
- Discussion on why explanation and chart did not follow each other
- Discussion on confusion or mismatch for Bangla and English name of different part of human brain
- Discussion on confusion with the grouping for hypothalamus
- Discussion on possibilities of brainstorming
- Discussion on motivation to engage students
- Discussion on low efficacy of teachers
- Discussion on the issue for exchanging the teaching aids
- Discussion on how challenging topics forces teachers to do more collaboration

Appendix 5

Post intervention Questionnaire (Descriptive)

Professional workshop

1. Explain, how do you feel about the concept of this “Professional Workshop”?
2. How does attending the workshop help you to get current ideas in subject matter knowledge? Please write some examples of current ideas that you got from the workshops?
3. If there any opportunities to enhance subject knowledge and pedagogy in science through discussion in the workshop? Describe your own experience?
4. How do you find the workshop effective for acquiring appropriate ideas instead of alternative conceptions of teachers about subject matter in science? Describe your own experiences.

Classroom Observation

1. Explain how do you feel about the idea of classroom observation?
2. Describe your experience after observing your colleague’s class teaching.
3. Describe your experience about the presence of any colleagues at your teaching time.

Post-teaching Discussion

1. Describe your experience for the discussion session immediately after the teaching.
2. How do find it effective for improving your teaching practice?
3. How do you find you have benefited from those discussions? Describe with examples?

Prediction-Observation-Explanation

1. How do you feel about the concept of POE?
2. According to you, what are the purposes to use POE in teaching?
3. What are the good aspects of POE?
4. Did you experience any problems in using POE?
5. Describe the nature of collaboration with your science colleagues during preparation time for teaching with POE?
6. To what extent does the POE teaching approach influence your teaching of science?
7. Do you believe that this POE strategy will work for the Bangladeshi context? Why?
8. Could you please mention what kinds of modification are needed to be undertaken in using POE properly?

Collaboration

1. Describe your experiences for getting collaboration from your colleagues during your class preparation time during this project.
2. How does collaboration with your colleagues help you to improve your teaching?
3. Did you experience any negative impact from the collaboration?
4. How do you transfer the concept of collaboration from this study project into your work place/school?
5. How does the collaborative attitude inspire other colleagues at your school to change the overall status of the school?
6. How do you continue with this type of collaborative work?

Professional Learning community

1. Explain how do you feel about the concept of "Professional Learning Community"?
2. How does the notion of PLC help to enhance your teaching profession?
3. Did you experience any difficulty to be a member of the learning community?

Appendix 6

Issues for Focus Group Discussion (FGD)

Content Knowledge and Teaching Strategy

1. How do you feel about the level of your content Knowledge?
2. Could you discuss about the impact of the process whether it is or not useful in overcoming yours' problem with the content knowledge?
3. Please make some comments about the teaching strategy you have used?
4. What kind of learning is encouraged by this strategy?
5. Did you find it more effective than your usual strategies? How?
6. What changes suggest by this teaching strategies compare to your current practice?

Collaboration with colleagues

1. Discussed what was good about the collaboration approach that you used during the study?
2. Discuss the negative impact of this collaboration approach?
3. What things need to be changed to make this approach more effective?
4. Discuss whether this collaboration approach make you more confident or confuse than before about your teaching?

Professional Learning community (PLC)

1. Discuss the idea of PLC?
2. Did you find it useful for your teaching? Discuss How?
3. Discuss how this learning community will help to dissolve your needs regarding your teaching practice(content knowledge, teaching strategy and Resources)
4. Discuss the impact of the learning community for overall enhancement of science teaching practice?

Appendix 7
Sample of Field Notes

Peer A: Teaching session One

POE

The teacher asked students for prediction for the nature of jets of water were coming out of the holes. It was observed that students were responding. Most of them were responding only that water will comes out from the bottle through the holes. Then teacher asked them to observe. Students observed that the jets of water felled at different places nearest and far away from the wall. At the same time, it observed that jet of water did not proceed perpendicularly too far. After that found I found teacher tried to explain rather provide scope students for reconciliations.

Resources

The teacher-1 used a number of bottles, basket, nails and beaker to do this experiment. However, it seemed to me that students find difficult to visualise when the teacher-1 providing some real life examples using without any teaching aids. He could use some poster or even draw picture at the board.

Content knowledge and organization

Teacher-1 observed confident in the concept regarding this topic. However, lecture mainly based on the students' text booked. He started with some basic concept related to the properties of liquid. However, he found difficult in explaining why more water coming out from the bottom hole as observed and asked by one student. Also, it seemed to me that he was confused in explaining why jets of water were not coming straight from the bottle. Otherwise, he seemed confident in organising the content regarding the topics. He provided few examples in relating the topics with real life however did not asked students any examples.

Pedagogy

The sequences of the class are seems to mismatch a little bit. It was not clear to me how he tried to motivate students in today's session. He asked different questions to explore the related prior knowledge. Teachers seemed more interested in proving answer rather waiting for response from students. His selected strategies encouraged students more in involving participation, but topics demand more to use for active students.

Learning Environment

Students were seemed interested and enthusiastic, but did not observed to reflective for their learning. They did not find enough scope to mention their concern regarding the problems. My understanding was that this lesson did not stimulate their thinking**.**

Discussion after the class

After the session, both teachers filled up (Putting tick mark at one of the three options-not observed, more emphasis recommended and accomplished very well) the same classroom observation checklist developed by the researcher. After that they started to discuss based on their refection on the checklist accordingly. As it was first conversation between them, they seemed to be felt shy in challenging each other. In most cases, they discuss only those issues where they found they differ in reflecting. In mean time, I found they challenged each other in several cases. For examples, teacher-1 reflected that "Recommended more emphasized on use of real life examples by students'. Its mean he asked students to tell whether they know any real life examples regarding the topics. Teacher-2 argued that he did not observe any of this during the class. Then he asked the teacher-1 to tell examples that students use. Then teacher -1 agreed that he did not asked anything about this which very important. This is considered of learning of teaching-1. In some cases, Teacher-1 also did not agreed with what teacher-2 observed. For example, Teacher-2 reflected that teacher-1 fully followed the student textbook sequence. However, Teacher-1 did not agree with the observation. He said that when tried to use POE the sequence of the student's textbook automatically broken. As he accomplished POE wee, he did not think that he only followed the textbook sequence. Teacher -2 then agreed with teacher-1. This is considered as learning or teacher-2 after discussion. In this discussion, they did not find any issue which was non-decidable.

After the discussion, both of them again check the observation check list to (re-reflect) re-tick at the appropriate box ex according to the conducted class. Wherever, they had changed the mind it considered as learning for individual teacher. So, discussion could bring learning for both of them. It is also interesting to note that in some cases they differ and then came to one decision but did not change their mind at the time of second checking. For example, teacher-1 agreed with teacher-2 that he need to more focus in using multiple strategies to make the lesson more effective. However, he did not mention it as its mind change during re-reflection.

Appendix 8

Consent Form of Science Teachers

MONASH University

Consent Form of Science Teachers

Title: Professional learning of junior secondary science teachers in Bangladesh

NOTE: **This consent form will remain with the Monash University researcher for their records**

I agree to take part in the Monash University research project specified above. I have had the project explained to me, and I have read the Explanatory Statement, which I keep for my records. I understand that agreeing to take part means that I am willing to:

1. be interviewed by the researcher	☐ Yes	☐ No
2. allow the interview to be audio-taped	☐ Yes	☐ No
3. to make myself available for a further interview if required	☐ Yes	☐ No
4. complete questionnaires asking me about science teaching	☐ Yes	☐ No
5. allow my colleagues to voluntarily observe my teaching practice	☐ Yes	☐ No
6. allow the classroom observation to be audio-taped	☐ Yes	☐ No
7. to make myself available to attend in the Professional workshop	☐ Yes	☐ No
8. to make myself available to attend a Focus Group discussion	☐ Yes	☐ No
9. allow the focus group discussion to be audio-taped	☐ Yes	☐ No

I understand that my participation is voluntary, that I can choose not to participate in part or all of the project, and that I can withdraw at any stage of the project without being penalised or disadvantaged in any way.

I understand that any data that the researcher extracts from the interview / focus group / questionnaire / survey for use in the thesis reports will not, under any circumstances, contain names or identifying characteristics.

I understand that I will be given a transcript of data concerning me for my approval before it is included in the write up of the research.

I understand that any information I provide is confidential, and that no information that could lead to the identification of any individual will be disclosed in any reports on the project, or to any other party.

I understand that data from the interview/focus group/transcript/audio-tape will be kept in a secure storage and accessible to the research team. I also understand that the data will be destroyed after a 5 year period unless I consent to it being used in future research.

Participant's name:

Signature:

Appendix 9

Explanatory Statement for Science Teachers

MONASH University

Date: 24 January 2008

Title: Professional learning of Secondary science teachers in Bangladesh

My name is S M Hafizur Rahman and I am conducting a research project under the supervision Professor John Loughran, Associate Dean and Dr. Amanda Berry, senior lecturer in the Faculty of Education towards a Ph.D. at Monash University.

I obtained the list of science teachers' contact details from the Ministry of Education database in the hope of finding possible volunteers to be involved in the follow up study from the initial questionnaire. I am interested in professional learning on science teaching in the secondary education and so seek science teachers for a case study approach to understanding their professional learning.

The proposed research aims to give participants an opportunity to express their opinion about their experience of science teaching. I am conducting this research to find out how the idea of the development of learning communities influences the teaching of science. The research will allow secondary science teachers to collaborate with their colleagues and reflect on their own teaching. The participants will then be encouraged to share their knowledge with colleagues in their school or community.

The study involves questionnaires, audio-taping semi-structured interviews, classroom observation, workshops and focus group discussions. The time needed to complete the questionnaire for the baseline survey is up to one hour (max). From that questionnaire I am hoping some respondents will volunteer to be involved in the other aspects of this study.

Each of the classroom observations will take maximum one hour. The workshop is a maximum of 3 hours. The focus group discussion will take a maximum of one hour. The questions that I am asking are not likely to cause distress to any participant science teacher. All of the questions relate to individual participant's understanding of science teaching and learning in their own experience of teaching in Bangladesh. At the same time, no participant will be able to be identified. All participants will be given pseudonyms and all questionnaire data will be anonymous.

There are no anticipated risks, but should you choose not to continue in the project you can withdraw at any time without the need to explain why. If any distress were to occur, referral to appropriate Counselling services will be suggested. Being in this study is voluntary and you are under no obligation to consent to participation.

Only I will have access to the original data. The consent form, questionnaire, interview transcript, audiotape will all be kept in a locked filing cabinet for five years. The electronic files will be kept secure for the same period. After five years, all records will be destroyed through the secure disposal system we use in the faculty.

All data used in the thesis will be anonymised, nobody will be named and no individual will be identifiable in any way.

Results

If you would like to be informed of the aggregate research finding, please contact S M Hafizur Rahman on +61 4 3367 9766 or Hafiz.Rahman@Education.monash.edu.au. The findings are accessible for next five years.

If you would like to contact the researchers about any aspect of this study, please contact the Chief Investigator:	If you have a complaint concerning the manner in which this research is being conducted, please contact:
Professor John Loughran Associate Dean, Faculty of Education, Monash University, Clayton, VIC-3800. Phone: +61 3 9905 2847 E-mail: John.Loughran@Education.monash.edu.au And Dr. Amanda Berry Senior Lecturer, Faculty of Education, Monash University, Clayton-3800. Phone: +61 3 9905 9118 E-mail: Faculty of Education, Monash University, Clayton, VIC-3800. Phone: +61 3 9905 9118 E-mail: Amanda.Berry@Education.monash.edu.au	Dr. Sharif As-Saber Senior Lecturer Department of Management Monash University, Clayton, VIC 3800. Australia Tel: +61 3 9905 8176 Email: Sharif.As-Saber@Buseco.monash.edu.au

Thankyou.

S M Hafizur Rahman

Appendix 10

Human Ethics Certificate of Approval

MONASH University

Standing Committee on Ethics in Research Involving Humans (SCERH)
Research Office

Human Ethics Certificate of Approval

Date:	**24 January 2008**
Project Number:	**2007002108 - CF07/4929**
Project Title:	**Professional learning of junior secondary science teachers in Bangladesh**
Chief Investigator:	**Prof J. John Loughran**
Approved:	**From 24 January 2008 to 24 January 2013**

Terms of approval

1. Approval is only valid whilst you hold a position at Monash University.
2. It is the responsibility of the Chief Investigator to ensure that all pending information (such as permission letters from organisations) is forwarded to SCERH. Research cannot begin at an organisation until SCERH receives a permission letter from that organisation.
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 SCERH.
4. You should notify SCERH 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:** Requires the submission of a Request for Amendment form to SCERH and must not begin without written approval from SCERH. 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. SCERH 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 SCERH 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.

[redacted]

Dr Souheir Houssami
Executive Officer, Human Research Ethics (on behalf of SCERH)

Cc: Dr Amanda Berry;

Postal – Monash University, Vic 3800, Australia
Building 3E, Room 111, Clayton Campus, Wellington Road, Clayton
Telephone +61 3 9905 5490 Facsimile +61 3 9905 1420
Email scerh@adm.monash.edu.au www.monash.edu/research/ethics/human/index/html
ABN 12 377 614 012 CRICOS Provider #00008C

Appendix 11

Permission letter from DHSE

Government of the people's Republic of Bangladesh

Directorate of Secondary and Higher Education

Shikha Bhaban, Dhaka

Memo No : OM/31-M/2008/9164-85 Date : 02.04.200

Sub : Permission Letter For "Professional Learning of Junior Secondary Science Teacher's Bangladesh"

Ref : Letter of 05 March 2008.

Thank you for your request to recruit participants from secondary science teachers for the abovenam research.

I have read and understood the Explanatory Statement regarding the research project 200770021(CF07/4929 and hereby give permission for this research to be conducted.

[redacted]

02.04.08

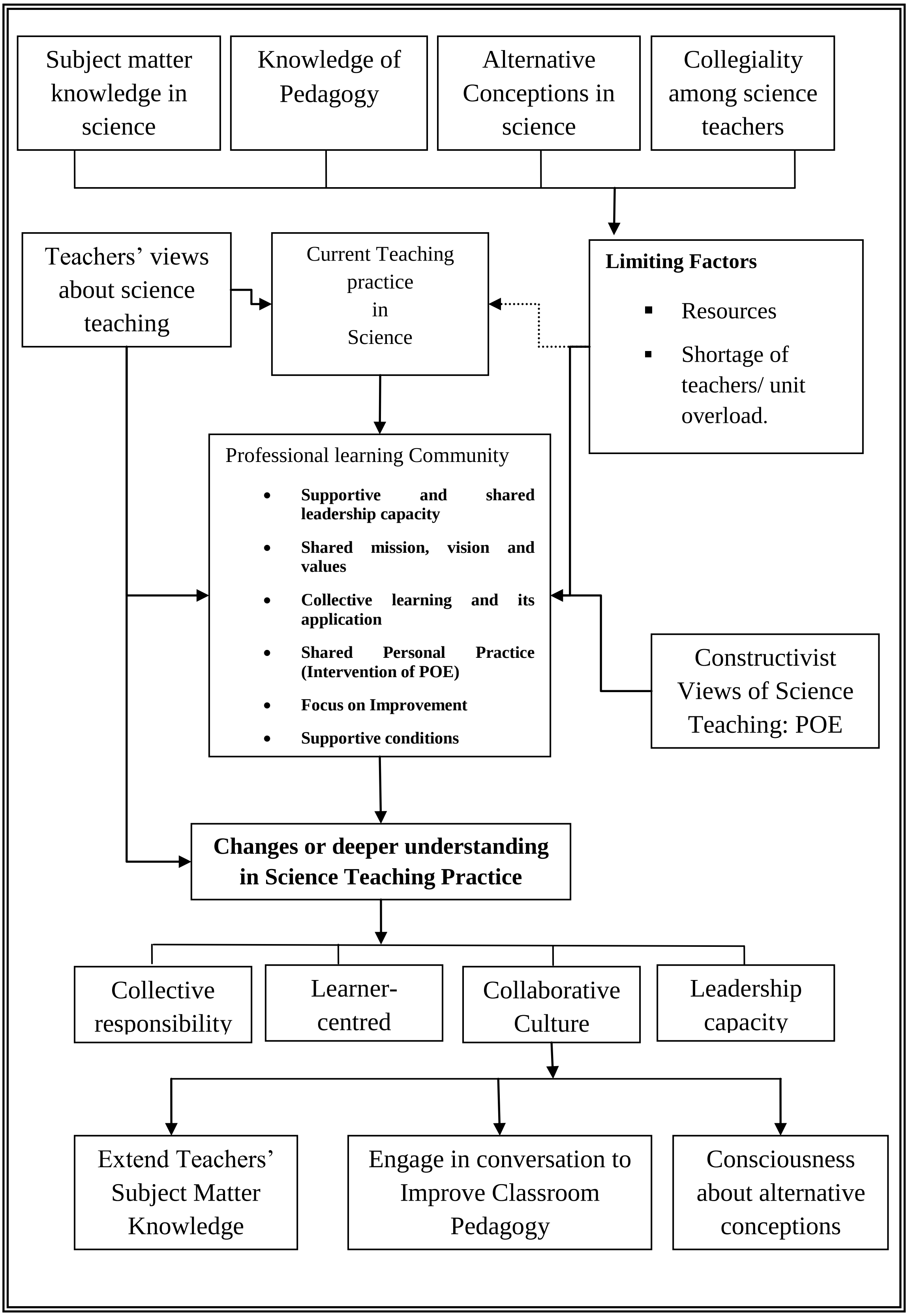
(Professor A.N.M Shareef)
Director (Secondary)

02.04.08

S M Hafizur Rahman
Building 06
Faculty of Education
MONASH UNIVERSITY VIC 3800
Australia.

Appendix 12

Mapping of Issues Influencing this Research



Appendix 13

A Sample of the Transcription of Semi-structured Interview

R: How are you?

T: I am fine thank you.

R: How many years are you in teaching?

T: I am in teaching for last 11 years.

R: How do feel in teaching?

T: I really enjoy teaching. I had a dream for teaching from my childhood. It is possible to come close to students who usually want to learn new things through teaching. I try to share with them what I know and what I also do not know.

R: How do you find the difference between an experienced teacher and a new teacher?

T: For me, eleven years ago I did not find myself confident to present topics, feel hesitation. Now I do not find any inertia in my teaching. For example, I have some difficulty in explaining the topics like mirage. Now I feel more confident from my experience. At the same I feel more confident in choosing my teaching strategies because of teaching experience.

R: How do you manage your teaching load?

T: We do not have required number of science teachers in our school; we have to take more classes than our normal load. If we do not want this kind of load, ultimately then students will suffer. In most case, we have to conduct class based on our experience without any preparation. It is difficult to take preparation for all classes. It mainly affects maintaining a quality education. If we have three classes every day, then it should be possible to be well prepared and collect all required teaching aids for all three classes and be able to maintain the quality. However, if I have six how can it be possible to maintain the quality of the classes?

R: I found from the baseline data that in many schools non science background teacher use to teach science in the junior secondary section, do you have the same experience in school? What is the impact for this?

T: This is because of the teaching load. According to my personal experience/opinion, I found general science in level six to eight is much harder than the individual physics and chemistry in level nine and ten for diversity of subject arrangement. So, it is not possible to conduct a proper science class with the non background science teacher. This is not a right decision. In most cases, the teacher asks students to prepare answers to the questions at the end of the each chapter. Students stay far away from understanding science and grow a concern that science is a hard subject. Ultimately students feel afraid in science and stop science at grade Nine and Ten. As result, participation in science is decreasing day by day. We will find no students for science teaching in the future.

R: How do you manage teaching aids for using in your teaching?

T: I think teaching is affected due to shortage of resources. On the other hand, it is difficult to complete a particular lesson for a fixed time using teaching aids. Besides, we try to use teaching aids what is available in our school. I try my best to use chemistry in class as much as possible. Actually, it is not possible if we have 5-6 classes in all day. However, if we collect once, we can use it for several times. Posters particularly are one kind of them.

R: How can teacher overcome the lack of teaching aids?

T: We can make or collect some in our teaching. However some of them are expensive, so that is not possible. Teaching aids for Chemistry are particularly expensive. In most cases, school do not have sufficient funds to buy these aids and management try to overlook this situation.

R: 'How do we use teaching aids if we have excess class load'- If it works as a belief, how it work in the classroom decision making?

T: We have to take 6-8 class. It is true that this kind of belief works in our mind before planning for a lesson and we sometime feel reluctant to use teaching aids.

R: How do you overcome your difficulties in subject matter knowledge?

T: In some cases, if I have lack in subject matter knowledge, I usually check book from higher classes.

R: How do you manage when you find that students' prior knowledge does not match with your class preparation?

T: In that case, I usually explain the topics properly. At the same time I try to explore what is the basic of the alternative conceptions in their prior knowledge by asking several questions and then I try to relate with the real life situation.

R: Do you have any experience like this?

T: I can't remember right now.

R: What are your concerns in choosing your teaching strategies?

T: First of all I try to find the basic information for a topic. I also consider the level of students understanding. I have to consider the individual case for weak and good students. If I try to explain any hard topics for weak students more than two times, better students then felt bored. Then I have to manage students' priority regarding their needs.

R: How do you feel in using new teaching strategies?

T: I am interested to use any techniques those help to explain anything to student easily. Sometimes, I find by myself some new technique from my own experience.

R: How do sharing/collaborations work among your science colleagues?

T: We all science teachers are loaded with classes, we discuss sometimes but we are not in good attitude for sharing with each other. Basically, class schedule does not give us any scope to observe each other's class.

R: Do you feel teachers have the opportunity to observe each other's class frequently?

T: I feel it is not possible. From my own experience as teacher and student I never found this opportunity to be happened. Even I never found a head teacher observe any teacher's class. However, I found sometimes, some administrative people came and observe my class for checking my performance. However, our concerns are growing as different project like TQI advice teachers to collaborate more with each other.

R: Do you have found any negative impact from this collaboration process?

T: I find no problem in this process rather than any benefit. But I am wondering how it will work with teachers with our existing teaching load.

R: What are you thinking for your professional development?

T: I have a plan to pursue MEd to learn more from that kind of advanced course.

R: How do consider using your colleagues for your professional development?

T: We can discus and observe each other's class.

R: What are your responsibilities in overcoming the lack of collegiality in schools?

T: We need to discuss with some proper plan and take it sincerely. We have to careful for not critique each other activity in negative way. We have to avoid negative attitude. We are lucky that our head teacher is an experienced teacher and we can share with him anytime.

R: If you have a community for your local science teachers, what should be the possible benefit you might get from there?

T: It will fine, we can discuss and then learn many think. It will helpful for our teaching.

R: Is it possible to arrange a free time for all same subject teachers to talk about their practice?

T: It is not working now, however, it is possible if we wish to do it. It is our culture that we need pressure from some authority to work anything. However, to become success a community, we need to sincere from ourselves.

R: Thank you for your long conversation.

T: You are welcome

Appendix 14

A Sample of Completed Classroom Observation Schedule

Directions: *Please put tick in the appropriate box to the right of each key indicator. Use the comments space below each section to provide more feedback or suggestions.*

No	Key indicator	Not observed	More emphasis recommended	Accomplished very well
Resources				
	Use of teaching aids			✓
	Teaching materials have a clear purpose			✓
Comments:				
Content knowledge and relevant organisation				
●	Lecture depends on only student textbook information	✓		
	Emphasis on recall, recognition of facts	✓		
	Explained ideas with clarity		✓	
●	Use practical application of science concept	✓		
	Use of real life examples by teachers			
●	Use of real life examples by students			✓
	Presented topics include current ideas or reference	✓		
	Presented topics with a confusion about science idea	✓		
Comments:				

No	Key indicator	Not observed	More emphasis recommended	Accomplished very well
Pedagogy				
	Following of student textbook sequence			✓
	Made clear statement of the purpose of the lesson			✓
●	Consider students' prior knowledge /prediction or		✓	
	Encouraged students to discuss their views		✓	
	Learning activities are linked with lesson purpose			✓
	Link of the selected teaching strategy with presented topics			✓
	Multiple strategies are used to make effective the lesson		✓	
	Presented topics with a logical sequence			✓
	Selected strategy encourage students' participation		✓	
●	Teacher acknowledge student's contribution who did most of talking		✓	
	Problem of time in presenting the topic	✓		
Comments:				

Classroom Environment				
	Students were reflective about their learning			✓
	Students are interested and enthusiastic			✓
●	Opportunities for students to mention their problems/concerns in the class		✓	
	The lecture has stimulated students' thinking			✓
Comments:				