

**THE ROLE OF PRACTICAL WORK
IN TEACHING AND LEARNING PHYSICS
AT SECONDARY LEVEL
IN BANGLADESH**

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THE ROLE OF PRACTICAL WORK IN TEACHING AND LEARNING PHYSICS AT SECONDARY LEVEL IN BANGLADESH

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ABSTRACT

This qualitative study focused on four secondary school physics teachers in Bangladesh using semi-structured interviews and observations to explore their understanding about the relationship between practical work and developing students' conceptual knowledge of physics. Recent studies indicate that practical work helps secondary science students easily and effectively learn the concepts and theories of physics. However, the secondary school physics teachers in Bangladesh in this study did not provide students with practical work during classroom teaching. Rather, they provided practical work in separate practical classes. Although the teachers believed that practical work made their teaching and also students' learning easier and effective, they did not offer frequent practical demonstrations in teaching the contents of physics.

The major findings of the study include that teachers used mostly transmissive pedagogy to assist students to understand physics concepts and theories. Even though there are clear and specific instructions for the teachers to do demonstrations in the secondary physics curriculum, there were constraints on teachers and on students trying to conduct practical work. Constraints included: a lack of sufficient equipment. Teachers and students in non-government schools faced comparatively more difficulties than those in government schools. Low teacher/student ratios and no positions for laboratory assistants were reasons given for teachers' intense workloads.

This study implies a need to provide government and non-government schools with necessary equipment for doing practical work; to appoint sufficient teachers with higher studies and training that includes practical work in physics; to create positions for laboratory assistants; to set up classrooms with a smaller number of students; and to develop awareness of the value of practical work among school administration and among physics teachers.

DEDICATION

**This thesis is dedicated to
my father, Nazim Uddin Ahmed, and my mother, Halima Banu
for their inspiration, blessings and enormous love.**

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LIST OF ACRONYMS

B Ed	Bachelor of Education
B Sc	Bachelor of Science
CPD	Continuous Professional Development
DEO	District Education Officer
DG	Director General
DSHE	Directorate of Secondary and Higher Education
LSBE	Life-Skill Based Education
M Ed	Master of Education
MoE	Ministry of Education
M Sc	Master of Science
PD	Project Director
STC	Secondary Teaching Certificate
TOT	Training of Trainers
TTC	Teachers' Training College
TTCR	Teachers' Training College, Rajshahi
TQI-SEP	Teaching Quality Improvement in Secondary Education Project

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Chapter One: Introduction

Education in general and science education in particular, is important for developing methods and standards of living. The development of a society without science education is unimaginable. Scientific knowledge depends on evidence. The acceptance of knowledge achieved through science education is high because of its practical dimension and application; hence priority is given to science education all over the world (Maleque, Begum, Islam, & Riad, 2007).

Some countries that are struggling to achieve developed nation status have undertaken the challenge of placing greater emphasis on science (Ishak & Mohamed, 2008) and they are spending more money in improving the quality of science education (Kasanda, 2008). Researchers such as Halai (2008), Kasanda (2008), Ranade (2008) have found that poor quality science education is common in many developing countries; and moreover, in these countries, the number of students studying science at secondary level is very small, while even fewer pursue science to tertiary level (BANBEIS, 2007; Ranade, 2008). Although results of different studies have shown various reasons for science students' poor content knowledge in developing countries, researchers such as Cook and Taylor (1994), Thair and Treagust (1999), Millar and Abrahams (2009), Nivalainen, Asikainen, Sormunen, and Hirvonen (2010) have argued that lack of practical work is an important factor. In many countries, physics as an individual subject is seen as abstract, difficult to understand and to conceptualise and the concepts of physics are usually learnt via rote memorisation, where the teachers transfer physics content knowledge to the students, filling their minds with facts, concepts, principles and laws (Ishak & Mohamed, 2008).

Many studies have shown that practical work plays a positive role in science teaching and learning by making it comparatively easier to understand; and can strengthen students' content knowledge.

According to Ranade (2008), the percentage of students in India taking up pure science has dropped from about 30% in the 1950s to about 20% in 2000; and at tertiary level, the gross enrolment ratio of students in 1995 was only sixty per one million of the population. In Bangladesh, only one third of the secondary science students study science at higher secondary level (BANBEIS, 2007), and a very small number of students take science subjects at tertiary level. My experiences as a lecturer in physics at higher secondary and tertiary levels, and as a teacher educator, indicate that many science students possess poor content knowledge of physics. It was very difficult for me to teach them to understand the physics material targeted at those levels. As a teacher educator in Bangladesh, I have experiences of monitoring the practice teaching of prospective teachers and also the actual teaching of in-service teachers in secondary schools. In Bangladesh, physics is taught as an independent subject in Grades IX and X; and in the physics curriculum, the teachers are urged to teach physics content using demonstrations (NCTB, 1996). But this suggestion is seldom practised; students achieve content knowledge of physics theoretically from teachers' lectures, and also through pair and group work; and practical work is usually conducted only in Grade X. The theoretical teaching of science subjects takes students beyond their sphere of experience and understanding, and thus, most science students regularly perceive the subjects as useful only for passing the examination (Kasanda, 2008). Since practical work is an essential part of science teaching and learning for developing students' scientific knowledge

(Millar, 2004), my observations as a lecturer in physics indicate that there is inadequate use of practical activities. This lack of practical work may be an important reason for students' poor content knowledge and understanding of physics at secondary level in Bangladesh.

Students are the future of a nation, and scientifically literate students can build a developed nation. Since secondary level is the foundation level for higher education, it needs to be as strong as possible. Physics is one of the most important subjects among the mathematical and natural sciences. Students who want to do higher education qualifications in physics or want to study in the fields of engineering or medical sciences must have a strong background knowledge of physics. Emphasis should be on providing secondary students with clear and standard basic physics content knowledge, which they understand and can utilise in their future study, in their daily lives, or in doing research activities.

Although many studies show that practical activities play a key role in teaching and learning physics, some studies [Asikainen & Hirvonen, 2010; Ishak & Mohamed, 2008; Kasanda, 2008; Taylor & Dana, 2003; and Zacharia, 2003] have shown that the main reason for students' failure to learn is science teachers' poor content knowledge, while others [Halai, 2008; Ranade, 2008; and van Driel, Beijaard, & Verloop, 2001] have found that teachers' lack of pedagogical content knowledge of science teaching is responsible. Some researchers suggest that well-designed teacher education programmes can help teachers to develop both subject matter knowledge and pedagogical content knowledge so that they can effectively teach their students. As a teacher and also as a teacher educator, I believe that teachers' subject matter knowledge and pedagogical content

knowledge of physics teaching are the preconditions for effectively teaching physics. The goal of providing science students with clear and standard physics content knowledge can be successfully achieved if the conceptual knowledge is supported by the inclusion of practical work.

According to Duffee and Aikenhead (1992), cited in van Driel et al. (2001), teachers are the most significant factor in bringing about change in educational practice and outcomes. Recent research indicates that the nature of teaching has significant influence on both what is taught and how teaching and learning occurs, which in turn influences learning outcomes (Lingbiao & Watkins, 2001). Teachers' practical knowledge consists of sets of beliefs and knowledge (van Driel et al., 2001), which have direct impact on their actual teaching and their interactions with students. It is essential to understand teachers' understanding and beliefs about the role of practical work in teaching and learning physics at secondary level. Although a small number of relevant research studies on the role of practical work have been conducted in developed countries and very few in developing countries, most of those are non-empirical. That is why I conducted a qualitative research study, where the main objectives were to understand teachers' beliefs regarding teaching and learning physics, and regarding the role of practical work in teaching and learning physics, because 'to understand teaching from teachers' perspectives, we have to understand the beliefs with which they define their work (Nespor, 1987, cited in Bryan, 2003, p. 837)'. It is likely that teachers' beliefs have a strong influence on what they do (Bryan & Abell, 1999, cited in Bryan, 2003). This study is significant also because this is a very challenging issue in science education in many developing countries and no such study has yet been done in this field in Bangladesh.

Research Question

The research question to guide my study is “How do secondary school physics teachers understand the relationship between practical work and developing conceptual knowledge of physics in Bangladesh?” Two sub-questions underpin the main question.

1. What important ideas do physics teachers in Bangladesh hold which they think determine what they teach?
2. How do they teach: what pedagogies do they use and what kinds of practical activities do they provide for their students?

Definition of terms

Secondary school physics teachers: The teachers who teach physics in Grades IX and X.

Practical work: Practical work includes the physics experiments or demonstrations selected for the science students to do or observe at laboratory sessions in Grades IX and X. It also includes the hands-on activities used to teach and learn the concepts and theories of physics.

Classroom teaching: Teaching the theories and concepts in classrooms.

Practical class: Classes for doing practical experiments.

Conceptual knowledge: The knowledge of the facts, concepts, principles and laws of physics.

Demonstration method: A process of directly and practically presenting facts or concepts or theories in classroom. In this method, teachers use a variety of teaching aids and verbal statements.

Lecture method: Teachers present the lessons only through verbal statements.

Question-answer method: Teachers check student understanding by asking questions after first delivering a mini-lecture on the lesson.

CPD: A subject-based training course lasting 14 days, arranged by the TQI-SEP for secondary school teachers in Bangladesh.

STC: A training course of three months arranged by the TQI-SEP for those secondary school teachers who have not taken the B. Ed. course.

TOT: A training programme arranged by the TQI-SEP for teacher educators.

Context of this study

The context of this study is outlined in five subsections: (1) The education system in Bangladesh; (2) Secondary education; (3) The science education and physics teaching and learning system in secondary schools in Bangladesh; (4) Teacher education for secondary school teachers in Bangladesh; and (5) Secondary school physics teachers in Bangladesh.

(1) The education system in Bangladesh

The education system in Bangladesh is divided into three main categories: the general education system; the Madrasah education system; and the technical-vocational education system (MoE, 2011). My study is based on the general education system in Bangladesh, and particularly on secondary science education. There are three main levels in the general education system: primary, secondary and tertiary. The primary level includes Grades I to V, where the age group is 6 -10. The secondary level is further divided into three sub-levels: the junior secondary level, which includes Grades VI to VIII, with students of age group 11-13; the secondary level that consists of Grades IX and X, with students of age group 14-15, and the higher secondary level for Grades XI and XII, where the age group is 16-17 (Maleque et al., 2007). After completing higher secondary study, those students who are interested in pursuing higher education are admitted into universities or colleges at tertiary level.

The Ministry of Education (MoE) is responsible for the formulation of education policies. The Directorate of Secondary and Higher Education (DSHE) under the MoE is responsible for implementing the curriculum and also for the management and supervision of the secondary education system. The National Curriculum and Textbook Board (NCTB, 1996) is responsible for developing curriculum and publishing standard textbooks.

The education system in Bangladesh is supported financially by the government. The majority of schools in primary, secondary and higher secondary levels are operated by the government of Bangladesh. The government schools are fully funded by the government

and the non-government schools are partly government funded (Maleque et al., 2007). There are many private schools financially subsidised by the government. In government-sponsored schools, students receive their education in Bangla, the national language, which is the language of the majority of people in Bangladesh. However, some of the private schools use English as the medium of instruction.

The Madrasah education system is a separate religious branch of education where all the basics are taught in Bangla; but religious studies are taught in Arabic. A special type of school-cum-college, named cadet college, is important in the education system of Bangladesh, where military education is compulsory. For all types of school, the school year starts in January.

At the end of Grades X and XII, there are respectively two nationwide public examinations: the Secondary School Certificate (SSC) and the Higher Secondary Certificate (HSC) examinations. Recently, two nationwide public examinations have also been conducted at the end of Grades V and VIII respectively. All public examinations are conducted by seven education boards placed in Dhaka, Chittagong, Rajshahi, Comilla, Jessore, Sylhet, and Barisal. The students of Madrasah education and English medium streams also sit their respective public examinations, which are Dakhil and Alim conducted by the Madrasah Education Board; and 'O' and 'A' levels conducted by London/Cambridge University, facilitated by the British Council.

(2)Secondary education

There are three subject streams within the secondary level in Bangladesh: Science, Arts and Business Studies. Science students are expected to build a solid base of science

knowledge for further study, and they study physics, chemistry and biology as distinct subjects. Students of Arts and Business Studies are expected to have a general understanding of science and its application and therefore they study general science (Siddique, 2008). Before 2010, students passing Grade VIII were admitted into Grade IX where they chose one of the three streams. However, from 2010, the Junior School Certificate (JSC) examination was started. Now, students who successfully complete the JSC examination, can be admitted into the secondary level. The students can choose one of the three streams, but in order to be admitted into the science group, they must achieve a certain level of marks in the JSC examination.

According to BANBEIS (2004), cited in Maleque et al. (2007), there are 317 government secondary schools where the number of students is 221,215, while there are 12,608 non-government secondary schools with 6,933,497 students. Government secondary schools make up 1.96% of the whole, with non-government secondary schools making up 98.08%. The number of students in most of the schools is very large compared to the number of the teachers. In the government schools, the average teacher/student ratio is 1: 32 and in non-government schools, it is 1: 45 (BANBEIS, 2004, cited in Maleque et al., 2007). According to the numbers of students in Science, Arts and Business Studies, they are divided into two or three groups, each of which is termed a section. In most schools, the number of science students is smaller than the other two groups and therefore, the number of science sections is also smaller. In some schools, there are two or three sections for the Science students in each of Grades IX and X, and in some schools there is only one section. In the schools where the total number of students in each Grade is not large, the common subjects are taught in one section and as the number of science

students is smaller, only the science students go to another classroom to attend the science subjects. At the same time, the students of Arts remain in the same classroom to attend the Arts subjects. If there are students of Business Studies, they also move to another classroom to attend the classes on their individual subjects. There are three examinations in each of Grades IX and X. For Grade IX, these are the first terminal, the second terminal, and the annual examinations; and for Grade X, they are the first terminal, the pre-test, and the test examinations. In the syllabi prepared by some schools, the content as well as the timetable for conducting each examination is specified. The first terminal examination is usually conducted in April, the second terminal and the pre-test examinations are in July, the test examination is in October and the annual examination is held in November.

There is a national curriculum for all subjects of all Grades at junior secondary, secondary and higher secondary levels. From this curriculum, teachers in the government schools prepare a syllabus handbook for each Grade. Most of the non-government schools follow the syllabus handbook prepared by the Forum and very few non-government schools prepare their own. The syllabus handbook is the academic plan for a specific Grade, which is prepared every year, and the teachers are provided with one copy of the syllabus handbook for the Grades they teach. In some schools, students are provided with the handbook; however, in some schools, students are asked to buy it from the market. The syllabus handbooks are used by the teachers to teach their classes.

From the curriculum, as for other Grades, the syllabus handbooks for Grades IX and X are prepared. The syllabus handbook for each Grade specifies the contents of all subjects to be taught within each of the three examinations in the year, the types of activities with

explanation to be provided to the students, the types of questions with examples to be set for the examination, the mark distributions for different types of questions for each examination, the time length of the examinations, and the timetable for each examination. In the syllabus handbook for Grade X, all of these along with the marks allocated for the practical examination are laid out. For the secondary science students there are eleven prescribed practical experiments in physics to be completed. In the physics text book for Grades IX and X, there are systematic descriptions for teachers as well as for students on how to perform each of the experiments.

A few years ago, School Based Assessment (SBA) was added to the curriculum at secondary level, according to which students have to do some course work. The course work includes preparing some research type homework assignments, such as collecting information on a specific topic from newspapers, books or from electronic media; locally collecting aids; preparing a questionnaire and completing it with the answers from classmates and their families, friends, or other people. But most of the government and the non-government schools do not follow the SBA course work; only a few government schools in the cities partially follow the work for students from Grades VI to VIII. Because of the vast syllabus in Grade IX, SBA has been withdrawn from the SSC examination.

(3) Science education and physics teaching and learning systems in secondary schools in Bangladesh

Physics and chemistry are compulsory subjects for science students at secondary level and they have to choose two other subject options. There are several science subjects for them to choose from, such as biology, computer education, higher mathematics, agriculture study etc.

Physics is taught as an individual subject in Grades IX and X. In the curriculum of physics at secondary level, there are twenty-five chapters of theoretical content and eleven practical experiments. Of the twenty-five theory chapters, approximately eighteen are taught in Grade IX and the rest are taught in Grade X. The eleven practical experiments in physics are conducted only in Grade X.

As in other science subjects, there are separate classes for teaching theoretical content and teaching practical experiments in physics. The class for teaching theories and concepts is called the theoretical class or classroom teaching, while the class for teaching practical experiments is named the demonstration class. The class where students do the practical experiments is termed the practical class. The demonstration and the practical classes are done in the laboratory and the theoretical classes are taught in classrooms.

As for other science subjects, physics practical work is assessed in the test examination in Grade X and also in the SSC examination. Of the 100 marks, 75 are allocated for assessing the theoretical content and 25 for assessing the practical component.

According to the physics curriculum, teachers are instructed to use demonstration methods for teaching physics content in the classroom and also for teaching practical activities for doing practical experiments.

As in many other countries, in Bangladesh the concepts of physics are usually learnt via rote memorisation. The teachers transfer physics knowledge to the students by presenting a series of facts, concepts, principles and laws (Ishak & Mohamed, 2008). The curriculum document for secondary physics comprises twenty-five chapters, with details given of the general aims and objectives and the learning outcomes of studying secondary physics (NCTB, 1996). Instructions on how to teach; what type of teaching methods and teaching aids are to be used to teach each chapter; and what type of knowledge and skills of students are to be assessed are explained elaborately. The curriculum also explains the general objectives of learning physics at secondary level; chapter-wise learning outcomes; and the mark distribution of Secondary School Certificate (SSC) examinations, both theoretical and practical. For the writers of the textbook of physics, there are general, design and content directions.

Teachers more or less follow instructions given in the curriculum document.

In teaching physics, teachers usually explain the theory or the content, sometimes by using special teaching aids and sometimes using only the textbook. They then ask students questions about that lesson. Most of the time, teachers assign individual work; and, infrequently, they assign group work. They regularly provide students with homework, which the students are asked to bring to the next class. Teachers do not usually provide any practical activities during classroom teaching. These observations are

drawn from my experience while monitoring teachers' teaching in Grades IX and X, and also from the reports received from my student teachers when they have gone on to teaching practices in schools. As practical activities in the curriculum document, there are only the eleven experiments which are to be conducted in the practical classes and only in Grade X.

(4)Teacher education for secondary school teachers in Bangladesh

There are several training programmes for prospective and in-service teachers in Bangladesh: the Bachelor of Education (BEd) degree, the Master of Education (MEd) degree, the Continuous Professional Development (CPD) course, Secondary Teaching Certificate (STC) course, Life-Skill Based Education (LSBE), Training of the Trainers (TOT). Teaching practice is an important part of some training programmes, and is regularly monitored and assessed. While on teaching practice, trainee teachers are assessed on whether they are evaluating students' previous knowledge of the lesson content, whether they are using special teaching aids related to the lesson, whether they are using participatory methods to involve all students in all the activities in the class, whether they are evaluating students' overall learning, and whether they are providing homework.

In teacher education programmes, trainee teachers are expected to complete study on the lessons before going into the classroom. They have to prepare written lesson plans and they are regularly monitored by the teacher educators of the Teachers' Training Colleges (TTCs). There is a specific format for lesson plans: evaluating students' previous knowledge of the lesson content, introducing the lesson and delivering a mini-lecture,

setting individual, pair and group work according to the lesson topic, evaluation of the learning, and providing homework. During the training programmes, emphasis is put on using teaching aids to explain the lesson and to assist students to understand concepts. Trainee teachers are taught how to prepare low cost and no cost teaching aids and afterwards, they are asked to prepare teaching aids for use in their practice during the training programmes. They are instructed to utilise this knowledge in preparing teaching aids for their actual teaching. Moreover, they are instructed to use participatory methods in their teaching in order to ensure students' active involvement in class, to use question-answer methods, and to provide students with individual, pair, and group activities. There is a subject based training programme named Continuous Professional Development (CPD) training, where for science subjects, the use of practical activities is partly emphasised.

(5) Secondary school physics teachers in Bangladesh

In most secondary schools in Bangladesh there is only one physics teacher. There are few teachers who teach physics at secondary level with a background in theoretical or applied physics. Most of the teachers who teach secondary school physics have completed their Master of Science (MSc) in some other subjects, and have studied physics as a subsidiary subject in their Bachelor of Science (BSc) with Honours course. Some other secondary school physics teachers have studied physics as an optional subject in their Bachelor of Science course (BSc).

Funding and resources

All government schools are fully funded by the government and the approved non-government schools are partly government funded. Usually schools have a large area occupied by school buildings and a large playground for the students. All government and non-government schools are provided by the government with the equipment for conducting practical experiments.

Chapter Two: Relevant Research and Theory

Researchers such as Asikainen and Hirvonen (2010), Millar (2004), Nivalainen et al. (2010), Halai (2008), Ranade (2008), Thair and Treagust (1999) have found various reasons for students' poor content knowledge of physics. These include a lack of physics teachers' content knowledge, a lack of pedagogical knowledge, inconsistent beliefs and understandings of teaching and learning physics, shortage of science teachers, large classes, lack of practical work and laboratory equipment, poor quality of text books, an examination-dominated education system, a lack of activity-based teaching, and poor teaching resources or poor academic environment.

Millar (2004) states that science education has two main aims: (1) helping students to gain an understanding of science content knowledge according to their needs, interests, and capacities; and (2) developing students' understanding of the methods of achieving this knowledge. According to Scanlon, Morris, Terry, & Cooper (2002), the construction of knowledge is difficult for science students particularly because they need to develop both their conceptual and procedural understanding by appropriate activities. Wellington and Osborne (2001), cited in Ishak and Mohamed (2008), state that science teachers' primary skills in mediating the concepts of science for secondary students lie in understanding and conveying a complex and fascinating subject, such as physics. Physics teachers should have knowledge of instructional approaches, experimental work, mathematical problem-solving, and students' preconceptions and models (Asikainen & Hirvonen, 2010). Teachers' use of the best instructional methods is considered to be a prerequisite for successful teaching (Klafki, 2000).

According to Boz and Boz (2008), a teacher cannot understand any discipline without adequate subject matter knowledge. According to van Driel, Verloop, and de Vos (1998), such knowledge is a precondition for teachers being able to understand students' learning difficulties and use strategies that can help students to overcome these difficulties. Klafki (2000) states that mastered subject matter knowledge is the precondition for teachers to transform subject matter knowledge to students and to select the best instructional methods. Asikainen and Hirvonen (2010) state that it is very important to identify the most important domains of teacher knowledge for student teachers' professional development during their teaching practice and also for the further development of teacher education.

Zacharia (2003) conducted research using a pre-post comparison study and the attitude-behaviour Theory of Reasoned Action (TRA) covering 13 prospective physics teachers. The results confirmed the TRA model that beliefs affect attitudes and attitudes affect intentions (Fishbein, 1980, cited in Zacharia, 2003). Science teachers' poor knowledge of science negatively affects their attitudes towards science (Lloyd, Smith, Fay, Khang, Wah, & Sai, 1998), which accordingly affects their classroom practice (Bencze & Hodson, 1999). The results of the qualitative research study over six physics teacher educators, conducted by Asikainen and Hirvonen (2010) show that the teacher educators concentrate mostly on knowledge that is useful in a practical sense and pay less attention to knowledge of theoretical and abstract aspects. The findings of both the studies conducted by Black and Halliwell (2000) and Meijer, Verloop, and Beijaard (1999) show that student teachers face difficulties in applying educational theories in their actual

teaching, because the teaching of their associate teachers differs from the educational theories to which they have been exposed.

The results of the study carried out by Taylor and Dana (2003) using qualitative methodology, where one pre-service and two in-service secondary school physics teachers were the participants, show that secondary school physics teachers' capacity to critically evaluate scientific evidence is complex. Taylor and Dana (2003), providing references of some studies (Borko & Putnam, 1996; Grossman, 1990; Shulman, 1986; Smith & Neale, 1989), state that science teachers must have appropriate concepts of scientific evidence themselves in order to help their students develop similar concepts. For several decades, science education researchers have recommended that science instruction should be designed to help students develop appropriate concepts of scientific inquiry (NRC, 1996, cited in Taylor and Dana, 2003) and of the nature of science (AAAS, 1993, cited in van Driel et al., 2001).

According to Abd-El-Khalick and BouJaoude (1997), cited in Asikainen and Hirvonen (2010), many science teachers possess insufficient subject matter knowledge of the nature of science which makes teaching difficult for them. Ishak and Mohamed (2008) and Kasanda (2008), in two different studies, state that physics teachers' lack of content knowledge is the main reason for students' poor content knowledge of physics at secondary level. In a non-empirical research study, Kasanda (2008) states that inadequately qualified science teachers fail to offer effective instruction to students and thus create science students with poor content knowledge. If teachers do not understand specific physics content, they will obviously have difficulty teaching that content. Kasanda (2008) states that since teachers are expected to be the backbone of popularising

science education at secondary level, their in-depth knowledge should be equal to or above the required knowledge to teach. Ishak and Mohamed (2008), in their quantitative research study, involving 113 pre-service physics teachers state that in many countries, teacher training is based on a 'pedagogical approach' in which most trainers struggle to develop trainees' pedagogical knowledge, rather than their content knowledge. Emphasis on 'how to teach', but not on 'what to teach' makes teaching and learning of science subjects difficult (Kasanda, 2008). The results from a study of pre-service teachers support the idea that training based on the 'didaktik approach' can help the teachers understand physics as it is understood by physicists, plan ways of teaching specific physics content, and enhance their teaching confidence (Ishak & Mohamed, 2008).

Asikainen and Hirvonen (2010) suggest that an in-service teacher education programme is needed for the associate physics teachers, in which they can update important elements of their knowledge. Such teacher education programmes can connect student teaching with adequate theoretical studies of education (Asikainen & Hirvonen, 2010). Taylor and Dana (2003) recommend that teacher education programmes should be designed to promote the development of appropriate conceptions of scientific evidence. Emphasis should be given to the science knowledge needed to evaluate secondary school student-generated scientific evidence. Similarly, science teachers should emphasise the development of appropriate conceptions of scientific evidence in their own teaching. (Taylor & Dana, 2003).

Ishak and Mohamed (2008) suggest that teacher education can play an important role in assisting physics teachers to develop specific content knowledge and to implement didaktik analysis-based teaching in their classrooms. By these means they can motivate

their students to engage meaningfully with relevant physics content, and learn more easily. Similarly, Kasanda (2008) suggests that teacher education programmes should improve science teachers' content knowledge, which will increase the self-confidence needed to teach science content effectively to their students, and this knowledge can make a difference in the constructivist learning process using learner-centred methods (NIED, 2003, cited in Kasanda, 2008).

In a non-empirical research study on the role of science teachers' practical knowledge in reforming science education, conducted in the Netherlands, van Driel et al. (2001) state that science is generally taught as a rigid body of facts, theories and rules to be memorised and practised. Similarly, in another theoretical research study on science education in India, Ranade (2008) points out the boring and mechanical style of teaching science as one of many reasons for the poor quality of science education and states that this poor quality of teaching discourages students from doing further study in science. In a research report based on the perspectives of developing science teachers' practical knowledge, van Driel et al. (2001) explain that teachers' practical knowledge and beliefs bear explicit relation to their classroom practice. If teachers' practical knowledge consists of elements which are not integrated, they often experience conflicts between their personal beliefs about science and science teaching and their actual teaching practice (Simmons et al., 1999, cited in van Driel et al., 2001).

Halai (2008), in her theoretical research study on curriculum reform in Pakistan science education states that lack of science teachers' pedagogical knowledge is the main reason for science students' poor content knowledge. Van Driel et al. (2001) outline how the development of pedagogical content knowledge (PCK) in experienced science teachers

provides them with a framework for teaching, where teaching experience is the most important factor in the development of PCK. If teachers can develop a conceptual framework in which knowledge and beliefs about science, subject matter, teaching and learning, and students are integrated logically, then it can help them to link the theory to teaching practice (van Driel et al., 2001). But Ishak and Mohamed (2008) state that in a PCK-based approach, there is little emphasis on science content compared with teaching methods.

In Shulman's (1987) categorisation of the components of teachers' knowledge, practical knowledge belongs to the categories of subject matter knowledge and knowledge of representations and strategies, and in Didaktik, it is not only a part of teachers' deep understanding but also belongs to knowledge of the best instructional methods (Asikainen & Hirvonen, 2010). Teachers' use of the best instructional methods is considered to be a prerequisite for successful teaching (Klafki, 2000), and is, according to van Driel et al. (1998) one of the most important categories of PCK.

Practical work is considered to be an essential part of science education, where the objectives are: (1) to motivate students by stimulating interest (Hodson, 1990); (2) to develop their understanding of laboratory skills; and (3) to enhance their understanding of scientific knowledge (Hodson, 1990; Millar & Abrahams, 2009; Lynch, 1986, cited in Thair and Treagust, 1999). Since the physical world is the subject matter of science, learning science must involve observing, managing and manipulating real objects; and teaching science should include demonstrating (Millar, 2004; Millar & Abrahams, 2009). Most UK science teachers tend to accept a more 'hands-on' approach in their teaching because they believe that practical work is an essential part of science teaching and

learning (Woodley, 2009). Practical work, as a teaching and learning strategy, is always expected to play an important role and the challenge is to make it more effective (Millar & Abrahams, 2009). Students naturally accept knowledge which they discover through their own efforts and this approach helps them to remember that knowledge better and encourages them to be more independent (Millar, 2004).

In a non-empirical research study on teacher training reforms in Indonesian secondary science focusing on the importance of practical work in physics teaching and learning, Thair and Treagust (1999) state that it is widely accepted that secondary science curricula should contain a significant amount of practical activity. Educators suggest that students must participate in processing information for developing a conceptual understanding of science (Woolnough, 1988, cited in Thair and Treagust, 1999), where practical activities are the only way of providing this opportunity (Thair & Treagust, 1999). If students are taught using practical work, they can effectively achieve physics content knowledge at a significantly higher level than that achieved using group discussion and lectures (Mertajaya, 1993, cited in Thair and Treagust, 1999). The reason, stated by Millar (2004) in his research paper on the role of practical work in science teaching and learning, is that practical work requires students to make links between the domain of objects and the domain of ideas. In their study, van Driel et al. (2001) make reference to studies that acknowledge the need for practical activities in teaching and learning science but they do not provide any suggestions regarding doing practical work. Perhaps they have made an assumption that all teachers of science naturally do practical work and give students practical work experiences. Although Asikainen and Hirvonen (2010) suggest not emphasising practical work, the results of their study show that experienced physics

teacher educators believe that physics teaching at school level is based on practical work along with theory.

However, some researchers have questioned the effectiveness of practical work and a lack of evidence for these benefits (Gallagher, 1987, cited in Thair and Treagust, 1999; Millar & Abrahams, 2009). Millar and Abrahams (2009) state in a research article about the effectiveness of practical activities in school science that although students like practical work, they often do not learn from a practical task the things they are expected to learn, and after a few weeks of carrying out a practical task, most students recall only specific surface details of the task and many are unable to say what they learned from it. Osborne (1998), cited in Millar and Abrahams (2009) suggests that practical work plays a very limited role in learning science and that it has little educational value. Hodson (1990) took a critical look at practical work as practised in many schools and states that the laboratory activities relating to learning scientific concepts, understanding science and acquiring scientific attitudes influence the learning outcomes. However, he claims that practical work practised in many schools in many countries is ill-conceived, confused, and unproductive, and has not yet been successful in achieving the goals of science education. Gunstone (1991) cited in Halai (2008) states that in order to get the certified benefits of practical work regarding reconstruction of the theory of science and linking of science concepts in different ways, students should spend more time in interacting with ideas than in interacting with apparatus.

While practical work can encourage, demonstrate, simplify, and develop understanding, it can also confuse students (Halai, 2008), because knowledge is based on observation, and scientific laws are acquired by a process of instruction from the facts of sensory data

(Driver, 1994, cited in Halai, 2008). However, many science teachers believe that practical work can expose students to sensory data that helps them to construct scientific concepts. The cliché “I do and I understand” is often used to support the use of practical work in science teaching.

Millar (2004) points out some limitations of the enquiry-based activity: (1) because of inexperience, the quality of the equipment, or the amount of time available, students often make incomplete, incorrect, or imprecise observations or measurements, and consequently, the collected data does not reveal the expected result; (2) since students believe that teachers know the possible answers of the experiments (Millar, 2004), they naturally expect that teachers will confirm their results [(Driver, 1975; Atkinson & Delamont, 1976; and Wellington, 1981), cited in Millar, 2004]. If practical work is used as a way of confirming theory (Thair & Treagust, 1999), it becomes fun-work rather than an activity to develop understanding (Halai, 2008; Osborne, 1993, cited in Thair and Treagust, 1999), where intelligent students can detect the right answer (Osborne, 1993, cited in Thair and Treagust, 1999). Similarly, Millar (2004, p. 4) states that if practical work is not effectively conducted, it becomes a game to the students, instead of real ‘discovery of knowledge’.

Providing references of some studies (Hodson, 1996, Nakhleh et al., 2002; Wellington, 2000) Halai (2008) states that, as currently conducted, practical work is not helpful enough in achieving the goals of science education. Open-ended investigations about relevant issues, project work, group discussions, reading and writing (Glynn & Muth, 1994, cited in Halai, 2008) can, however, improve science learning and this is sometimes, more effective than using structured practical activities (Halai, 2008). According to

Millar (2004), open-ended and investigative types of practical work can expand the implicit scientific knowledge of students.

In a research article on the importance of practical work, Woodley (2009) states that most researchers and teachers believe that effective practical work can develop important skills in understanding the process of scientific investigation and can also develop students' grasp of concepts. Similarly, Scanlon et al. (2002) believe that practical work has an obvious role in developing science students' conceptual and procedural understanding. Although challenging, effective practical activities build a bridge between 'hands-on' and 'minds-on' activities (Woodley, 2009). Millar and Abrahams (2009) suggest that the 'minds on' aspects of practical work must be increased in order to make it more effective in developing students' understanding of scientific ideas. Before carrying out any practical activity, it is useful to consider what teachers expect the students to learn by doing this activity (Millar, 2002, cited in Woodley, 2009). To think about the effectiveness of a teaching and learning activity, it is useful to consider the steps in developing such an activity, and in monitoring what happens when it is used (Millar & Abrahams, 2009). Hence, to make the practical work effective, teachers need to identify its objectives, clarify the task well, monitor students' activities, and judge what students have learnt (Millar & Abrahams, 2009).

Science Community Representing Education (SCORE) made a structure for school practical science (SCORE, 2009a, cited in Woodley, 2009), which defines science practical work as a 'hands-on' learning experience that stimulates thinking about the natural world (Woodley, 2009). The report (SCORE, 2009b, cited in Woodley, 2009, p. 49) identifies a list of possible practical work that are of two kinds:

(1) Core activities: Investigations, laboratory procedures and techniques, and fieldwork, which support the development of practical skills and help to shape students' understanding of scientific concepts and phenomena.

(2) Directly related activities: teacher demonstrations, experiencing phenomena, designing and planning investigations, analysing results, and data analysis using ICT, which are closely related to the core activities and are either a key component of an investigation, or provide valuable first-hand experiences for students.

Although the science curricula of developing countries recommend the use of practical activities, a number of constraints prevent the implementation of these into classrooms (Thair & Treagust, 1999). Among the existing constraints, those that seem important are: (1) low maintenance standards for laboratory facilities and (2) lack of laboratory assistants requiring teachers to spend lengthy periods preparing experiments (Thair & Treagust, 1999). Indeed, the lack of teachers' knowledge, skills, and confidence restrict the amount of practical work that can be performed (Cook & Taylor, 1994). Although science curricula are well-designed, due to lack of laboratory equipment, science teachers have to depend on lecture methods in their teaching. This induces students to follow rote learning (Ranade, 2008). The findings of the study conducted by Nivalainen et al. (2010) also show that practical work in physics is challenged by the limitations of the laboratory facilities, teachers' insufficient knowledge of physics, problems in understanding instructional approaches, and general lack of organisation of practical work. Process skills not being examined in national examinations is another weakness of science education in many developing countries (Cook & Taylor, 1994). This is perhaps the most

crucial factor to be addressed by the education system of some developing countries (Thair & Treagust, 1999).

Kemper (2000) cited in Lyons (2006) states that science teachers do not have time to do practical activities due to the overloaded curriculum. According to Koballa and Tippins (2000), cited in Lyons (2006), overloaded science curriculum compels teachers to focus more on completing the syllabus than on the pedagogy of science teaching. Osborne and Collins (2001) cited in Lyons (2006) believe that this is the reason why teachers use transmissive pedagogy. Although Ranade (2008) does not mention overloaded science curriculum as a reason that compels teachers to use transmissive pedagogy, she does mention this as a burden on school science students. Thair and Treagust (1999) and Halai (2008) also mention the overloaded science curriculum as one of the commonly reported constraints in science education.

Halai (2008) states that there is a significant shortage of science teachers in the largest and the most developed province of Pakistan; and the situation is much worse in rural areas. She also mentions that there are teachers who never studied science in school, yet teach science subjects because of the shortage of science teachers. According to Omari (1991) cited in Kasanda (2008), there is a lack of science teachers even in some highly developed countries, such as Canada, USA, the UK, and Sweden. Halai (2008) states that the shortage of science teacher creates extra workload for the teachers which compels them to teach a large number of classes with a large number of students; and that is why 'they tend to focus on covering the syllabi for the examinations' and 'cannot do justice to their teaching' (p. 118). Ranade (2008) mentions that large class size is a hindrance for

the teachers to using activity methods; and it leads them to the teaching of science through the over use of lecture method.

The purposes of science education align with the selection of curriculum content and to specific emphases and rationales for the use of practical work (Millar, 2004). According to Thair and Treagust (1999), since there are differences in perspective, function of schooling, and outcomes depending on cultures, practical activities offer different functions for the students in different countries. Hence, in the design of practical activities, science education requires consideration of: (1) what kind of practical work science students of a particular country need and (2) what type of skills teachers need to teach science through practical work (Halai, 2008; Thair & Treagust, 1999).

For the implementation of meaningful practical activities in physics, researchers propose some consideration and strategies to overcome the existing limitations. Stating that if science achievement tests neglect to measure the skills developed during practical activities, the expected benefits of practical work will remain uncertain, Lewin (1993), cited in Thair and Treagust, 1999) suggests that physics curricula in developing countries should be developed with modifications to existing syllabi to remove obvious colonial distortions, increase emphasis on teaching using practical activities, and reduce emphasis on factual recall. Nivalainen et al. (2010) suggest that teacher education programmes should provide physics teachers with well-designed courses in practical work, which should aim to familiarise the teachers with practical work to make them understand the purpose of practical work at school. This is especially important in education systems where the teacher trainees have not experienced much practical work themselves and, therefore, may not have experienced the benefits of practical work. Thair and Treagust

(1999) recommend that teacher education programmes should support teachers so that they can effectively implement laboratory activities into their teaching in school, and should also encourage them to use a range of interactive methods including group discussion, group activities, and practical activities, which will help students to increase their level of understanding and consequently, their level of achievement in physics. Halai (2008) suggests that a minor change in the ways of doing demonstrations can increase the effectiveness of demonstrations, for example, including activities as 'prediction-observation-explanation' (Gunstone, 1991, cited in Halai, 2008, p. 127). Cook and Taylor (1994) advise that the provision of laboratory assistants may lessen some problems regarding the availability and maintenance of laboratory equipment in secondary schools.

Chapter Three: Research Design

This chapter presents the qualitative methodology under which this study was conducted. The approach used incorporated semi-structured interviews conducted face to face and observations of teaching of theory classes and practical classes in order to explore how physics teachers from different secondary schools understand the relationship between practical work and develop a conceptual knowledge of physics. This included developing case studies. This chapter therefore describes the case study methods, semi-structured interviews, theory class and practical class observations, settings and sample sizes. It then describes the data collection and data analysis procedures. Ethical considerations, the concept of trustworthiness and the validity of this study are also discussed.

Qualitative Methodology

Qualitative research is an investigation that emphasises quality rather than quantity. It is often termed “fieldwork”, because data are collected in the field, rather than in controlled situations (Junker, 1960, cited in Bogdan and Biklen, 2007). According to Willis (2008), qualitative research is a way to understand people by entering into their worlds in order to represent and interpret these worlds. Qualitative researchers are concerned with accurately capturing the perspectives of the participants and also with the outcomes along with the process (Bogdan & Biklen, 2007; Willis, 2008), where the researchers continually ask questions to discover what the participants are experiencing, how they interpret their experiences, and how they structure their social world (Psathas, 1973, cited in Bogdan and Biklen, 2007). Qualitative research is a methodology where a small

number of places, situations, or people are examined over a longer period of time where the researchers, acting as the key instruments, collect data through observation, participation, and interview (Willis, 2008). In some qualitative studies, the researchers give an in-depth description of only one participant (Bogdan & Biklen, 2007).

In qualitative research, the collected data is termed 'soft', because the data is rich with description of people, places, and conversations, which are not easily handled by statistical procedures and the research questions are formulated to investigate topics in detail (Bogdan & Biklen, 2007). Although the researchers formulate research questions to guide their inquiry, the questions may change during the study (Willis, 2008).

In education, this type of research is termed naturalistic, because the researchers collect data from natural settings, such as classrooms, cafeterias and teachers' rooms (Bogdan & Biklen, 2007). Qualitative data are collected from people engaging in normal behaviour, such as talking, eating (Guba, 1978, cited in Bogdan and Biklen, 2007), and in my opinion, playing and teaching, because people's behaviour is significantly influenced by their usual setting, where it is best to understand them (Bogdan & Biklen, 2007). In qualitative research, the researchers try to describe a particular situation in narrative form and analyse data including interview transcripts, fieldnotes, photographs, videotapes, personal documents, memos, and other official records (Bogdan & Biklen, 2007).

According to Bogdan and Biklen (2007), the best techniques of qualitative methodology are observation and in-depth interviewing. Through observation, the researchers enter the participants' world to know them and to gain their trust, keeping a detailed written record of what they hear and observe in the settings (Bogdan & Biklen, 2007). This material is

supplemented by school memos and records, newspaper articles, photographs, and so on (Bogdan & Biklen, 2007). Since interviews are conducted as purposeful conversations to gather descriptive data in participants' own words that help the researchers to understand participants' perspectives, the researchers spend considerable time with participants in their own environments, where they use semi-structured interviews, asking open-ended questions and recording their responses (Bogdan & Biklen, 2007). The open-ended nature of semi-structured interviews allows the respondents to answer from their own context and to freely express their thoughts (Bogdan & Biklen, 2007). Although semi-structured interviews are time consuming, researchers can capture participants' views and emotions using this method, where there is flexibility to clarify and simplify complex questions (Cohen et al., 2007, cited in Kakai, 2010).

According to Bogdan and Biklen (2007, p. 35), "if you want to understand the way people think about their world and how those definitions are formed, you need to get close to them, to hear them talk and observe them in their day-to-day lives" and qualitative methodology explores the understanding of people from their viewpoint, where reasons behind actions are explored. I consider that a qualitative methodology is suitable for a study where multiple case studies will be presented. Case study is an empirical inquiry of conducting social science research, is suitable when the researcher has little control over occurrence, and the focus is on a current occurrence within a real-life context (Yin, 2009). According to Flyvbjerg (2006), case study is useful for both creating and analysing a theory, based on an in-depth investigation of a single individual, group, or event (Yin, 2009). To conduct case study research, I conducted observations and had semi-structured interviews to gain an understanding of Bangladeshi teachers'

perspectives of teaching and learning physics in secondary schools. I collected data from Bangladesh observing the participants engaging in their activities in actual settings, because the setting has significant influence on people's behaviour (Bogdan & Biklen, 2007).

Invitation to participants

Firstly, I sought the permission (Appendix B) from the Bangladesh Ministry of Education (MoE) for collecting the data for the study in Bangladesh. After having obtained the ethics approval (Appendix A) for this study from the Educational Research Human Ethical Committee (ERHEC) at the University of Canterbury (UC) in October, 2010, I went to Bangladesh to collect data. For twelve days (from 20 Nov, 2010 to 01 Dec, 2010) I collected information about the schools and teachers. The information letters and the consent forms (Appendices C, D, E and F) for the Head teachers and also for the participating teachers were hand-delivered, because it was an effective way to receive prompt responses in Bangladesh.

In the letters (Appendix C) to the Head teachers, there was a request to allow the physics teacher to be involved as a participant of my study. The Head teachers were asked to sign the consent form (Appendix E). In the information letters to the participants and to the Head teachers, the basic information (Appendices C and D) about the study was outlined. The letters included information about classroom and practical class teaching observations, receiving the written lesson plans, and participating in interviews. While talking to the participants, I explained the aim and the significance of the study. The participating teachers were asked to sign the consent forms (Appendix F).

After collecting the written consents from both the Head teachers and the participating teachers, I arranged the schedule for the five observations and also for the first interview.

Participants and settings

I selected four experienced and trained physics teachers: two male and two female from four different schools in the Rajshahi district, one of the biggest districts in Bangladesh. Two of the schools were selected from the city and two from outside the city so that I could understand teachers' perspectives of teaching and learning in different settings. It is likely that setting influences teachers' behaviour (Bogdan & Biklen, 2007). Another reason for choosing four participants from four different schools was that there is usually only one physics teacher in each secondary school in Bangladesh. Of the four school settings, I selected two government schools and two non-government schools because there are differences in adequacy of resources and other physical facilities between the government and the non-government schools in Bangladesh. The teachers were chosen on the basis of having at least five years of teaching experience because experienced and skilled teachers are expected to have a wider understanding of physics teaching and learning. Moreover, the experienced and trained teachers are expected to have clear conceptions of teaching and learning and they are also expected to be more familiar with modern methods of teaching and learning physics. Teachers with fewer than five years of teaching experience may not have had sufficient professional development training. The participants were selected from those who teach in ninth and tenth grades because in Bangladesh physics is not taught as an independent subject in other classes in secondary level. The respondents were also selected on the basis of their teaching reputation

because so called “famous teachers” can influence others to reform their existing understanding and practice of teaching. Whether a teacher is “famous” or not is decided on the basis of the District Education Office documents, from the records of the secondary school physics teachers in Teachers’ Training College, Rajshahi, and also through discussions with their colleagues. Both male and female teachers were selected to understand teaching and learning physics from a male-female point of view. Since in qualitative research, a small number of samples are examined using in-depth data (Willis, 2008), I selected only four participants in order to be able to manage the data efficiently, given the scope of the project. All schools and teachers involved in the study were given pseudonyms.

How I selected the participants

As I am an inhabitant of Rajshahi city, and as I have worked as a teacher educator in the Teachers’ Training College, Rajshahi (TTCR), all the schools in this city where there is secondary education are known to me. Therefore, it was easy for me to select participants from two of these schools. For selecting two participants from outside the city, I sought help from some senior teacher educators of TTCR. I selected two male and two female participants from the records of the teachers in TTCR and this was done on the basis of both the name and fame of the school and the teacher and also on the basis of the teachers’ experience in teaching physics at secondary level.

The participants’ perceptions reflected a range of infrastructural conditions in science classrooms and specifically in the laboratories in the schools in Bangladesh.

Data collection procedures

The procedures for collecting and recording data for this study were based on the work of Creswell (2003). The procedures included:

- 1 Identifying the data sought;
- 2 Selecting the participants;
- 3 Methods for data collection; and
- 4 Data recording technique.

The qualitative data for this study were basically the participants' voices, the fieldnotes from the observations, teaching resource documents, the syllabus handbooks, the secondary physics curriculum and rationales about the role of practical work in teaching and learning physics at secondary level in Bangladesh.

Tools for data collection

To collect data for my study, I used audiotaped semi-structured interviews with each of the participants. The observations took place over three months to gain sufficient understanding of the participants' perspectives and beliefs (Bogdan & Biklen, 2007). I asked the teachers open-ended questions, allowing them to freely express their thoughts (Bogdan & Biklen, 2007). I observed teachers' teaching in order to understand: how they teach, what teaching methods they use, what teaching aids they use for teaching physics in classrooms, what activities they do in the practical classes, and how they do that; and also their attitudes towards students, towards physics teaching, and towards doing

practical work. For each participant, I conducted three observations in the classroom of Grade X, and two observations in the laboratory to observe the practical activities. Since teachers' behaviours and attitudes may be different at different times, several observations at several times helped me understand teachers' perspectives. I also asked the participants to provide me with the lesson planning related to their teaching and the syllabus handbooks prepared by their schools for Grades IX and X. I also collected the physics curriculum document, and the selected textbooks for classroom teaching and for conducting practical work, because these documents can supplement observation (Bogdan & Biklen, 2007).

I conducted semi-structured interviews with the participants in a quiet location and in an informal manner, because this type of interview is suitable for collecting in-depth data and enables a good rapport to be established between the researcher and the participants (Cohen et al., 2007, cited in Kakai, 2010). Of the four participants interviewed, I interviewed three participants twice, once after the first observation and once after the last observation; and I interviewed the other participant only once. The first observation helped me to shape additional questions for the first interview. The second interview allowed me to check any gap in understanding that I might have after transcribing the first interview. I rearranged the order of the interview questions as I found it necessary. I used nine open-ended questions to consider their teaching. These questions were supplemented by twelve additional probing questions (see Appendix H). Like Lingbiao and Watkins (2001), I encouraged the participants to respond elaborately, and freely. See Appendix G for interview questions.

Interviews with participants

I interviewed the first participant, the third participant and the fourth participant twice, once after the first observation and the other after the last observation, because after the observations, I realised the need to obtain more information for my study. Another reason for conducting the second interview was that I found some mismatches between the information given by the participants during the first interview and the information that I collected during observations. With the second participant, I had only one interview and this was after the first observation. However, while transcribing the data, I contacted all of the participants either by telephone or by e-mail, because I found several mismatches and also because I felt the need to obtain more information from them.

The first interviews with the four participants took place between 05/01/2011 and 16/01/2011 and lasted from 22-50 minutes. The second interviews lasted for only about 10 minutes and were taken after the last observation of the three participants.

All participants were provided with the interview question sheet at least one week before the first interview and before any lesson observations were made. I had explained to the participants what each question meant by rephrasing and translating the questions.

I conducted two interviews each week, but on two separate days. I had pre-arranged the time and place for the interview sessions after discussion with each participant. The time for the interview sessions was arranged in a way so as not to hamper the participants' regular classes. The interviews were conducted in pre-arranged places familiar to the participants, such as the science laboratories, the office, and a new classroom where lessons had not yet been conducted. During each interview, I sat next to the participant, so that the interview resembled as much as possible a normal conversation.

The interview questions were written in English, but the medium of conversations was Bangla which is the national language of Bangladesh. The participants, in speaking Bangla, were more fluent and also more comfortable expressing their perceptions and feelings.

Before starting the main interview questions, I asked each participant about their academic and professional backgrounds, their experience of teaching physics at secondary level, and about their school and classes. I asked them about the co-curricular activities in their schools and also commented on some activities that had I observed and enjoyed. These conversations were conducted as conversations between two colleagues and were used to build my rapport with the participants.

The order of my questions was based on decisions I made during the interview sessions, and depended on the participant's responses to the questions. I did not need to present all of the questions to each participant, because sometimes I obtained the answers to two questions from the response to one question.

Data recording

I audio-recorded the interviews. After each interview, I wrote down supplementary fieldnotes which helped me to understand the logic and rationale behind the participants' explanations (Borko et al., 2007, cited in Kakai, 2010). I also collected some relevant documents for triangulating the data for my research. For example, I collected the secondary physics curriculum, copies of lesson plans prepared by one participant,

samples of questions from the practical examinations, and the syllabus handbooks for Grades IX and X prepared by one school.

Audiotape recording

Head teachers and participating teachers gave informed consent for their interviews to be audio-recorded. For this purpose, I used a portable voice recorder placed on a table close to where the interview was conducted. The voice recorder was small in size and so was unobtrusive.

Fieldnotes

During the lesson observations, I took short notes or placed tick marks in the observation checklist that I had prepared for my observations. The fieldnotes mainly recorded the activities of the participants and of the students during a lesson. I also noted my views and reflections about my observations of the activities of the participants and students.

Participants

Two of the participants selected from the city were Master trainers of physics, meaning that they both conducted training classes for other secondary school physics teachers, along with teaching in their own schools. All the participants used to teach other subjects in other Grades in their schools, along with teaching physics in Grades IX and X. The teachers and schools have been given pseudonyms. I now discuss teachers' backgrounds in the following sections.

Participant-1: Nilufar Rahman

Nilufar Rahman is a 37 year old Assistant teacher at KSB Girls' High School, which is a non-government school situated outside Rajshahi city. In her school, there were students from Grade VI to Grade X. She has been teaching for eleven years and from the beginning has been teaching physics. She has completed the Bachelor of Science (BSc) degree, where her subjects were physics, chemistry and mathematics, and she has also completed the Bachelor of Education (BEd) degree with chemistry and mathematics as optional subjects. Although she did not take any special degree for physics, she has taken an in-service training course, named CPD (Continuous Professional Development) in physics, a subject based training programme. She takes 26 classes each week among which are three theoretical physics classes at Grade IX, three theoretical physics classes and one practical physics class at Grade X. The rest of her classes are in chemistry, general mathematics, general science, and also higher mathematics at Grades IX and X. She is the only physics teacher in her school.

Participant-2: Rakib Hasan

Rakib Hasan is a 42 year old Assistant teacher and has been teaching for 13 years at CT Govt. Boys' School which is situated in Rajshahi city. In his school, there are students from Grade III to Grade X. From the beginning of his teaching, he has been teaching physics. He has completed a Bachelor of Science (BSc) with Honours and a Master of Science (MSc) in geology and mining. In his BSc with Honours degree, physics and chemistry were the subsidiary subjects. He has taken the Bachelor of Education (BEd) with mathematics and general science as optional subjects, and also taken the Master of Education (MEd) degree. He has completed CPD training in physics. Moreover, he has

participated in the Training of the Trainers (TOT) program for physics. He is a Master trainer of physics, and therefore also takes training classes for other secondary school physics teachers. He teaches 26 classes each week among which are 8 classes in physics. At Grade IX, he takes three theoretical classes in physics, and at Grade X, two theoretical and three practical classes in physics. Other classes are in chemistry, general mathematics, general science, and also in higher mathematics at Grades IX and X. In his school there are four physics teachers, but he is the only one who teaches physics practical classes.

Participant-3: Rawnak Sultana

Assistant teacher Rawnak Sultana is 45 years old and teaches at BMC Govt. Girls' School, which is situated in Rajshahi city. In her school there are students from Grade III to Grade X. She has over 19 years teaching experience and for 19 years she has been teaching physics. She has completed a BSc with Honours and an MSc in applied physics and electronics. She has also taken the BEd and the MEd degrees. She has completed the CPD training in physics and has taken the TOT for physics. She is a Master trainer of physics and therefore also takes training classes for other secondary school physics teachers. Each week she teaches 24 classes all of which are in Grades IX and X. Among those classes, there are 19 classes in physics and 5 classes in mathematics. Among the 19 physics classes, she teaches seven theoretical physics classes in Grade IX and nine theoretical and three practical classes at Grade X. In her school there are three physics teachers, but she is the only one who teaches physics practical classes.

Participant-4: Fuad Chowdhury

Fuad Chowdhury is a 67 year old experienced Assistant teacher at TLP High School, which is a large non-government co-ed school situated outside Rajshahi city. In his school there are students from Grade VI to Grade X. Fuad has been teaching for 42 years and from the beginning he has been teaching physics. He has completed a BSc where his subjects were physics, chemistry and mathematics. He has also completed the BEd degree and has attended a few professional development workshops on teaching. He teaches 28 classes each week: seven classes in physics and the rest other subjects. For physics, he teaches three theoretical classes in Grade IX, and three theoretical classes and one practical class at Grade X. Sometimes, in one week, he teaches one practical class for girls only and in another week he teaches one practical class for the boys. He also teaches general and higher mathematics, and general science in other Grades.

Background of the participants

Table 1: Backgrounds of the participants

Pseudonym	Age	Gender	Academic qualification	Professional qualification	Teaching experience
Nilufar Rahman	37	Female	BSc (Subjects: physics, chemistry and mathematics)	<ul style="list-style-type: none"> ➤ BEd (Optional subjects: Chemistry and mathematics) ➤ CPD training in physics and mathematics 	11 years
Rakib Hasan	42	Male	MSc in geology and mining [In BSc (Honours) course, one of the subsidiary subjects was physics.]	<ul style="list-style-type: none"> ➤ MEd ➤ BEd(Optional subjects: mathematics and general science) ➤ TOT [He is a Master Trainer of physics] ➤ CPD training in physics 	13 years
Rawnak Sultana	45	Female	MSc in applied physics and electronics	<ul style="list-style-type: none"> ➤ MEd ➤ BEd ➤ TOT [Master Trainer of physics] ➤ CPD training in physics ➤ Training in structured questions 	19 years
Fuad Chowdhury	67	Male	BSc (Subjects: physics, chemistry and mathematics)	<ul style="list-style-type: none"> ➤ BEd ➤ Workshops on general teaching [not on any specific subject] for 1, 3, and 5 days 	42 years

The background of the participants indicates that there were both differences and some similarities among the participants. Two of the four participants have completed the MSc at the Rajshahi University, one in applied physics and electronics, and the other in geology and mining. Both of these participants are Master trainers of physics. The other two participants have completed their BSc with physics, chemistry and mathematics as optional subjects. One has completed a training course on physics teaching and the other has attended workshops on teaching, but he has not attended any training course dealing specifically with physics teaching. The participants' experience of teaching physics at secondary level varies from 11 years to 42 years.

School settings

In the two school settings situated in the city there are students from diverse communities. The students in the two other school settings outside the city are mostly from communities of comparatively lower economic status. Since two of the settings are government schools and the other two are non-government schools, there are variations in the adequacy of resources and other physical facilities among the school settings. The selected schools represent different categories of schools in the education system of Bangladesh. Like the majority of the schools in Bangladesh, three schools among the four start at 10 am and close at 4 pm. The other school setting starts at 7.30 am and closes at 12.45pm.

Like other schools in Bangladesh, each of the four schools has students in Grades IX and X grouped into several sections according to the number of students. In each section, there are students from Science, Arts and Business study groups and these students are

taught the common subjects that are compulsory for all students in that Grade. When they have classes in the subjects for their specific group, they move to the class specified for that group. For example, after completing a compulsory subject class, a science group may move to a science class. If the number of science students is large, then they are divided into two or three sections and are taught science in two or three separate classrooms. These groups are formed at the beginning of the academic year.

For example, in BMC Govt. Girls' School, there are three sections in Grade X for Science and Arts groups and no students in the Business study group. When there is a physics class, science students are divided into three sections and they are taught in three classrooms, and at the same time the students in the Arts group have their class in a specific Arts subject, such as General History.

Table 2 shows the variation in the types of school settings. There were two girls' schools, a boys' school, and a co-education school. Two of the schools were government schools and two non-government schools. There were both similarities and differences in the school sizes, the class sizes, and also in the teacher-student ratios. For example, KSB Girls' High School is a non-government secondary school where there were only 350 students in total, 7 science students in Grade X and the number of teachers was 14, where as in BMC Govt. Girls' School there were 1400 students, 166 science students in Grade X and 26 teachers.

Table 2: Descriptions of school settings

Pseudonym of school	Type of school	Total no. of students in school	Total no. of students in Grade X	Total no. of sections in Grade X	Total no. of science sections in Grade X	Total no. of science students in Grade X	Total no. of teachers
KSB Girls' High School	Girls' school, [From Grade VI to Grade X]	350	41= 7 (Science) + 34 (Arts)	1	1	7	14
CT Govt. Boys' School	Boys' school [From Grade III to Grade X]	852	109= 102 (Science) + 7 (Business Studies)	2	2	102 A: 54 B: 48	27
BMC Govt. Girls' School	Girls' school [From Grade III to Grade X]	1400	224= 166 (Science) + 58 (Arts)	3	3	166 A: 49 B: 50 C: 67	26
TLP High School	Co-ed (From Grade VI to Grade X)	1400	270 = 70 (Science) + 150 (Arts)+ 50 (Business Studies)	3	1	70 Girls: 27 Boys: 43	24

Table 3 presents information about the classes taught by the participants in this study.

Table 3: Classes taught by the participants

Participant (Pseudonym)	Total no. of classes per week	Total no. of physics classes in Grade IX		Total no. of physics classes in Grade X		Total no. of classes on other subjects	Class duration
		Theoretical classes	Practical classes	Theoretical classes	Practical classes		
Nilufar Rahman	26	3	No	3	1	19	40-50 minutes
Rakib Hasan	26	3	No	2	3 [one day for each section]	18	
Rawnak Sultana	24	7	No	9 3 days for each section	3 [one day for each section]	5	
Fuad Chowdhury	28	3	No	3	1	21	

This table shows that each week all participants teach 24- 28 classes, each of which lasts for 40 to 50 minutes. Along with teaching physics, all participants teach mathematics in Grades IX and X. Some also teach general science in other Grades and some teach higher mathematics and chemistry in Grades IX and X.

Rigour and trustworthiness

According to Golafshani (2003), cited in Kakai (2010), rigour and trustworthiness refer to the reliability and validity of a qualitative study, where rigour involves the concept of subjectivity, reflexivity and social interactions, while trustworthiness, according to Bell and Cowie (1996), cited in (Kakai, 2010), shows whether the study can be trusted to be

accurate. In their study, Harrison, MacGibbon, and Morton (2001) mention the interrelatedness of rigour and trustworthiness and state that trustworthiness is the process of meeting the validity, credibility, and believability of a study, as assessed by academic peers, community, and participants. Asking participants to check fieldnotes and early analyses of a study can ensure trustworthiness of a study (Harrison et al., 2001).

If the rigour and trustworthiness of a study are not ensured, then the validity and reliability of the study will be questionable. If a study becomes questionable, the work undertaken to conduct the study seems to be worthless and the aim of the study will also be unsuccessful. Hence, researchers need to ensure the rigour and trustworthiness of a study.

To maintain rigour and trustworthiness, I designed the study carefully. During the three months of data collection I observed the participants' classroom teaching and laboratory activities five times, interviewed the participants two times (in three out of four cases), and used the secondary physics curriculum, syllabus handbooks, written lesson plans, and textbooks to supplement collected data. The checking of fieldnotes and transcribed interview conversations for accuracy, and the triangulation of data sources, all proved the rigour and trustworthiness of my study. To avoid bias, as Lingbiao and Watkins (2001) have recommended, I asked the participants to elaborately and honestly respond to the questions, and I paid attention to building a relationship of trust between the participants and myself in order to encourage them to respond freely. While conducting the study, I maintained honesty during the whole process and no coercive power was exercised over the participants. I endeavoured not to be biased and tried not to influence how the

participants responded. These and the triangulation of data sources (i.e. interview responses and classroom observations) contributed to the trustworthiness of my study.

Ethical issues

In research, ethical matters are the principles of right and wrong, accepted by a particular group at a particular time (Bogdan & Biklen, 2007). According to Cassell and Jacobs (1987), cited in Glesne and Peshkin (1993), ethical codes represent desire and efforts to show respect to others' rights, execute responsibilities, avoid harm, and supplement benefits to the subjects. Punch (1986), cited in Glesne and Peshkin (1993) states that ethical codes deal with 'individual rights to dignity, privacy, confidentiality and avoidance of harm (p.39)'. In my study, two ethical guidelines were followed:

- 1) Participants enter the study voluntarily, knowing the nature of the study, and possible dangers and obligations involved in the study, and
- 2) Participants are not exposed to any risk, which is greater than the gain they might derive (Bogdan & Biklen, 2007).

If the ethical issues are not maintained while doing a study, the study will be questionable and the subjects of the study may face risks or their rights may be dishonoured. Since ethical issues are the responsibilities of the researchers to the public, the discipline, sponsors, researchers' own government and the host governments (Glesne & Peshkin, 1993), researchers need to take care to follow ethical guidelines.

Before embarking on this study, I sought the ethical approval of the Educational Research Human Ethics Committee (ERHEC) of the University of Canterbury. As the participants in the study were in Bangladesh, I also sought ethical approval from the Director General (DG) of the Directorate of Secondary and Higher Education (DSHE) in Bangladesh. I then sought and obtained the written informed consent from the Head teachers of each school and the teachers who were to be participants in my study. I assured all participants that there would be no probable risks to them for being participants of my study, and they would be free to withdraw from the study at any time without penalty. I also assured them that their names would not be used without their permission and if they wished, complete anonymity would be guaranteed. This would be achieved by the use of pseudonyms within the write up of the study and in any future publications that may arise from it. Confidentiality of all records of the participants and settings were maintained by not giving any description that might identify them. I conducted classroom observations and conducted interviews at times suitable for the participants. I was also respectful of their culture. Since the participants and settings of my study were in Bangladesh, it was not difficult to maintain awareness of ethical issues, because as a Bangladeshi, I am very familiar with the culture of the country.

Data analysis procedures

Data analysis

Data was analysed in the three months following collection. While observing classes in action, I prepared short fieldnotes to help me write descriptions of the classroom

environment and the classroom activities of both the teacher and students. I also transcribed the audio-recorded interviews.

Transcribing

Since the interviews were done in Bangla, I transcribed the data collected from the seven audio-taped interviews in Bangla. While transcribing the data, I found some mismatches between the information given by the participants and my fieldnotes of observations. To resolve these issues I communicated with the participants by telephone and e-mail and made the necessary corrections. After preparing the transcripts, I sent them to the participants for checking for accuracy, as Lingbiao and Watkins (2001) did in their study. Any corrections to the transcripts were then made and the corrected transcripts were sent again to the participants for checking.

The Bangla transcripts were translated into English, and checked by a peer who can fluently speak, read and write both the Bangla and the English languages. I then started the analysis of the data collected from the interview transcripts, from the fieldnotes of the observations of the participants, and also from the collected documents.

Generating themes from data

In order to generate themes, I repeatedly read the interview transcripts, the fieldnotes of the observations, the secondary physics curriculum, the syllabus handbooks for Grades IX and X prepared by one school and the lesson plans for teaching prepared by one participant. Like Bryan (2003), I triangulated these data sources in order to code the data, which were categorised on the basis of emergent ideas and themes. From each category, more than one subtheme emerged and I gave each subtheme a title. After repeatedly reading all the subthemes, main themes that showed the findings of my study began to

emerge. Thus, this extensive and in-depth analysis of data disclosed teachers' perspectives on the role of practical work in teaching and learning physics.

At first, I composed all the interview transcripts and all the fieldnotes of observations in four Microsoft word files named for the pseudonyms of the four participants. Then, I cut the interview transcripts from these four files and pasted them into a new file, named 'Interview transcripts'.

From this new file, I copied the basic information about the participants and then pasted the descriptions of all participants and all school settings in a file, from which I prepared three tables: one for the participants' backgrounds, one for the descriptions of the school settings; and another one for the descriptions of the classes taught by the participants.

Next, I copied and pasted the responses of each participant to each interview question in a new file; and named it according to the emerging themes, for example, "Teachers valued practical work in teaching and learning physics".

I used the same process for analysing all of the interview questions. Sometimes there were several themes emerging from the responses to some questions. Using this process for analysing the responses to nine interview questions, I derived files with five main themes; and under each main theme, there were several subthemes. Similarly, from the fieldnotes, I prepared files which were saved by name according to each emerging theme. From the hard copies of these files, I grouped the similar themes by highlighting each theme with one colour and then I copied and pasted the quotes under similar themes in a new file. I used one separate colour in each file, where there were different quotes under a similar theme. This resulted in five files, which were named by the emerging main

themes. For example, the first file was named “Teachers’ perceptions of the relationship between practical work and developing conceptual knowledge of physics”.

Chapter Four: Findings

Through the interviews with the participants I investigated the four physics teachers' perceptions of the relationship between practical work and developing conceptual knowledge of physics in teaching and learning physics at secondary level in Bangladesh. Through the observations, I identified their actual teaching practice in both the theoretical and the practical classes. I found some matches, and sometimes some mismatches between what the participants said they do and what they actually do in their teaching. This chapter outlines the views of the four participating physics teachers about the role of practical work in developing conceptual knowledge of physics and also my views from the observations of their teaching and students' learning.

The findings will be presented as main themes with subthemes under each main theme.

Emerging Themes

The data were grouped into five emerging main themes under which there were several subthemes. The main themes are: (1) Teachers' perceptions of the relationship between practical work and developing conceptual knowledge of physics; (2) Teaching methods; (3) Factors hindering teaching and learning practical work; (4) Role of teachers' training on teaching practical work; and (5) Role of teachers' attitudes towards practical work.

The findings are presented with the quotations extracted from the participants' interview transcripts and also from my fieldnotes of the observations of their teaching. For example, the notation 'Nilufar' is used following a direct quote from Nilufar's interview transcripts.

1) Teachers' perceptions of the relationship between practical work and developing conceptual knowledge of physics

The participants were interviewed about the role of practical activities in teaching and learning physics and also the purposes of teaching and learning physics at secondary level in Bangladesh. This theme is divided into four subthemes that emerged from the participants' responses and from my fieldnotes of observations of their teaching.

a) Teachers valued practical work in teaching and learning physics

According to all of the participants, practical work plays a very important role in the teaching and learning of physics at secondary level in Bangladesh schools. The participants thought that after being taught theoretically any conceptual knowledge, students should be provided with related practical activities to reinforce the ideas.

Fuad, a physics teacher for 42 years, indicated that students are not able to achieve a clear understanding of physics concepts without doing practical activities. He said:

I think that in teaching physics, the importance of practical activities is enough, because until I practically show students, or let them practically do those activities, they will not be able to get a clear conception of the contents. When I theoretically teach them, just after that I should teach the related practical work. (Fuad)

He believed that theoretical learning supported by practical work allows students to better utilise their knowledge in the future. He continued:

It makes learning effective, and very effective. When students achieve knowledge through practical work, I hope that they can utilise that knowledge; and that knowledge will be useful for their real life. (Fuad)

Rawnak, with the experience of 19 years physics teaching and Nilufar, with 11 years physics teaching, both expressed the view that the knowledge achieved using practical work becomes stable because students can do it and observe it by themselves. Rawnak stated:

It (practical work) has a very important role in teaching and learning physics. [...]The reason is that they (students) can practically observe what happens; they can do it on their own. That is why the learning becomes more stable. (Rawnak)

Nilufar stated:

It makes learning effective. When they (students) do practical work, the unclear concept that they had, becomes clearer to them, because they are doing it themselves. Since they are observing things to happen, it becomes easier to remember. The knowledge they get by doing practical work, becomes stable for a longer time in their memory. Moreover, students more easily understand the concepts. (Nilufar)

Rawnak further clarified her thoughts about the usefulness of practical work.

We mostly need the practical work. I believe that if I could teach my classes in the laboratory, it would be the best, because I could teach them the theories and concepts using the practical instruments. Then my teaching would be more fruitful. When I would explain the content, I could practically show that. They would have clearer understanding. (Rawnak)

With 13 years experience of physics teaching, Rakib echoed that students' knowledge of physics becomes more stable when achieved with practical knowledge. Like Fuad, Rakib also thought that his students gain clear physics concepts when he uses practical work. Rakib asserted that if students are not provided with the practical elements of physics learning, their knowledge will remain incomplete. He commented:

Actually, knowledge is not completed without the practical knowledge. If practical knowledge of physics can be provided with the students, then their knowledge of physics concepts becomes more stable. If I use practical work, students get clear conception of that knowledge. [...] Practical knowledge makes the theoretical knowledge more effective. (Rakib)

The participants in this study thought that practical work is very valuable, because students can observe what happens, they gain greater conceptual understanding and they can utilise their knowledge in real life.

b) Purposes of teaching and learning physics

The comments from the participants given during their interviews indicate that they considered there were a variety of purposes for teaching and learning physics at secondary level. For example, as one teacher said:

By teaching and learning physics at secondary level, I understand that students will know some theories, and they will also do some hands-on activities/practical activities so that they will be able to do different experiments. [...] They will become interested in doing different experiments, and also become confident to do practical work, because from the confidence of doing small experiment, the confidence of doing big thing will be developed among them. (Nilufar)

This teacher thought that practical work serves to promote confidence in students through experience and also to grow interest in learning physics concepts among them.

Another participant indicated how knowledge of physics contributes to advancing technology. He considered that the purpose of teaching and learning physics is to teach both theoretical and practical knowledge so that students can utilise the acquired knowledge in their everyday lives. He explained:

Without the development of science and technology, the overall development of a country is not possible. The knowledge of technology is closely related to physics. In physics of [Grades] IX and X, there are discussions on theories along with some knowledge related to real life. For example, in the case of measurement, firstly, I provide students with the theoretical knowledge related to our real lives, and then I provide them with the practical knowledge so that they can utilise it in their real lives. (Rakib)

Learning specific content and practical skills was also given as a main purpose of teaching and learning physics, as indicated by the following two participants.

We are provided with a theory related textbook for physics. My teaching is based on that textbook. I provide the content knowledge of physics. By teaching [...], I mean to teach them the content knowledge of physics using the selected textbook for the students of Grades IX and X. (Rawnak)

By teaching physics at secondary level, I understand that we have to provide students with such theoretical as well as practical knowledge, which will be helpful for them to study physics at higher secondary and tertiary levels, where the syllabi are broader. [...] I understand that to theoretically, practically, and through demonstration method provide students with the content knowledge of physics so that at higher levels, they will be able to utilise that knowledge. (Fuad)

The participating teachers believed that they should provide their students with the theoretical and the practical knowledge of physics that will develop confidence and grow interest among them (students) through helping them to learn specific content and practical skills. Teachers also believed that the knowledge and skills can be utilised in the students' everyday lives and will be useful for higher studies.

c) Practical work makes teaching and learning physics easier.

All four participants of my study held the view that practical work makes their teaching and students' learning easier.

According to Nilufar, teaching using practical activities is easier than teaching only using lectures, because the lecture method is time consuming regarding assisting students to understand the physics concepts. She added that when she uses practical work in her classroom teaching, students easily understand the content. She said:

When I teach practical class, I can easily teach them. It is easier than theoretical teaching. When I orally teach a topic, it takes time to assist them to understand. But if I teach them with practical work, they easily understand. I understand that practical work makes my teaching easier. (Nilufar)

Rakib also emphasised that practical work makes his teaching as well as students' learning easier. He asserted:

Definitely practical work makes my teaching easier; and it helps my teaching and makes learning easier. (Rakib)

To clarify, he said that he can properly teach his students the concepts of physics if he uses practical work.

This view was further affirmed by Rawnak when she mentioned that teachers should teach all physics classes using practical activities. She pointed out:

Certainly, certainly, practical work certainly makes my teaching easier. That's why I think that all physics classes should be practically oriented. (Rawnak)

Giving an example of physics content, Fuad expressed the view that if teachers do not use any practical activity and teach using only the lecture method, they will face difficulty.

He commented:

I think that it is difficult to help them understand only by delivering lecture. Suppose, I orally told them that a magnet always faces along the north and south poles of the earth, but I did not practically show them. If I could show them with a magnet hanging by a thread, they could practically watch that it really faces along the north and south poles. (Fuad)

Like the three other participants, Fuad also had the belief that practical work helps students to learn more easily, and makes teaching easier.

According to all four participants, when they teach without any practical work it takes longer to help students understand the concepts of physics and when they teach using practical work, they find that students more easily understand. Moreover, they thought that students can properly achieve the knowledge of physics when they are taught through doing practical work. They also thought that it is difficult to help students understand the content of physics only through delivering lectures.

d) Practical work makes learning interesting and effective.

All four participants believed that if a theoretical knowledge of physics is provided along with some practical activities, students become more interested in their learning. They stated that from their experience when students are more interested in their learning, they are more likely to be more effective learners.

During his classroom teaching Rakib found that when he teaches using practical work his students' learning becomes effective because they are interested in learning the concepts

and theories of physics and that is why they pay proper attention to the class and actively participate. He highlighted:

Practical knowledge makes the theoretical knowledge more effective. When I provide them with any practical activity, I find that their interest in study increases. They become more attentive. Their knowledge becomes more stable [.....] and their participation also increases. They become more interested in achieving the knowledge. (Rakib)

Rakib added that when he brings any apparatus into the class, students' interest increases.

Nilufar also had the view similar to Rakib's, that students are very interested in doing practical work, which makes their learning effective. Mentioning an example of equipment related to physics content, she clarified how students get clear conceptual knowledge of how a device works when they observe it. She said:

They are very much interested in doing practical work. If it is possible to practically show them, then the learning becomes more effective. In today's class, if I could show them the electroscope; and explain its structure and how it works, they could have clearer understanding of the device. (Nilufar)

Rawnak found that her students feel an attraction to the lesson and do the practical work in a pleasant way when she teaches physics concepts and theories supported with practical activities.

In her explanation, she commented:

[.....] students become very glad when they work in the laboratory rather than attending the theoretical class. (Rawnak)

Fuad echoed the views of Rakib and Nilufar that practical work increases interest among students and makes learning effective. In his physics class, he found that students were less interested in learning physics content when there is no practical activity. He emphasised:

Students become interested when I teach practical class; and they love to learn physics. If I teach classes without any practical activity, they are less interested. (Fuad)

During the observations I also found that students were more attentive when they were provided with practical work. The following extract from my fieldnotes records this.

I found that all students were very much interested in doing practical work, which I did not find during theoretical classes. Some students were attentive to the theoretical classes, but they did not seem to be interested. (From the fieldnotes of the fourth observation in setting 2)

During the observations of practical classes I also found that after having practical experience, students achieved a clearer understanding:.

I asked each group to tell me what the vernier constant is. Only one group correctly answered my question. When I explained it, I found that they very easily understood it. When I again asked them, all gave me the correct answer. I understood that they had a theoretical idea, but they were practically doing it for the first time. I believe that if they can have regular practice, they will have effective learning. (From the fieldnotes of the fifth observation in setting 3)

All four respondents were confident that practical work is helpful for increasing students' interest in learning physics theories and concepts and, accordingly, for making their learning effective. During my observations I found that when students are provided with practical activities, they become more interested in their learning and their learning

becomes more effective. I also found that they were much more attentive and active in a practical class compared with a theoretical class.

In summary, all four participants held the view that there is an essential relationship between practical work and developing a conceptual knowledge of physics, because practical work can better help their teaching and students' learning of the theories and concepts of physics at secondary level. As well, my observations also found that practical work makes students interested in learning physics concepts; and therefore, their learning becomes more effective.

2) Teaching methods

Participating teachers were asked to respond to questions about their preparation for teaching and also about the methods they use to teach physics concepts at secondary level. From their answers and also from my fieldnotes about their teaching, two subthemes emerged.

a) Lesson planning

As all four participating teachers had to take many classes each day, it was difficult for them to prepare written lesson plans for each class. When I asked the participants about preparing written lesson plans for their teaching, two of them (Rakib and Fuad) told me that they usually did not prepare written lesson plans, but two others (Nilufar and Rawnak) told me that they usually prepared written plans.

While conducting the five observations of the teaching of Nilufar, I found that she regularly prepared written plans for her lessons.

Although some of the participating teachers did not prepare written lesson plans, all asserted that teachers should regularly prepare these. For example, Fuad said:

For teaching well, teachers should have a clear conception of that subject. They should have preparation for the class. (Fuad)

Rawnak stated during an interview that she regularly prepared written lesson plans and carried out preparation in the evenings for her classes the next day.

[...] last night I studied the topic of my lecture for today's class, although I have been teaching this for 19 years. (Rawnak)

She believed that if teachers regularly study the subject they teach they will have expert knowledge of that subject which will be helpful for good teaching. She emphasised:

I would say that he/she is a good teacher who does his/her study every day. I believe that he/she will be a good teacher if he/she will regularly study to have expert knowledge on the subject, which I have been doing for 19 years of my service time. (Rawnak)

Moreover, she thought that studying the physics books for higher levels along with the book for secondary level can help teachers teach effectively. She continued:

There are the books of higher secondary physics on my table, which I regularly study. In the textbooks selected for Grades IX and X, the contents are not given in detail. After reading the books for higher secondary physics, I can provide my students with clearer concepts of those contents. (Rawnak)

Although Rawnak stated that she regularly prepared written lesson plans for her classes, I did not observe her using such lesson plans with her classes. However, from her

confident teaching and clear explanation of the theories and concepts of physics, it was easy to believe that she carried out regular preparation for every class. When she asked students questions on the lesson, I realised from their responses that most of the students appeared to have a good understanding of the lesson.

Similarly, Nilufar believed that teachers need to do their study properly in order to teach their students well.

Although Rakib and Fuad stated that they did not prepare any written lesson plans for their teaching, they stated that they regularly prepared themselves for their lessons by studying the content from the textbook of physics they would teach from the next day.

All four participants thought that teachers must study the subject regularly to have expert knowledge of it and that this study is essential for teaching students well. Two participants stated that they regularly prepared written lesson plans but only one of the four participants was observed to regularly do this. During interviews all of the participants stated that they regularly studied for their teaching.

b) Approaches used in physics teaching

Lectures as a source for content

Teachers used different methods to assist their students to understand the physics content.

All four participants emphasised that the lecture method by itself is not enough for providing the content knowledge of physics. Rakib asserted:

I don't think that students will completely achieve the knowledge through lecture method only. (Rakib)

Pointing out the disadvantages of the lecture method, Nilufar stated:

Sometimes, during the lecture, they lose their attention, talk among themselves, or after listening a while, they do not pay further attention to my lecture. (Nilufar)

Providing real life examples in teaching physics concepts

All participating teachers stated that they taught physics content using real life examples so that students can easily achieve a conceptual knowledge of physics. They believed that since physics is the science of nature the contents of physics are related to real life.

While observing classroom teaching I saw all four participants teaching physics using relevant examples from daily life. They did this to provide students with a clear understanding of content for which there were no practical experiments in the syllabus. I noted in my research diary:

She (Rawnak) uses examples of daily life, which makes learning interesting to the students and this strategy makes learning easy to them. (From my research diary)

During an observation of classroom teaching of Rawnak, I found that she asked her students to give examples of heat transfer through the process of conduction. After students gave some examples, she gave another.

Teachers' use of questions

During their interviews, all the participants articulated that they frequently used the question-answer method in their classroom teaching. They stated that at first they

explained concepts to their students and then they asked the students to solve problems.

One participant (Rawnak) explained the lesson through asking questions.

Nilufar stated that sometimes she asked the students to solve mathematical or theoretical problems in written form. She also asked short-answer theoretical questions to elicit oral answers.

Rakib also mentioned:

After teaching the content or theory, I ask them to solve some mathematical problems related to that theory. I provide them with some problem solving activities on the theories, which develop their knowledge. But, in teaching most of the chapters, I use question-answer method after explaining the contents. (Rakib)

Rawnak clarified her comments with an example. After explaining a law she asked her students to write down the law and its explanation. She added that sometimes she asked them to solve mathematical problems.

During the observations of classroom teaching I found that all four participants used the question-answer method to teach the concepts and theories of physics. Usually, when delivering a mini-lecture on a topic, they explained the concepts or the theories and then they asked students questions on that topic. They sometimes asked students to answer orally, to write down the answers in their exercise book, to complete a table, or to solve mathematical problems. For example:

Then he drew a chart on the board, and asked students to fill the blank column with appropriate answers. (From the fieldnotes of the first observation in setting 2)

While explaining concepts of physics, some teachers asked questions to set up the active participations of the students. For example, Rawnak explained the concept 'Refreezing' by asking students several questions.

Frequency of group work

All the participants stated that they did not regularly provide students with group work in their classroom teaching. They would occasionally ask students to complete activities in groups. As one participant affirmed:

If I realise that students would not be able to individually solve an activity within the 45 minute class, then I ask them to solve the problem in groups. That time, I divide them into several groups; and ask them to solve it. [...] It depends on the task whether I will ask them to do individual work or group work. (Rawnak)

During the observations, I also found that the teachers usually did not ask students to do any group work. During only one classroom observation did a teacher (Fuad) provide students with group work. The following extract from my fieldnotes indicates this.

Afterwards, the teacher divided the boys into two groups, and the girls into two groups. There were 7 students in each group. Teacher then started to ask questions [...] His first question was "What is hybrid magnet? He asked students to discuss among themselves, and then to answer. (From the fieldnotes of the first observation in setting 4)

Although this teacher provided students with group work, I realised from the class activities that he did this infrequently.

Demonstration in classroom teaching

During the interviews, all four participants stated that they only occasionally used special teaching aids available in their schools for teaching physics content. Nilufar acknowledged that she taught physics mainly by the lecture method and only sometimes used teaching aids.

Two participants (Rakib and Fuad) stated that they sometimes used teaching aids in their classroom teaching. Rakib stated that he brought easily moved equipment to his class to teach physics concepts. Fuad also mentioned that he taught the theoretical class with related instruments.

Rakib stated that depending on the type of content, he sometimes used demonstrations to assist students to understand the contents of physics. He commented:

There are different types of content in different chapters. Different methods are suitable for (teaching) different chapters. If I need to use demonstration method to teach one chapter, then I take relevant equipment with me and teach using those equipment (Rakib).

He added that students can gain a good understanding of knowledge through demonstrations. He said:

Suppose, in today's class, after I had delivered a mini lecture on 'the electroscope', and students observed what actually happens. They themselves explored whether the distance between the two leaves of the electroscope increased or decreased. (Rakib)

Rawnak stated that although she did not use any equipment for demonstrations, she used the board to explain the theories of physics. She believed that explaining the concepts by using the board is one type of demonstrations. She stressed:

Not only the lecture method, I also use the demonstration method. I use the board and explain the theories and concepts through the demonstration method.
(Rawnak)

However, during observation of their classroom teaching, I found that although all participants regularly used general teaching aids such as text books, board, chalk or marker pen, three of them very infrequently used special teaching aids particularly related to physics. During the three classroom teaching observations for each participant, I found these three participants only once using special teaching aids. The following extracts from my fieldnotes point towards this.

After completing their reading, Nilufar hung a poster on a hook set beside the blackboard. On the poster, there was a figure of a gold-leaf electroscope, drawn by her. The names of some parts of the electroscope were written, but not of all the parts. (From the fieldnotes of the first observation in setting 1)

He (Rakib) used a poster paper where there was a figure of a gold-leaf electroscope. He had also brought a real electroscope, a silk cloth, and a pen. He was describing the structure of the device by introducing the students with the different parts of the electroscope labelled in the figure. (From the fieldnotes of the first observation in setting 2)

Then with two bar magnets, teacher started to say and show that the similar poles of two magnets repulse each other, and the opposite poles attract each other.
(From the fieldnotes of the second observation in setting 4)

But, these three participants did not often use any special teaching aids. For example:

He (Rakib) did not draw any figure, or did not use any teaching aid.He explained the Coulomb's law using mathematical calculations on the board.
(From the fieldnotes of the second observation of setting 2)

During the three observations of Rawnak's classroom teaching, I never observed her using any special teaching aids to assist students to understand the concepts of physics. She always used the board for her teaching.

During interviews, all of the participating teachers stated that they mostly used only the board for teaching the content of physics. This was supported by my observations. I noticed that they drew figures and solved mathematical problems on the board in order to explain the lesson. Examples from my observation notes are provided below.

He drew a figure of a simple electric cell, and started to explain how it is used to produce electric current. He was explaining using the chemical equation $\text{H}_2\text{SO}_4 = 2\text{H}^+ + \text{SO}_4^-$. (From the fieldnotes of the third observation in setting 2)

Then teacher drew a figure of a bar magnet and started to explain 'the magnetic field'. (From the fieldnotes of the first observation in setting 4)

Moreover, two participants (Rawnak and Rakib) regularly asked their students to solve mathematical problems or to draw a figure related to the lesson on the board. The following extracts from my fieldnotes reflect this.

Then teacher started to discuss about the parallel connection. She asked, "Who will come to draw a circuit with resistances connected in parallel?" One student came, and drew a figure of resistances connected in parallel. But she did not draw a full closed circuit. Then the teacher asked for another student to draw a full circuit. Another student came and drew a full circuit where there were three resistances connected in parallel. (From the fieldnotes of the first observation in setting 3)

Then he asked one student to come to the board, and asked him to solve a mathematical problem. That student easily solved it. (From the fieldnotes of the second observation in setting 2)

Although it happened infrequently, Nilufar sometimes asked students to solve a mathematical problem on the board. The extract from my fieldnotes refers to this.

Nilufar asked the students one after another to come near the poster and to tell the names of all the parts. Some students had correctly answered, but some couldn't have answered. This task was given after the reading they had just done. (From the fieldnotes of the first observation in setting 1)

However, Fuad did not ask students to solve any problems or to do any tasks on the board. He only asked students either to answer orally or to write an answer in their exercise book. Before asking them questions he often asked them to read aloud sections from the text book. During his class students did not appear to be interested in learning the concepts of physics.

Demonstration of practical experiment

All participants mentioned during their interviews that they regularly did demonstrations before starting any practical experiment in the practical class. For example, two participants stated:

At first, I teach a demonstration class on an experiment, and then I ask them to prepare a rough exercise book. In a subjective class, I demonstrate to them how to use the apparatus. (Rawnak)

Before teaching a practical class, I provide students with an overall idea about the experiment in the theoretical class. I show them how to do the experiment, and help them understand. Then I let them do that experiment. (Rakib)

When I asked Nilufar whether in the demonstration class she showed her students how to do an experiment she replied that instead of demonstrating the whole experiment she demonstrated some parts of it at the beginning of the practical class.

However, from the observations of practical classes of all four participants I discovered that among them only two (Rawnak and Rakib) regularly taught separate demonstration classes for the experiments and then asked their students to replicate the experiments on their own in practical classes. Two others did not teach any separate demonstration class; they did demonstrations in the practical class before students started an experiment.

An interesting finding from my observations of practical classes was that most of the students of Rawnak and Rakib were confident in doing the experiments. The extract from my fieldnotes indicates this.

All groups of students themselves were doing the experiments. [...] Since most students had attended the demonstration class on this experiment, they were confidently doing the experiment. [...] They completed their experiment in time. (From the fieldnotes of the second observation in setting 3)

I also watched Rakib demonstrate how to use equipment during a practical class before asking students to start the experiment. However, sometimes, some students were doing activities related to the experiment before their teacher (Rakib) demonstrated them. For example:

Before teacher (Rakib) had showed them how to measure the instrumental error of the slide callipers, one group had already measured it. From this type of activities, I can recognise their regularity and attentiveness about their study. (From the fieldnotes of the fourth observation in setting 2)

Most groups had taken the reading of linear scale, and only two groups had additionally taken the reading of the circular scale. (From the fieldnotes of the fifth observation in setting 2)

From observations of the practical classes of two other participants (Nilufar and Fuad) I found that they did not regularly demonstrate practical work before doing experiments in

the practical class; they usually did this in the practical class. Nilufar herself admitted during an interview that she demonstrated during the practical class when students did any experiment. I also found during observations that both Nilufar and Fuad firstly demonstrated how to use the equipment and how to do an experiment and then asked their students to do the experiment on their own.

Practical activities in classroom teaching

Although all of the participants thought that practical work plays a very important role in teaching and learning physics, all of them usually did not provide students with any practical activity in their classroom teaching.

During the interviews they said that they provided students with practical activities only in the practical classes in Grade X and they only did the practical experiments included in the syllabus. For example, Rawnak stated that her theoretical classes covered only theories and that she provided students with practical activities only during the practical classes. Similarly, Nilufar stated that most of the time, she taught physics mainly by the lecture method, sometimes using teaching aids and sometimes not using teaching aids.

Rawnak mentioned that, very infrequently, she provided students with an extra assignment so that they might feel more interested in their study. She affirmed:

In the theoretical class, I ask them to prepare a small electric circuit, where some inputs are given, and they are asked to find out the output. It is just like as students usually do in a science fair. I ask them to do this type of task, which is out of activities of the practical class. (Rawnak)

Fuad told me that he sometimes provided students with practical activities while teaching the content related to a practical experiment.

The topic on which there are practical experiments included into the board syllabus, I teach those topics using practical activities and ask them to do those activities so that they can achieve a complete knowledge of those topics. (Fuad)

During observations, I also found that Nilufar and Rawnak did not provide students with any practical activities. The following statements from my observations indicate this.

There was no practical work for them. [...]I was thinking that if the teacher had explained how the electroscope works using a real electroscope, students could have gained better understanding and a clearer conception of it. I believe that then, all the students would have been able to correctly answer the question. (From the fieldnotes of the first observation in setting 1)

She told the students, “If we could practically do the experiment using instruments, we could understand that it really happens. Since it is not possible, we have to imagine.” (From the fieldnotes of the third observation in setting 1)

The teachers did not use any practical activities, but they repeatedly and very elaborately explained the theoretical concepts of physics in order to help the students understand the concepts. For example:

The teacher again started to explain the whole lesson in the best possible theoretical way-it seemed to me. She was trying her best to provide her students with a clear conception of the lesson. [...] she was asking them some questions. If they could not answer correctly, she was again explaining to help them understand. (From the fieldnotes of the third observation in setting 1)

While teaching content related to the law of Archimedes, Rawnak drew figures on the whiteboard, and also presented the students with some real life examples in order to help them understand the concepts. She explained the whole phenomenon in a way that helped the students but she did not use any practical activities. Some but not all of the students appeared to understand the lesson. The extract from my fieldnotes specifies this.

Although it was a theoretical class, and there was no practical activity, I realised that some students got a good idea about the law of Archimedes, but not all students. All of them would definitely have a better understanding if some practical activities were done. (From the fieldnotes of the fourth observation in setting 3)

Very unusually, I found Fuad explaining the concept of attraction and repulsion between two magnets through practical work during his theoretical teaching.

Then the teacher gave some magnetic needles to the students. He brought a bar magnet near the magnetic needles, and showed them that both magnets were attracting each other. (From the fieldnotes of the first observation in setting 4)

However, while teaching the topic of induced magnetism he did not use any practical activity, although he had access to real magnets in his classroom. From my observations of his classroom teaching I found that he usually did not provide students with practical activities.

Rakib used practical activities only once during the occasions on which I observed his lessons and this was when he used an electroscope to detect electric charge on an object.

In order to show how the device works, the teacher charged the pen by rubbing it with the silk cloth. [...]Then he brought the charged pen near the metal terminal of the device. He started to show them what happened. (From the fieldnotes of the first observation in setting 2)

The observations of Rakib's other classes indicated that he taught students physics content using only the lecture method and without doing any practical activities. After his teaching, he asked questions about the lesson and very few students could provide correct answers. From this observation, I realised that some students failed to understand the concepts.

Practical experiments taught at secondary level

Teachers stated that there were eleven practical experiments included in the secondary physics syllabus. Three of the four participants said that they usually taught nine or ten of the eleven experiments. The following statements of the participants specify this.

Students have some specific practical work in their syllabus. I teach some of those with whatever apparatus we have in our school. I can't teach all the experiments included in the syllabus, because we don't have enough instruments to do all experiments (Nilufar)

Actually, I teach at least nine experiments. Due to time limitation, I can't teach all the experiments. (Rakib)

However, only Fuad said that he tried to teach and let students do all the experiments included in the syllabus.

Although all participants stated that providing the content knowledge of physics using only the lecture method was not enough for helping students understand, they mostly used the lecture method during their classroom teaching. They also taught using a question-answer method where they regularly used the board to explain concepts.

Although all participants used the board for teaching physics content, only two regularly and one participant infrequently asked students to solve mathematical as well as theoretical problems on the board, whereas another participant never provided his students with any tasks to solve on the board. Three out of four participants did not provide any group work and one asked his students to answer questions while working in groups, but this was quite unusual. All four participants used examples related to physics

concepts from real life in order to help the students understand the concepts and theories of physics.

From all the observations made of the classroom teaching I found that two of the participants infrequently did practical demonstrations for teaching the concepts and theories of physics, while two others never did demonstrations. All participants were, however, aware that teaching the concepts and theories of physics through practical activities can ensure effective learning.

From all the observations of practical class teaching, I found that two teachers regularly taught separate demonstration classes for practical experiments while the other two demonstrated during experiments. Although all participants emphasised that practical work makes teaching and learning easier and more effective, three participants stated that they usually taught at least nine experiments, and only one said that he tried to teach all the eleven experiments as recommended in the physics syllabus.

3) Factors hindering teaching and learning practical work

This theme was developed from the participants' responses when they were asked to share their experience about the factors that hinder the teaching and learning of practical work both in practical classes and in theory classes, and from my observations of their teaching. There are eight subthemes.

a) Lack of sufficient equipment to do practical classes

Three participating teachers thought that practical classes were hampered by the lack of sufficient equipment. In the non-government school settings, there was less equipment

available for doing practical work than in the government school settings. As a result, the non-government school teachers faced comparatively more difficulties in teaching practical classes and their students also faced greater difficulties in learning.

Nilufar expressed her disappointment, “Even we don’t have all the instruments, so we can’t do all experiments included into the syllabus.” Although there was a limited amount of equipment, I observed that Nilufar was able to share it among small groups in practical classes, because there were few students in her class.

Although TLP High School is a non-government school, Fuad thought that there was sufficient equipment in his school. But from his experience, he mentioned that insufficient amount of equipment was the main problem in doing practical work in most of the non-government schools in Bangladesh. He pointed out:

Lack of sufficient instruments is the number one factor that hinders teachers to teach practical classes. This is the problem in many non-government schools. But, in our school, there are sufficient instruments. (Fuad)

Although, during the interview, he emphasised that there was sufficient equipment in his school, I observed that in his practical classes, he instructed students to work in a few groups with a large number of students. Consequently, all of the students did not get the opportunity to use the apparatus to take readings for the experiment. The extract from my fieldnotes reflects this.

Teacher (Fuad) divided the students into four groups: two girls’ and two boys’ groups. There were 8 students in each group. Then he provided each group with a bar magnet and a compass needle. (From the fieldnotes of the third observation in setting 4)

However, compared with the non-government schools, there was sufficient equipment in the government school settings. Rakib stated with satisfaction, “As our school is a government school, we have adequate amount of practical equipment and other physical advantages.”

During my observations in two government school settings (CT Boys’ School and BMC Govt. Girls’ School), I found that they had a specific laboratory furnished with practical equipment, which is reflected by the following extracts from my fieldnotes:

I was monitoring the laboratory. It was specifically for doing physics practical class. There was sufficient equipment. (From the fieldnotes of the second observation in setting 3)

This is a laboratory particularly for physics practical classes. [...] On the table near the door, there were few instruments, such as few balancing machines, glass jars, glass slabs, measuring glasses, and few boxes of slide callipers. Behind that table, there were six wardrobes, where most of the instruments were kept. (From the fieldnotes of the fourth observation in setting 2)

Although there was sufficient equipment in BMC Govt. Girls’ School compared to the non-government schools, during the observations of the practical classes, I found that Rawnak used to form a small number of groups each with a large number of students. The extract from my fieldnotes imitates this.

There were six students in three groups, and four students in two groups, and seven students in one group. [...] I was thinking that since there was sufficient equipment in the laboratory, there could be a small number of students in each group. (From the fieldnotes of the fifth observation in setting 3)

I came to know the reason for this during the second interview with her (Rawnak), where she told me that although there was sufficient equipment in the government schools, teachers faced difficulty in teaching practical classes because of the large number of

students. As a result, every student did not get an opportunity to do the experiment by taking the apparatus in their hands. Rawnak highlighted:

There is a factor that hinders me to properly teach the practical class, and that is the huge number of the students in one class. (Rawnak)

To further clarify, she continued:

According to the number of students, the number of the apparatus is not sufficient in the laboratory. As a result, I form five or six groups, and provide each group with one apparatus. If there was sufficient apparatus according to the number of the students, I would not have to ask them to do in groups; and each student could herself do the whole experiment, and could get more knowledge. (Rawnak)

However, CT Boys' School (setting 2) was an exception in this case. As there was sufficient equipment, even according to the number of students, the teacher (Rakib) did not face any problem in teaching practical classes. As well, the students did not seem to face any problems doing practical work.

In total, there were 12 groups of students. There were eleven groups each with three students, and only one group included four students. The teacher started to provide each group of students with one slide callipers and one rectangular object. Each student got the opportunity to measure the readings. [...]There was enough equipment in the laboratory. (From the fieldnotes of the fourth observation in setting 2)

Hence, although there were differences in availability of sufficient resources between the government and non-government schools, most of the participants of this study thought that the lack of sufficient equipment compared to the number of students was a major problem in doing practical work, which hampered their practical class teaching and also students' learning. They thought that if they could have enough equipment in their

school, every student would get the opportunity to do the experiment on their own, which could be helpful for developing their skills.

b) Lack of practical equipment for classroom teaching

Most of the participants thought that if they had more practical equipment, they would be able to relate the theory better to their students. For example, Rawnak thought that all the theoretical classes of all science subjects should be taught in the laboratory, where teachers can use the appropriate equipment for teaching the content. According to her, if she could teach both the theoretical and practical classes in the laboratory, and if there was sufficient equipment related to all the contents of physics, it would be easier for her to teach; and accordingly, students' learning would be more effective. The following statement indicates this:

For an example, today I taught them the lesson on series connection. If I could show them by making a real circuit: "See, there are the resistances, or the amount of voltage is [...] and [...] this much current is flowing through the conductor. Now calculate the equivalent resistance." Then they would acquire an effective learning, which would be more stable in their memory. [...]. Then it would be clearer. (Rawnak)

According to her, the equipment for teaching all the contents of physics was insufficient in her school.

Using the whiteboard, I demonstrate, because we don't have instruments to teach all the theories or concepts of physics. We only have those instruments, which are used to do the experiments included into the syllabus. (Rawnak)

Although there was sufficient equipment for doing practical experiments in his school (CT Govt. Boys' School), Rakib thought that the equipment was not sufficient for

teaching theoretical classes. According to him, if there was more equipment, all students in his class would get the opportunity to take the equipment in their hand and could have a closer look at how the equipment works. He pointed out:

In today's class, if there were more devices, all of them could have clearly observed. But, it is difficult to manage so many devices. Actually, we don't have. (Rakib)

That was why he stated that he faced problems in teaching and his students faced problems in learning physics concepts. I also noticed during one observation of his classroom teaching that he brought only one electroscope in order to describe its structure and to explain how it works.

He started to show them what happened. This time, the class became disrupting, because only the students of front rows were able to clearly watch what teacher was showing. (From the fieldnotes of the first observation in setting 2)

Nilufar also stated that there was no equipment in her school to teach the theoretical content of physics, except those that were used for doing practical experiments.

However, Fuad mentioned that there was sufficient equipment in his school; and he brought the related equipment into his classroom to teach the concepts and theories of physics. But, while observing his classroom teaching, I noticed that he used only the equipment that was related to an experiment included in the syllabus.

Therefore, from the interviews and observations of the classroom teaching, I realised that the teachers faced a problem of lack of sufficient equipment in properly teaching the content of physics.

c) Quality of equipment

During interviews, teachers (Nilufar and Fuad) of the two non-government school settings told me that they, as well as their students, faced problems in doing practical work because of the damaged equipment. In these schools, a lot of the practical equipment was faulty and measured with errors, which created problems for doing practical experiments properly.

[...]It is in such a condition that we can't use it. In the syllabus, there is an experiment to measure the volume of an irregularly shaped object using a balance and a measuring glass. We can't do this experiment because of the problem of the apparatus. (Nilufar)

There are some old instruments in the school, which students cannot properly use. When I start to explain their use to the students, they cannot properly find the lines on the instruments to take the readings. (Fuad)

When I asked the participants about the reasons for the equipment being damaged, Fuad replied that it was because they had been used for a long time.

Since teachers were aware of the value of practical work in teaching and learning physics, they wanted to have quality equipment in their schools for quality teaching in order to provide quality conceptual knowledge for their students. Both Nilufar and Fuad stated that accurate instruments should be provided to the schools; and damaged instruments should be replaced.

During the observation of practical classes in the first setting, I found that it was really difficult to take readings for the experiment because of the state of the instruments.

I saw that the test object, the wire was not good at all. It was not a straight wire. So, students were facing problems to set it in the screw gauge. They were also

facing problem in taking the readings, because the lines on the device were not clear enough. (From the fieldnotes of the fifth observation in setting 1)

Therefore, the teachers of the non-government schools faced the problem with damaged equipment. However, teachers (Rakib and Rawnak) of the government schools did not face any problem with damaged equipment, stated by them during interviews; and I also observed this during their practical classes.

d) The length of time for practical classes

In three out of the four school settings, the duration of practical classes was around 40-45 minutes, which, according to the three participating teachers, was short. One participant said:

The factor that mostly creates a problem is the limitation of time. It is not enough. If it would be one hour, or one hour and 20 minutes, it would be better. (Rakib)

While observing the practical classes (excluding in the third setting), it seemed difficult to complete an experiment within 40-45 minutes. Most of the practical classes that I observed lasted for around 45-60 minutes. Extract from my fieldnotes:

The bell rang. Student could not start to measure the width and the height of the test object. [...]Although the bell had rung, teacher (Rakib) asked them to measure the width and the height. He asked them to quickly do the rest of the work, because “We don’t have enough time”, he said. (From the fieldnotes of the fourth observation in setting 2)

Fuad commented during his interview: ‘Two hours time is needed to do one experiment.’”

During observations of his practical classes, I found that although he ended the class within the scheduled time length (40 minutes) for the practical class in that school,

students could not properly complete the experiment. Instead of taking three readings for each item, students were able to take only one reading. Extract from my fieldnotes:

With the readings of only one observation, all groups calculated the value of the area of cross section, because there was not enough time to take more readings, and then to calculate the mean. The bell rang, and teacher ended the class. (From the fieldnotes of the fifth observation in setting 4)

In the third school setting (BMC Govt. Girls' School), the duration of practical class was 50 minutes. As the teacher (Rawnak) regularly did demonstrations to teach the class before each practical experiment, both the practical classes that I observed, were completed within 50 minutes, the exact time length for the practical class in that school. Rawnak did not demonstrate any activities to her students while doing any experiments. Students did the whole experiment on their own, unless they faced difficulties. Extracts from my fieldnotes reflect this.

All groups of students themselves were doing the experiments. Teacher was monitoring. (From the fieldnotes of the second observation in setting 3)

During the experiment, one student from one group came to the teacher, and told her that they faced a problem. After gaining clarification, that student joined her group again. (From the fieldnotes of the second observation in setting 3)

e) Practical class as part of the weekly routine

In all four school settings, practical work was usually not taught in Grade IX, only in Grade X. During interviews, all participants told me that there was no practical class in Grade IX in their schools. For example, Nilufar stated:

Here what happens, in Grade IX, practical work is not provided. [...]Each week, I take one practical class in Grade X. (Nilufar)

Nilufar further illustrated:

Even when students are in Grade X, at the beginning of the year, first 2/3 months, practical class is not taught. After that, it is taught on a regular basis, once in a week. (Nilufar)

Fuad also stated that he taught the theoretical knowledge in Grade IX, and provided practical knowledge in X. He mentioned:

In secondary level in Grade IX, I provide them with the theoretical knowledge, and then in Grade X, I give them the practical knowledge. It helps perfect their knowledge. (Fuad)

However, he had also taught practical classes in Grade IX in year 2009, which was an exception. In Fuad's voice:

The students of Grade X had done three experiments from the syllabus of practical work when they were in Grade IX, because it was a special task arranged by the TQI-SEP, which was monitored by the Teacher trainers of the TTCs. [...]Before that, we did not teach practical class in Grade IX. (Fuad)

The number of practical classes in a week was different for different school settings, because the number of classes depends on the number of students. In two settings (CT Govt. Boys' school and BMC Govt. Girls' school), teachers taught three practical classes per week, while in two other settings (KSB Girls' High School and TLP High School), teachers taught only one practical class in a week. Since in the former two schools there were large number of students, teachers had to teach more physics classes than the teachers of the later two schools, because there were comparatively small number of

students in these two schools. However, in all the school settings, each week there was only one practical class for each student.

Although each student can attend only one practical class each week, two (Rakib and Fuad) of the participants thought that it was enough for teaching the small number of practical experiments. For example, Rakib asserted:

Since there are only eleven experiments in the syllabus, and we get more than twice the eleven practical classes, we can provide them with the proper practical knowledge about those eleven experiments. Sometimes, if necessary, I teach some extra classes to complete all experiments. (Rakib)

Sometimes, Fuad taught only one practical class for one group of students in two weeks. Therefore, one student got the opportunity to do practical work once in two weeks, which differed from three other school settings. Fuad frankly said:

For one week, the boys attend the practical class, and next week, the girls attend. For avoiding disruption, I arrange this. (Fuad)

However, like Rakib, Fuad thought that it did not create any problem, because, according to him:

[...]That is enough for completing all the experiment, because there are eleven experiments in the syllabus. [...]If it is needed, I take some extra classes for completing the syllabus. (Fuad)

The timing of practical classes was also different in different school settings, because the timetables of classes were prepared by each school. In the two government school settings, practical classes were set either at the second or at the third period. But, in two non-government school settings, practical classes were set at the end of the day.

Fuad stated that as in most of the schools in Bangladesh, practical class was taught at the end of the day in his school (TLP High School). Students did not feel interest in doing practical class, because after attending several classes, they became tired and hungry. Consequently, they could not pay full attention to the practical classes. He highlighted:

The practical classes are at the end of all classes according to the routine; it is taught in the afternoon. As a result, students say, “Sir, we became hungry and tired; we are no longer interested to continue the class. If this class could be taught earlier, it would be better.” (Fuad)

Sometimes, practical class was taught at a time when it was sport-time for some other Grades, which created problems doing practical work in one school setting. During one observation of practical class in KSB Girls’ High School, a cricket match was started in the field and almost at the same time one practical class started. Since the play-ground was at the centre of all the classrooms, the noise from the play-ground interrupted the practical class. Extract from my fieldnotes:

Since there was too much noise of shouting and clapping in the field, it was difficult for the students and the teacher, and also for me to pay attention to the class. Sometimes, the students were looking through the window, and their teacher was, and so was I. (From the fieldnotes of the second observation in setting 1)

f) Laboratory for teaching practical classes

I came to know from Nilufar and Fuad that in many schools, there was no laboratory, not even a specific room for teaching practical classes. For an example, during an interview, Fuad said:

There are many schools, where there is even no room set up as a laboratory. They may have stored 2/4 damaged instruments in the wardrobe; and later on, may give those to students' hand. (Fuad)

My first setting (KSB Girls' High School) was one of those schools. While observing practical classes in that school, I found that there was no laboratory and no specific specialised room for teaching practical classes. In that school, since there was no laboratory, teachers taught practical work in the room where they taught the theoretical classes. For physics, Nilufar brought the necessary equipment for teaching an experiment with her when she went to take the practical class. Nilufar expressed her regret:

We don't have a laboratory. All the instruments are kept in the office room. We have to carry those to the class to teach practical classes. Sometimes, if I forget to take any instrument, I have to go again back to the office room to bring it.
(Nilufar)

During observations, I found that as there was no laboratory, the students and the teacher (Nilufar) faced problems in doing practical work in the classroom, where there was not sufficient light for doing experiment. Extract from my fieldnotes:

Since the light in the classroom was not sufficient, students were facing difficulty to take the readings. When teacher went to see it, she told them, "Even I can't see." I said, "Sufficient light is necessary during practical work." (From the fieldnotes of the fifth observation in setting 1)

In the other three settings, there were laboratories for physics practical classes. However, although there was a specific laboratory in TLP High School, Fuad taught two practical classes, which I observed, in the classroom where he taught the theoretical classes.

Extracts from my fieldnotes:

Although there was a laboratory in the school, the teacher taught the practical classes in the classroom. I thought that most probably, the laboratory was not ready to use. (From the fieldnotes of the third observation in setting 4)

I could not understand why the teacher was not teaching the practical class in the laboratory, although there was a specific laboratory in this school. (From the fieldnotes of the fifth observation in setting 4)

During the second interview, I asked him why he did not teach the practical classes in the laboratory, although there was a specific laboratory in the school. He replied:

In the classroom, I usually teach those experiments for which it is easier to bring the instruments; otherwise, I teach practical classes in the laboratory. (Fuad)

In the other two school settings, which were government schools, there were laboratories particularly for physics; and I observed all the practical class teaching of both the teachers (Rawnak and Rakib) in the laboratories.

g) Problems with irregular attendance of students

All the teachers said that they faced difficulties in properly teaching the students who attended irregularly. They asserted that the students who attended irregularly themselves also faced difficulties in properly doing practical experiments. For example, Fuad stated with frustration:

Those students who are irregular in class, they face difficulties in doing practical experiments. (Fuad)

Similarly, Rawnak regretted, “Some students face difficulties in doing practical experiment because of that they do not attend the demonstration class.” During the

observations of the practical classes, I found that some students did not confidently do the experiment like others in the class. Extract from my fieldnotes:

I found that few groups were not doing well. Teacher was also monitoring them. She told me that those students, who were not regular in the demonstration class, were facing difficulties. (From the fieldnotes of the fifth observation in setting 3)

Moreover, in KSB Girls' High School, I found that some of the students were not actively doing the experiment. They were only watching the activities of others in their group. Nilufar indicated that those students did not regularly attend the school.

h) Teachers' workload

The ratio of teachers to students was 1: 25 in the first school setting; 1: 31 in the second; 1: 54 in the third and 1: 58 in the fourth school setting (Table 2 in Chapter Three).

According to the participants, large numbers of students were a problem for providing practical activities; and they also created an extreme work load for the teachers, because each teacher had to take many classes. All participants taught many classes each week: both Nilufar and Rakib taught 26 classes, Rawnak 24, and Fuad 28. Nilufar stated:

There is no subject-based teacher in our school. Here, although I am appointed as a mathematics teacher, I have to take mathematics, physics, chemistry, and general science. Every teacher in our school has to take classes on his/her subject and also on other subjects. (Nilufar)

The three other participants made similar comments.

The work load per week for every teacher was extreme. According to Rakib, "Actually, the pressure of classes is very high." He was referring to the stress of teaching, and also to the stress of preparation for teaching too many classes in a week.

According to all four participants, there was no post for laboratory assistant in their schools, which was, according to them, also the same for the other government and non-government secondary schools in Bangladesh.

We don't have any post for laboratory assistant in our school. (Rakib)

i) Overloaded curriculum

According to the participants, the secondary physics curriculum is overloaded with theoretical content. When I analysed the text, I found there are 25 chapters of theories and concepts of physics. In contrast, there is only one practical experiments chapter, containing a minimal 11 experiments. According to Rawnak, it is difficult to teach the 25 theory and concept chapters in time, which further limits teachers providing their students with more practical activities in classroom teaching. Rawnak stated:

It is not possible to ask them to often do practical activities, because there are 25 chapters in the syllabus, and I have to complete the whole syllabus in time. So, it is tough. (Rawnak)

4) Importance of training for teaching practical work

Participants were asked about their professional qualifications (see page 45 above for details) and also about the importance of training for teaching practical work. Their responses and my observations of their practical class teaching generated this theme and two subthemes.

a) Teachers' inquiry-based knowledge for properly teaching practical classes

All four participants thought that inquiry-based knowledge is necessary for teaching theoretical as well as practical classes properly. They thought that along with the theoretical knowledge, training on teaching practical work is necessary for proper teaching of practical classes. The following statements of the participants indicate this.

[..]I believe that teachers should have both of them: theoretical knowledge and inquiry-based knowledge. Each one is needed. (Nilufar)

There is no alternative of training in order to achieve skill. In order to teach practical classes, teachers must know how to use the instruments. They must be expert of that. If they get training, they can do it better and then, it will be possible to provide students properly with practical knowledge. (Rakib)

They believed that if teachers do not have expert knowledge of using practical instruments, and of doing experiments, then they cannot properly teach practical classes.

Rawnak thought that teachers whose inquiry based knowledge is not sufficient will obviously face problems.

Similarly, Fuad stated:

I believe that the teacher who will get training, he/she will be able to teach more effectively. Since physics is a subject of science, practical class is needed for a complete teaching of physics. If teacher does not understand anything about the instruments, then obviously he/she cannot teach practical class properly. (Fuad)

However, while observing his practical classes, I found that he himself was confused about using the equipment. Extract from my observation notes:

I noticed that teacher himself was little bit confused about taking the readings. (From the fieldnotes of the fifth observation in setting 4)

b) No specific training programme for practical work

All participants thought that training for practical work can be helpful for properly teaching practical classes. All of the participants were the only physics teacher in their own schools who taught physics practical classes along with the theoretical classes in Grades IX and X; other physics teachers in their schools taught only the theoretical classes of physics. All the participants stated that though there is no particular training on teaching practical classes, the CPD course for physics focuses partly on it. For example, Nilufar said:

Not particularly on practical work, but I have taken a short training course CPD for physics, where there is some emphasis on practical work. (Nilufar)

Like Nilufar, Rakib commented:

We have learnt the knowledge of using the instruments while doing our study. We have also got some knowledge after reading books on practical work. Actually, there is no special training on practical work. However, in CPD training, there are some classes on practical work. CPD training can help teachers in properly teaching practical classes. (Rakib)

5) Teachers' attitudes towards practical work

a) Lack of awareness of school administration

Two participants (Nilufar and Fuad) thought that there was a lack of awareness in the school administration about the importance of practical work in teaching and learning physics or other science subjects. For example, Fuad stated:

[...] if those, who are in administration, would be a little more interested in the practical classes, then it would be better. If they would think that the importance of practical work is high, it would be better for the teachers. (Fuad)

He stressed:

Initiatives should be taken so that school administration should be aware of whether teachers are regularly teaching practical classes. (Fuad)

Sometimes, teachers faced problems in properly teaching practical classes with damaged equipment and felt the need to buy new equipment. But since buying equipment is under the control of the school administration; and decisions need to be taken by the school administration, the administration had to feel the need of buying equipment. Fuad gave an example:

There are some old instruments in our school that are unsuitable for student observation. May be, we have to buy later; but time is being wasted by thinking “we are buying today, or tomorrow”. (Fuad)

Fuad emphasised that if schools could be provided with money for buying sufficient instruments, or could be provided with sufficient instruments on a regular basis according to the longevity of the instrument, it would be better. He expressed his expectation:

If it is possible to get fund for buying instruments for doing practical activities, then I think that teachers can properly teach practical classes. If steps are taken to allocate money, or to provide necessary instruments, it would be better. (Fuad)

He also added that it could be provided after monitoring the condition of the instruments. Nilufar also stated that she faced difficulties with equipment for teaching practical work, a reflection of the negligence of the school administration. In her voice:

We have two balance machines in two separate boxes. Still today, I couldn't open one box. Another one is opened, but it is damaged. It is not yet fixed. (Nilufar)

b) Negligence of some science teachers

According to Fuad, there were many schools, specifically in rural areas, where there were instruments, but these were not regularly used; and as a result, became unusable. Fuad thought that the reason might be that the science teachers of those schools were not interested enough to teach practical classes regularly. He uttered his dissatisfaction:

Practical work is little bit hampered due to the negligence of some science teachers. Some science teachers themselves are not interested to teach practical classes, or to ask the Head teacher, "Instruments are necessary, and we need to buy those." Specifically, the science teachers in the schools in rural areas do not have interest; and they are not sincere about students having clear conceptions. (Fuad)

He also mentioned the negligence of the Head teachers of those schools. He stated, "It is same for the Head teachers of those schools."

Nilufar herself admitted that although she recently started to teach practical classes regularly, practical classes were not regularly taught in her school a few years ago, and the equipment was not regularly used. That was why she could not discern whether the equipment had become damaged or was faulty from the beginning.

I am not sure whether we had got those with error, or those are damaged for our fault, because when those instruments arrived at our school, we had not opened those boxes for a long time. Then, when we opened, those were already useless. Sometimes, if things are not regularly used, become damaged. (Nilufar)

However, according to Rawnak, the reason was that as some teachers did not have expert knowledge on practical work, they avoided teaching practical classes. From her point of view, since the practical work of physics is complex compared with other science subjects, teachers with an MSc in physics should be appointed, because those teachers must have expert knowledge of practical work:

I think that physics practical work is also more complex than the practical work of other subjects. That's why in each school, only the subject based teachers, who teach the theoretical classes for a particular subject, should be allowed to teach the practical classes. (Rawnak)

Rawnak added that her students told her that they faced difficulties in understanding the concepts of physics when other teachers, who had not completed higher studies in physics, taught physics and they asked her to teach the complex chapters of physics.

Two participants thought and my observations indicated that there was a lack of awareness in the administration about the value of practical work in teaching and learning physics. One of them stated that some physics teachers were not sincere about students' learning; and that was why practical work was hampered. One of two other participants believed that as physics practical work is comparatively complex, subject-based teachers should teach physics practical classes.

Summary of Findings

In this chapter, I have presented the findings of this study from the interviews with four secondary school physics teachers and also from my observations of their theory and practical classes. It indicated that the teachers valued practical work in teaching and

learning physics, because according to them, if the theoretical knowledge of physics is provided along with practical activities, then the teaching becomes easier and students' learning becomes effective. Moreover, the participants stated that students can utilise their knowledge achieved through practical work in doing higher studies and also in their real lives. Although all four participants were aware of the importance of practical work, they usually did not provide their students with any practical activities in the theoretical classes. Furthermore, they hardly did demonstrations in their classroom teaching, even though they expressed their awareness of the demonstrations; and they regularly taught using lecture and question-answer methods. However, all of them regularly taught practical work in practical classes. The participants' views indicated that there were limitations in doing practical activities in both theoretical and practical classes with regards to the teaching equipment, class sizes, and the time-length and also the timing of practical classes. Teachers also thought that practical classes were sometimes hampered due to the lack of awareness of school administration; and also due to the negligence of some science teachers and of Head teachers. Additionally, there appeared to be no training programmes devoted particularly to teaching practical classes.

In the next chapter, I will discuss these findings with respect to the relevant literature reviewed in Chapter Two; and to the secondary physics curriculum in Bangladesh. I introduce references also to additional literature.

Chapter Five: Discussion

The purpose of this study was to explore secondary school physics teachers' perceptions of the relationship between practical work and developing conceptual knowledge of physics in Bangladesh. Through this study, I tried to understand what physics teachers in Bangladesh think are the key ideas determining what they teach, what pedagogies they use and what kinds of practical activities they provide for their students. This chapter discusses the findings (Chapter Four) of this study (collected through the semi-structured interviews with the four participants and also from my observations of their actual teaching) relating to the relevant literature reviewed in Chapter Two, to the secondary physics curriculum (Chapter One), and also to my own perceptions and experiences as a teacher educator in Bangladesh. This discussion considers the research questions of my study along with issues related to teaching and learning physics at secondary level in Bangladesh. Firstly, I discuss the findings that indicate teachers' perceptions of the relationship between practical work and developing conceptual knowledge of physics. Secondly, I discuss their actual teaching and the factors that hinder teaching, and the incorporation of practical activities that might be used to enhance learning. Finally, the teachers' perceptions and ideas about training for practical work are discussed.

Findings about teachers' perceptions of the relationship between practical work and developing conceptual knowledge of physics

Teachers' perceptions of the role of practical work in developing conceptual knowledge of physics relate to the pedagogies that teachers think are important and actually use to teach physics theories and concepts.

The previous chapter showed many aspects of how the four participating teachers perceived teaching and learning physics at secondary level in Bangladesh.

All four participants valued practical work in teaching and learning physics. They were aware that practical work is essentially related to developing conceptual knowledge of physics, which according to Woodley (2009) is in line with the perceptions of most UK science teachers, who believed that practical work is an essential part of science teaching and learning. According to the report given by SCORE (2009b), cited in Woodley (2009), teacher demonstrations as directly related activities and laboratory procedures and techniques as the core activities are included in practical work. All four participants of my study thought that after theoretically teaching any conceptual knowledge of physics, teachers should provide students with related practical activities to reinforce the ideas. This perception is similar to that of Woolnough (1988), cited in Thair and Treagust (1999).

Findings show that teachers believed that it is difficult to help students understand the theories and concepts of physics only through delivering lectures, which confirms the view of van Driel et al. (2001) that science taught as a rigid body of facts, theories and rules to be memorised and practised, leaves students with poor science concepts.

Teachers thought that practical work makes teaching and learning of physics easier. All four participants believed that when they teach using practical work, students understand more easily; and when they teach without any practical work, it takes a longer time to help students understand the concepts of physics. According to them, when they explain the concepts by doing practical activities, and when students can also do practical activities, students can observe how things happen and grasp the underlying concepts. This view is related to those of Millar (2004) and Millar and Abrahams (2009): that learning science must involve observing, managing and operating real objects; and teaching science should include demonstrating.

It is interesting to note that none of the teachers mentioned that students' participation in practical work would lead to their development of practical skills. According to Millar (2004), practical work develops students' scientific knowledge, because they need to make links between the domain of objects and the domain of ideas. My study shows that no participating teachers pointed out anything about developing students' scientific skills. However, two of the participating teachers said the purpose of teaching and learning physics is to develop both theoretical and practical knowledge of physics to enable students to utilise the acquired knowledge in higher studies and also in their real lives. All four teachers believed that students would not achieve a clear understanding of physics concepts without doing practical activities. It is very surprising to me that, given these beliefs, the teachers do not include more practical activities in their theoretical classes.

This study shows that participating teachers believed that teachers must study regularly in order to have expert subject matter knowledge, which will be helpful for good teaching. One participant thought that studying the physics books for higher levels along with the

book for secondary level can help secondary teachers teach effectively (mentioned in the previous chapter). This view was also expressed by Taylor and Dana (2003). They indicate that science teachers must have appropriate conceptions of scientific evidence in order to help students develop similar conceptions, because teaching for understanding requires flexible subject matter knowledge. This view matches the views of Abd-El-Khalick and BouJaoude (1997), cited in Asikainen and Hirvonen (2010) that science teachers' insufficient subject matter knowledge makes teaching difficult for them.

According to Boz and Boz (2008), a teacher needs to possess subject matter knowledge in order to understand a discipline, and according to van Driel et al. (1998) and Klafki (2000), mastered subject matter knowledge is a precondition for teachers as it also assists teachers to identify concepts that the students have difficulties with.

In this study, Rawnak considered practical work in physics to be complex compared to other science subjects. She indicated that teachers with an MSc in physics should be appointed, because those teachers must have expert knowledge of practical work.

According to her, students find it difficult to understand the concepts of physics in the classes of the teachers who have not done higher studies in physics.

Asikainen and Hirvonen (2010) believe that knowledge of practical work is a part of teachers' deep understanding, which at the same time, belongs to knowledge of the best instructional methods. According to Shulman (1987), practical knowledge belongs to the categories of subject matter knowledge and knowledge of representations and strategies. Therefore, not only for theoretical teaching, but also for teaching practical activities, expert subject matter knowledge is necessary. However, it is interesting that although all participating teachers stated that subject matter knowledge is necessary for teaching in

general, they did not mention anything about the necessity of subject matter knowledge in teaching practical activities.

One of the participants believed that the purpose of teaching and learning physics at secondary level is to provide students with the theoretical and the practical knowledge of physics that will develop their confidence. This belief may be related to the belief of Carl Rogers (1969), cited in Entwistle (1997) that significant learning is possible only when students have self-confidence in their ability to learn. My experience and my studies have led me to share this belief.

My study for this thesis shows that participant teachers thought practical work was helpful for increasing students' interest in learning physics theories and concepts. All four participants confidently stated that when they teach their students through practical activities, or when the students do practical activities by themselves, they become more interested in learning physics concepts. The teachers' view matches with that of Hodson (1990), that practical work plays an essential role in interesting and motivating students. My observations of the teachers' classroom teaching reinforce the same belief. When Rakib used an electroscope to explain how it works, students became more interested. Similar interest was observed in the practical classes for all four school settings, when students were doing practical experiments, either in laboratory or in classrooms.

The findings of this study also indicate that teachers believed that when students become interested in learning, they become more attentive. A previous study by Swarat (2009) has shown that interest motivates learning, which relates to the similar idea by Entwistle (1997) that interest in a lesson affects the quality of learning. Similarly, Joseph and Nacu

(2003) show that educators largely agree that interest plays an important role in learning, because interest is considered as a sustained personal phenomenon, which is an experience parallel to the curiosity that arises from a surprising incident. According to Joseph and Nacu (2003), interest is an important form of intrinsic motivation, which is considered to arise directly from personal connection and enjoyment. When students find enjoyment in their study, they become interested and then they pay more attention to their learning (Joseph & Nacu, 2003). These authors believe, as I do myself, that interest is related either to enjoyment or to a sense of importance of the content or activity, or to both, because an activity or idea that is inherently interesting (i.e. enjoyable and valuable) to a learner provides a very powerful context for learning. Motivation arising from interest is very close to a desire to know more about the activity or idea, not just a desire to do the activity (Joseph & Nacu, 2003). Interest carries with it an implicit motivation to learn (Joseph & Nacu, 2003). As a teacher, I realise also that when students pay proper attention, they need comparatively less time to understand the concept of a lesson.

My study shows that according to the participating teachers, practical work makes learning effective; and the knowledge achieved using practical work becomes more stable than the knowledge students get only by listening to their teachers' lectures or by reading the books, because practical work ensures students' active participations in the learning process. This view confirms the view of Millar (2004) that students naturally accept those things they discover through their own efforts; and this helps them to remember those things better and encourages them to be more independent. It is also in line with the objectives of science education stated by Hodson (1990) and Millar and Abrahams (2009) that practical work is considered as an essential part of science education for developing

students' understanding of laboratory skills; and enhancing their understanding of scientific knowledge. Moreover, Mertajaya (1993), cited in Thair and Treagust (1999), believes that students effectively learn physics content knowledge when they are taught using practical activities, to a level significantly higher than that achieved when taught using group discussion and lectures.

Approaches to teaching physics and the factors that hinder teaching and learning practical activities

It is interesting that although teachers were very much aware of the value of doing practical work in teaching and learning physics; and although they are instructed in the secondary physics curriculum to do demonstrations in teaching physics, none of them regularly did demonstrations or used practical activities in teaching the concepts of physics. Findings show that they did demonstrations only to teach the practical experiments. They mentioned reasons for not being able to do demonstrations in classroom teaching: the teaching aids particularly related to all the contents of physics, were not available in their schools, or the equipment provided was only that which was required to do the experiments included in the syllabus. Some of them infrequently used equipment in teaching the contents of physics, because they did only practical work related to the set experiments. This indicates that in these schools, as in schools in some other developing countries, lack of equipment presents a major problem in effective teaching and learning of physics in Bangladesh. Findings indicate that, in two school settings, there was insufficient equipment compared to the number of students for doing the practical experiments included in the syllabus. In four school settings, no equipment

or almost no equipment was available for teaching the theoretical content, especially content not related to the practical experiments. The lack of equipment seemed to be one of the important factors hindering teachers and students from doing a reasonable amount of practical activities both in theoretical and practical classes in Bangladesh. It is strange that although one participant hardly did demonstrations in his classroom teaching, he stated that he regularly used demonstrations related to the practical experiments. In one government school setting (CT Govt. Boys' School), my observations revealed that there was sufficient equipment for doing practical experiments, even compared to the large numbers of students, which is an exception in comparison with other secondary schools in Bangladesh.

My study finds that students did not do any practical activities in the theory classes; and the only practical activities they did were in practical classes, which were also minimal, only one practical class for each student each week. However, two participants thought that this was sufficient for completing all the practical experiments (eleven) included in the secondary physics syllabus. In response to one interview question, one of these participants mentioned that due to the limitation of time, he usually teaches nine out of eleven experiments, contradicting his previous statement that he was able to complete all the required practical experiments. Thair and Treagust (1999) state that secondary science curricula should contain a significant amount of practical activities. Since the teachers participating in my study found it difficult to complete eleven experiments, it is little wonder they did not seem to think about doing more practical work out of the sphere or beyond the 11 set experiments.

The large numbers of students in one class also hindered the teachers including practical activities. This probably applies in all types of schools in Bangladesh. I observed two participating teachers creating a small number of large student groups to carry out practical experiments, because of insufficient equipment. Large numbers of students in groups means that not everyone in the group gets to physically handle the equipment or participate directly in the practical activities. Consequently, few students got the opportunity to do the experiments and others had nothing to do except watch. The value of providing practical work when there are large numbers of students per group is questionable, particularly if developing practical skills is the aim.

Table 2 in Chapter Two shows that 166 science students in Grade X were divided into three sections in BMC Govt. Girls' School, and in each section, the minimum number of students was 49; in CT Govt. Boys' School, there were two sections for 102 students, and minimum 48 students in each section; and in TLP High School, there was only one section for the science students, but the number of students was 60. If there were fewer students in each class, more students would get opportunity to do the experiments physically. Although there was not much equipment in one school setting (KSB Girls' High School), all students in the class (seven, as shown in Table 2 in Chapter Two) had opportunities to do the experiments on their own because of a small class size.

Another constraint that hindered teachers from doing demonstrations and teaching all the practical experiments included in the syllabus might be their intense work load, which they all mentioned in their interviews. They indicated that large numbers of students created an extreme work load for them. The teacher/student ratio is low, and consequently, each of the participating teachers had to take many classes each week. For

example, in BMC Govt. Girls' School, there were 1400 students while the number of teachers was only 26 (Table 2 in Chapter Two). As already mentioned in Chapter Two, all four participating teachers taught various subjects including physics to various Grades in junior secondary and secondary levels. Table 3 in Chapter Two shows that each week both Nilufar and Rakib taught 26 classes, Rawnak 24, and Fuad 28. If there were more teachers corresponding to the large numbers of students, teachers would have fewer classes to teach; they would be able to prepare written lesson plans for each class; and they might also be more likely to provide students with practical activities more frequently. If teachers had less work load, they could also prepare different teaching aids for effective teaching and learning of physics concepts.

Like Ishak and Mohamed (2008) and Ranade (2008), I found from my study that students in Bangladesh learn the concepts of physics through rote memorisation, where teachers transfer the knowledge of physics to the students using lecture methods, filling them up with facts, concepts, and laws. In a report on studies done in three developed countries, Australia, Sweden and England, Lyons (2006) shows that science subjects are taught in a very similar way wherever the teachers use transmissive pedagogy. The participating students in those three studies mentioned that teachers usually write the lesson on the board or read it aloud; and students copy it down. The teachers in my study regularly used the board to explain the concepts and theories of physics. Although all emphasised that providing the concepts of physics using only lecture methods is not enough for developing students' clear conceptual knowledge of physics, this study shows that they used mostly lecture method for teaching most of the content. Teachers stated that since they cannot do demonstrations using related equipment, they use lectures, which matches

with the view of Ranade (2008) that science teachers have to depend on lectures in their teaching due to lack of laboratory equipment.

Osborne and Collins (2001), cited in Lyons (2006), argued that teachers use transmissive pedagogy because of an overloaded science curriculum. Their view supports the view of one participating teacher (Rawnak) in my study who stated that the overloaded secondary physics curriculum is a factor that holds teachers back from providing much practical activity in classrooms. Her thought relates to the view of Koballa and Tippins (2000), cited in Lyons (2006), who noted that teachers are compelled to fit the overloaded science curriculum into a significantly reduced instruction time. Similarly, Kemper (2000), cited in Lyons (2006), stated that since science teachers are stressed to cover the overloaded curriculum, they do not have time to waste doing activities.

One participating teacher's teaching approach was to ask students one after the other to read out parts of the lesson; then to explain it sometimes using teaching aids, and sometimes using the blackboard; after that he asked the students questions. According to my observation, this strategy seemed boring to the students. Students participating in the study done by Osborne and Collins (2001), cited in Lyons (2006), expressed similar feelings. One participating teacher in Entwistle's (1997) study believed that something goes on in the class which diminishes students' willingness to get down to work.

Similarly, Ranade (2008) stated that boring and mechanical styles of teaching science are a reason for the poor quality of science education.

According to Lindahl (2003b), cited in Lyons (2006), students felt that teachers never made clear why students needed to learn particular content. Similarly, Osborne and

Collins (2001), cited in Lyons (2006), found that teachers did not provide many examples from everyday life and that was why students found the lessons irrelevant and boring.

Mayoh and Knutton (1997), cited in Lyons (2006), explored the same finding that teachers rarely referred the lesson to students' experiences. However, findings of my study show that all the participating teachers regularly provided students with appropriate examples from everyday life so that students could have better understanding. According to Lyons (2006), concepts should be made practically relevant to most students, because familiar everyday life contexts give students better understanding of those concepts.

Findings of my study indicate that Rawnak taught in a way which was helpful for students' good understanding: she explained the concepts using real life examples and through asking questions. Some of her students grasped concepts well. However, while observing her classes, I realised that all of her students would definitely have a better understanding, if she included some demonstrations using relevant equipment.

According to Rawnak, if she could teach all the theoretical and practical classes of physics in the laboratory, where there was sufficient equipment for the number of students, then she would be able to teach more effectively using the teaching aids particularly related to physics contents; and her students would be able to achieve clearer conceptual knowledge of physics. This teacher exhibited sincerity and awareness of complex teaching and learning issues. Her aspiration is in line with physics teaching in developed countries. In New Zealand, for example, there is no separate classroom for teaching the theories and concepts of physics and for teaching practical experiments of physics; both the theoretical and practical classes of physics are taught in the rooms equipped with related teaching aids.

An interesting finding of this study was that only the non-government school teachers faced difficulties with damaged equipment. There was no such problem in the government schools. According to the participant (Nilufar) in one non-government school, she cannot teach all the experiments because some equipment is damaged; the participant in the other non-government school mentioned that his students cannot properly make measurements for the experiments. This corresponds to the view of Millar (2004) that students cannot make complete or correct observations or measurements if they have poor quality equipment. However, Nilufar was not sure whether the school was provided with damaged equipment or it was damaged due to lack of proper maintenance. Thair and Treagust (1999) state that having a low maintenance standard for laboratory facilities is one of the constraints that prevents the implementation of practical work in schools. As well, the schools did not have technical support to maintain equipment nor to build or create new pieces of equipment. This finding points towards the lack of awareness of science teachers and also of school administration about the value of practical work, and hence the need to maintain equipment to a high standard.

According to participants in the non-government schools, there was a lack of awareness among some science teachers and of school administration about the importance of practical work in teaching and learning physics or other science subjects. One of them admitted that it was only recently that she started to teach practical classes regularly. According to another participant, in many schools, specifically in rural areas, although there are instruments, teaching and learning physics are hampered by some science teachers' knowledge about what is needed for students' effective learning. According to him, those science teachers are not interested enough to teach practical classes. This is an

echo of Fishbein's (1980) attitude-behaviour Theory of Reasoned Action (TRA), cited in Zacharia (2003), where he indicates that beliefs affect attitudes and attitudes affect intentions. According to another participant in a government school, some teachers avoid teaching practical classes because they do not have expert knowledge of teaching practical work. This view matches that of Lloyd et al. (1998), that science teachers' poor knowledge of science negatively affects their attitudes towards science which affects classroom practice (Bencze and Hodson, 1999). Woodley (2009) also states that science teachers' beliefs and understanding of teaching and learning science are responsible for students' poor content knowledge of science.

My findings also indicate that three participants in two non-government and one government schools thought that the time-length (45 minutes) of practical class is short, and it is difficult to complete one experiment within that time. Millar (2004) observed that the amount of time available for doing experiments is one of the limitations of the enquiry-based activity approach. The three teachers in my study thought that practical classes should be increased up to minimum one and a half hours. My observations confirmed that students could not complete experiments in the short time-length of the practical classes. Although the time-length of the practical classes was almost the same in the four schools, only one participant (Rawnak) did not mention time as being a constraint. My observations show that her students confidently completed the experiments in time (50 minutes). My conclusion here is that the teacher in this school regularly taught separate demonstration classes in order to show the students how to use the equipment to do the experiments and asked her students to do the experiments on their own in the practical classes. Of the other three participants, one (Rakib) in a

government school setting also taught separate demonstration classes using practical experiments. But, since he repeated the demonstration in the practical classes, his students could not complete the experiments in time. Despite this, they participated in the experiments with confidence. Another one of those three participants, who did not teach any separate demonstration classes, thought that the time-length of practical classes should be two hours. The reason might be that he did demonstrations on an experiment in the same class before asking his students to start that experiment.

If teachers teach a separate demonstration class on an experiment and let their students do that experiment in practical classes, then it would be helpful for the students to have time to do the experiment properly. Forty five minutes is enough time for demonstration classes, but it does not seem to be enough for students to do the practical experiments themselves. As a teacher of physics, and also from the observations of teachers' practical classes, I think that the time-length for practical classes should be increased up to one hour.

Another important finding of my study was that there was no post for the laboratory assistant in any government and non-government secondary school setting, and according to the participating teachers, it was the same for other secondary schools in Bangladesh, creating extra work load for the teachers. According to Thair and Treagust (1999), lack of laboratory assistants is a constraint that hinders practical activities, with teachers required to spend lengthy periods preparing experiments.

It is remarkable that although practical work makes students more interested in learning physics, in the two non-government schools, practical classes are taught at the end of the

day, when it is difficult for the students to pay full attention to the class. This finding shows the lack of awareness of school administration, because each school administration is solely responsible for preparing the timetable of classes for each school. Findings show that according to one participant, due to the odd timing of practical classes, students felt less attraction and paid less attention to the class, which hampered teaching and learning practical work. That teacher thought that the timing should be changed and it should be set at the second or third period in the daily routine, when students have full attention. He believed that students need to pay proper attention while doing physics classes, because physics is a complex subject. His view is in line with the view of Ishak and Mohamed (2008) that physics is seen as abstract, difficult to understand and to conceptualise. However, in the two government schools, the timing of practical classes was good.

In one non-government school, there was no laboratory or no specific room for doing practical classes. In this school setting, the equipment for doing practical experiments was kept in a wardrobe in the office room and the teacher brought necessary equipment from the office room to the classroom where she taught the theoretical classes so that she could include practical work. This situation is the same for many non-government schools in Bangladesh, according to another participant. Although there was a laboratory for doing practical work in his school, he did not teach practical classes in the laboratory. In the two government schools, there were specific laboratories supplied with equipment and the teachers regularly taught practical classes in the laboratories.

All four teachers indicated that they faced difficulties in teaching concepts to the students who attended irregularly. I observed a few students who faced more difficulties in doing

practical experiments than the others, and I came to know from the teachers that those were the students who attended the classes irregularly.

Findings of this study indicate that students who did not have theoretical knowledge related to an experiment, faced difficulties in doing the experiment properly; and the students who had clear overall theoretical ideas about the experiment (and were not impeded by difficulties with equipment) quite successfully completed the experiment. As Shulman (1987) has mentioned, subject matter knowledge includes practical knowledge. Students need to understand content knowledge to be able to make links between the domain of objects and the domain of ideas (Millar, 2004). Even though participants in my study did not state that students must have the related theoretical knowledge before starting an experiment, to me such a conclusion is inescapable.

My findings also show that teachers valued training programmes for teaching theoretical as well as practical classes. According to them, inquiry-based knowledge is necessary for teaching theoretical and practical classes; and training for practical activities would be helpful for teaching practical classes more effectively. In their view, teachers without expert knowledge of using equipment and of doing experiments cannot be effective in teaching practical activities. This view corresponds with that of Thair and Treagust (1999) where they indicate that teacher education programmes designed to support teachers to effectively implement laboratory activities into their teaching, can assist students' understanding and achievement in physics.

An interesting finding of this study was that there was no particular training programme for teaching practical activities in classrooms, nor for teaching experiments in practical

classes. According to the participating teachers, although there are various training programmes for theoretical teaching, there is no training programme specifically for teaching practical work. Three of them indicated that a few classes in the CPD course can help teachers somewhat to teach practical work. Fuad was the only participant who did not attend this course, and he seemed to be confused about using the equipment while demonstrating practical classes.

One participant (Rawnak) in my study, who was a Master trainer, thought that teachers with insufficient inquiry-based knowledge face problems in teaching practical activities. She identified a need for training for teaching practical classes so that teachers gain enquiry-based knowledge which assists directly in the confident teaching of practical classes. Such teachers would be aware of the importance of teaching separate demonstration classes and they would also learn skills to teach students to do the experiments as instructed, within the allocated time.

In Pakistan, Halai (2008) found that science education faces similar problems: a lack of laboratories, equipment, and other resources needed to teach science; a shortage of science teachers; and poor training of science teachers. Similarly, researchers such as Asikainen and Hirvonen (2010), Millar (2004), Nivalainen et al. (2010) in their study found lack of laboratory equipment and lack of practical work, and shortage of physics teachers, to be some of the reasons for students' poor content knowledge of science. According to Monk, Fairbrother and Dillon (1993), cited in Thair and Treagust (1999), the commonly reported constraints that may prevent doing practical activities in classrooms include lack of equipment, large classes and overcrowded syllabi.

The findings of this study are comparable to the findings of many studies in countries experiencing similar constraints and conditions.

According to Cook and Taylor (1994), because process skills are not examined in national examinations in many developing countries, practical work is therefore not highly valued which causes a problem for science education. This is an essential factor that needs to be addressed by the education system of those countries (Thair and Treagust, 1999). However, practical work is examined in the national examinations in Bangladesh; although it is a developing country and there are many limitations in science education, this dimension of science learning is still nationally important.

In the SSC examination for physics, out of 100 marks, 75 marks are allocated for theoretical and 25 for practical work. Among 25 marks of practical examination, 15 marks are for doing an experiment; 5 for viva; and 5 for preparing the practical exercise book.

Although in the Bangladesh secondary physics curriculum, there is detailed information about teaching and learning the concepts and theories as well as practical work, in the school syllabus for Grade X, apart from the total mark allocated for practical work on each science subject, nothing is mentioned about how many and which practical experiments are to be conducted in the syllabus handbook of Grade X. In the physics text book for Grades IX and X, there are descriptions of 11 practical experiments.

As the practical work instructed by the curriculum was not being done properly, teachers were aware only of how to do the instructed amount of practical work by diminishing existing limitations. This might be the reason why they did not mention or even think of

anything about how to make the practical work more effective. They also did not mention anything about whether the practical experiments included in the syllabus are useful, or how useful they are for Bangladesh contexts. Recent researchers are considering the effectiveness of existing practical work in developing conceptual knowledge of science in developing and even in developed countries.

According to Wellington (2000), cited in Halai (2008), the practical work currently conducted in both developed and developing countries is not helpful for teachers to achieve curricular goals. Thair and Treagust (1999) think that practical activities offer different functions for the students in different countries because of different contexts and perspectives. Hence, according to Halai (2008) and Thair and Treagust (1999), practical activities should be designed to consider the need of the science students of a particular country and also to consider the type of skills teachers need to teach science through practical work. Halai (2008) believes that Pakistan needs to identify the particular kind of practical work needed for Pakistani students, to help them to develop an understanding of science. Like Halai (2008), I believe that Bangladesh needs to do the same for Bangladeshi students in order to develop science education in Bangladesh. This may be an issue for a future research project.

My main purpose was to study secondary school physics teachers' perceptions of the relationship between practical work and developing conceptual knowledge of physics in Bangladesh secondary schools. However, related ideas and observations emerged from interviews and observations.

Overall, this study shows that participating teachers perceived that teaching and learning of physics at secondary level in Bangladesh is hampered by a lack of equipment; large numbers of students in classes; and a lack of awareness in the administration about the importance of practical work. Moreover, this study shows that lack of sufficiently qualified physics teachers; intense workload of teachers; and lack of laboratory assistants hamper teaching and learning physics. The quality of equipment in some schools was questionable. Findings also pointed out that when the teachers regularly teach separate demonstration classes, the students can confidently do the practical experiments. The problematic timing of practical classes was a very important observation in this study.

Although all four participating teachers possessed positive attitudes towards students' effective learning, due to lack of equipment for doing practical activities in their classroom teaching; due to lack of sufficient equipment compared to the number of science students in any one class for doing practical experiments; and also due to damaged equipment, teachers faced difficulties in teaching and students faced difficulties in learning physics.

Despite the issues hindering teaching and learning physics effectively, Bangladesh secondary science education has good physics curriculum. If the authority concerned (Ministry of Education) takes steps to implement the curriculum, secondary science students can look to achieve a standard and clear conceptual knowledge of physics.

This study shows differences in perceptions of teachers from different contexts.

Teachers' perceptions varied depending on their training experiences, the availability of resources, and also on the schools' status. There were differences between the

perceptions of the teachers in government and in non-government schools; having comparatively sufficient amount of equipment and having insufficient amount of equipment; and having training experience and without having training experience.

Chapter Six: Conclusion, Implications and Future research

The aim of this study was to investigate physics teachers' perceptions of the value of practical work and its importance in developing conceptual knowledge of physics at secondary level in Bangladesh schools. This study collected qualitative data based on the teachers' comments during semi-structured interviews and my observations of their teaching and students' learning. The collected data was then used to interpret what teachers said they do and what they actually do in practice. It was expected that the findings of this study could be used to explore the reasons for secondary science students' poor conceptual knowledge of physics; and to consider aspects of secondary science education; and in a broader sense, to make recommendations to develop science education in Bangladesh.

The findings of my study indicate that participating teachers believed that providing theoretical knowledge of physics accompanied by essential practical work can ensure effective teaching and learning of physics. For this purpose, one participant thought that all physics classes should be taught in the physics laboratory furnished with necessary equipment. Although all four participating teachers valued practical work in teaching and learning physics, they did not do much practical work in their classroom teaching because of a lack of equipment related to the contents of the physics curriculum. The only practical activities nearly all students did were the experiments in the practical classes. Lack of sufficient equipment for the large numbers of science students also hindered practical experiments. The teacher/student ratio was low in most of the schools, creating an extreme work load for the teachers. There were no laboratory assistants in any of the

four schools in this study, and participants indicated that this is the case for other secondary schools in Bangladesh.

Compared to the teachers and students in government schools, the teachers and students in non-government schools faced more difficulties with practical equipment, timing of practical classes, and also with not having a laboratory or a specific room for doing practical classes. Since 98% of the secondary schools are non-government (BANBEIS, 2004, cited in Maleque et al., 2007), this is a huge issue for secondary science education.

Lack of sufficient physics teachers with higher studies in physics was another factor that hindered effective learning of physics. According to the participants of this study, school administration and some physics teachers' awareness of the value of practical work in teaching and learning physics can reduce the existing problems those hinder practical work.

Implications

The findings of this study have several implications for the development of secondary science education in Bangladesh. I was enabled to reflect on and understand four secondary school physics teachers' perceptions of the relationship between practical work and developing conceptual knowledge of physics and also to reflect on their actual teaching. The participating teachers were conscious of the importance of practical work in teaching and learning physics at secondary level. They were aware of the limitations of doing practical work; the ways of reducing those limitations; and also the ways of making teaching and learning physics more effective. They pointed out the importance of

students' regular presence in classes for students' effective learning and also the importance of appointing sufficient teachers with higher studies in physics for the effective teaching of a complex science subject. They were mentally ready to teach effectively if the limitations were reduced. These findings have implications for other physics teachers and also for the school administrations who read the findings of this study.

The findings of my study imply that there is a need to improve the physical facilities for teaching and learning physics in classrooms as well as in the practical classes. Due to the lack of equipment needed to do practical activities, teachers and students faced difficulties in teaching and learning the theories and concepts of physics, where these ideas could be supported or enhanced through practical work. The physical facilities were comparatively worse for the non-government schools in Bangladesh. According to some of the participants, if school administration and also the physics teachers in some schools were aware of the value of practical work, it could reduce the existing difficulties in teaching and learning practical work.

Ways to reduce teachers' work load need to be explored and implemented in order to provide effective, quality teaching and learning of physics. The teacher/student ratio in most of the schools studied was low and the class size was large. There were no laboratory assistants in any of the government and non-government schools. Therefore, teachers did not get assistance to organise equipment or develop creative ways to demonstrate key concepts.

This study broadened my view of the present situation of teaching and learning of physics in general, and in particular, of practical physics at secondary level in Bangladesh. I will use this information as a teacher educator to indicate to my secondary school teachers' training classes how important practical work is. In particular, I think it is important that I provide them with examples and ways to demonstrate key concepts, as well as lead them through practical considerations related to resource and student management when requiring students to do practical work.

If steps can be taken to reduce the existing problems, then secondary science students can effectively achieve better conceptual knowledge of physics. Paying attention and emphasising practical work can play an important role in developing science education in Bangladesh and in other developing countries. I hope that the Ministry of Education will consider the findings and recommendations below, such as providing sufficient equipment, appointing sufficient well-trained physics teachers with higher studies in physics and appointing science staff according to the number of science students in each school.

Limitations of the study

No study can be perfect. This study involved a small sample, limited to four physics teacher participants to collect qualitative data within a short period of time (three months). Hence, the perceptions of the participants in this study cannot represent all teachers, but can reflect only some ideas from a diverse population of physics teachers in Bangladesh.

For this study, there were limitations for collecting data, including the number of classroom observations. Hence, I was not able to observe the teaching of the participating teachers throughout the whole school day. Moreover, due to time constraints, I selected participants from two government and two non-government secondary schools in only one district in Bangladesh; and I could not cover any Madrasah, any English medium school, any private school, any Cadet College, or any school in rural areas. Hence, I was not able to explore the perceptions of the physics teachers and their teaching in those types of schools, where the contexts of secondary science education may be different from the contexts of the school settings in this study.

The timing of data collection was another limitation of this study. I collected the data at the very beginning of the year, when the classes were just beginning. If the data had been collected during the middle of the year, then the reflection on teaching and learning may have been different. As I was studying in a New Zealand University and went to Bangladesh to collect data, I had no other option than choosing that timing.

Another limitation was that due to the nature of the semi-structured open-ended interview questions, the responses were quite open, although probing was used to get more detail on some aspects that were worth noting. However, the rich detailed data generated from the interviews helped me to interpret the participating teachers' perceptions and their actual teaching.

Secondary school science students' or the Head teachers' perceptions were not examined in this study.

In spite of the limitations mentioned above, this study sheds light on the perceptions of the selected four secondary school physics teachers and also on the present situation of secondary science education in government and non-government schools in Bangladesh. Their perceptions of the relationship between practical work and developing students' conceptual knowledge of physics is important, and these may widen other physics teachers' conceptual understandings of the value of practical work.

In response to the limitations of this study, I have suggested a few considerations for future research.

Suggestions for Future Research

The focus of this study was to explore secondary school physics teachers' perceptions of the relationship between practical work and developing conceptual knowledge of physics, via a qualitative study with a small sample size. In future, a quantitative research study on the same topic could be done with a large sample of physics teachers selected from a range of types of schools: some private secondary schools, Cadet Colleges, Madrasah, and also schools in rural areas. Physics teachers could be selected from some government and some non-government secondary schools in different districts in Bangladesh and asked to generate quantitative data related to how often they do practical work and student achievement data. The findings of such a study may represent the perceptions of a more diverse population of the secondary school physics teachers in Bangladesh.

Future research could be done to explore secondary school science students' or the Head teachers' perceptions of the same issues: the purpose of practical work and the factors which help or hinder practical work.

Further studies could also be done into teachers' perspectives of the impact of professional development training on teaching and learning physics at secondary level; to understand secondary science students' perspectives on teaching and learning physics that includes practical activities; or to explore students' beliefs of the role of practical work in teaching and learning physics.

A study could be done on a topic such as "What difference does including more practical work make to students?" or "Does it make a difference if one group of students is taught with more practical work and another group with less practical work for the same physics content?"

Recommendations

The findings of this study lead to the following recommendations regarding the effective teaching and learning of physics at secondary level in Bangladesh. They are:

- Necessary equipment could be provided in such quantities that the teachers in government schools and also in non-government schools can teach all the theories and concepts of physics using demonstrations, by which students gain clearer conceptual knowledge of physics.

- A sufficient amount of equipment for doing a wide range of practical experiments enables a large number of students to participate in practical work – this equipment must be available in as many schools as possible.
- The class size must be small so that every student can get the opportunity to do practical experiments through hands-on participation.
- In order to complete an experiment within the scheduled time length, teachers must teach separate demonstration classes before the students do that experiment in the practical class.
- There could be a specific laboratory for doing practical work.
- Correctly calibrated instruments must be provided. If necessary, practical equipment could be replaced or resupplied to the schools, and regular monitoring should be maintained to support that need for equipment.
- To ensure students' effective learning, all theoretical as well as practical physics classes should be taught in the laboratory, so that teachers can use the necessary equipment to explain the theories and concepts of physics.
- The time allocated for practical classes could be increased.
- The practical classes could be set at the beginning of the day whenever possible when students have the capacity to pay full attention to their learning.
- To ensure effective teaching and learning, only the teachers with higher education in physics should teach both the theoretical and practical classes of physics. For

this purpose, a number of subject based teachers could be appointed in schools according to the number of science students.

- There could be initial teacher education programmes and also on-going professional development training programmes for physics teachers for teaching practical experiments in practical classes and also for teaching the theories and concepts of physics using related equipment for demonstrations.
- In order to reduce the load of classes, the teacher/student ratio could be increased; and sufficient number of subject-based teachers for each subject could be appointed in each school.
- Posts for laboratory assistants could be created in order to reduce teachers' work load and also for the proper maintenance of laboratory equipment.
- Proper and regular maintenance of the equipment must be ensured.
- How many experiments and what experiments must be done, and how many classes must be taken for teaching and learning: these details could be mentioned in the syllabus handbook.
- Practical classes during teacher training and actual teaching practice should be monitored, as are the theoretical classes.
- Regular attendance of students must be ensured.

- Awareness of the value of practical work in teaching and learning of physics and in developing students' clear conceptual knowledge of physics must be developed in administration staff as well as among the physics teachers.

Final Reflection

If initiatives are taken to provide secondary schools in Bangladesh with sufficient equipment to teach and learn practical activities; to appoint sufficient amount of physics teachers; to increase the teacher/student ratio; to create posts for laboratory assistants; and to train the secondary school physics teachers for teaching practical work, then it will be possible for the teaching and learning of physics to be more effective. This will play an important role in developing secondary science education and science education, generally, in Bangladesh.

References

- Asikainen, M. A. & Hirvonen, P. E. (2010). Finnish cooperating physics teachers' conceptions of physics teachers' teacher knowledge. *Journal of Science Teacher Education, 21* (4), 431 – 450.
- Bangladesh Bureau of Educational Information and Statistics [BANBEIS]. (2007). *Output Statistics*. Retrieved 2 February, 2007, from <http://www.banbeis.gov.bd>
- Bencze, L. & Hodson, D. (1999). Changing practice by changing practice: Toward more authentic science and science curriculum development. *Journal of Research in Science Teaching, 36* (5), 521-539.
- Black, A. L. & Halliwell, G. (2000). Accessing practical knowledge: How? why? *Teaching and Teacher Education, 16* (1), 103-115.
- Bogdan, R. C. & Biklen, S. K. (2007). *Qualitative research for education: An introduction to theory and methods* (5th ed.). Boston: Pearson Education.
- Boz, N. & Boz, Y. (2008). A qualitative case study of prospective chemistry teachers' knowledge about instructional strategies: Introducing particulate theory. *Journal of Science Teacher Education, 19* (2), 135-156.
- Bryan, L. A. (2003). Nestedness of beliefs: Examining a prospective elementary teacher's belief system about science teaching and learning. *Journal of Research in Science Teaching, 40* (9), 835-868.

- Cook, A., & Taylor, N. (1994). Robust adaptive processes: The case for laboratory assistants in Fiji high schools. *Journal of Science and Mathematics Education in South-east Asia*, 17 (2), 7–15.
- Entwistle, N. (1997). Contrasting perspectives on learning. In F. Marton, D. Hounsell, & N. Entwistle (Eds.), *The experience of learning* (pp. 3-22). Edinburgh, Scotland: Scottish Academic Press.
- Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry*, 12 (2), 219-245.
- Glesne, C. & Peshkin, A. (1993). *Becoming qualitative researchers: An introduction*. USA: Longman.
- Halai, N. (2008). Curriculum reform in science education in Pakistan. In R. K. Coll & N. Taylor (Eds), *Science Education in Context: An International Examination of the Influence of Context on Science Curricula Development and implementation* (pp. 115-129). Rotterdam: Sense Publishers.
- Harrison, J., MacGibbon, L., & Morton, M. (2001). Regimes of trustworthiness in qualitative research: The rigors of reciprocity. *Qualitative Inquiry*, 7 (3), 323 - 345.
- Hodson, D. (1990). A critical look at practical work in school science. *School Science Review*, 71 (256), 33-40.
- Ishak, M. Z. & Mohamed, Z. (2008). Teacher training of secondary school physics teachers in Malaysia: Critical issues and a new direction. In R. K. Coll & N.

- Taylor (eds), *Science Education in Context: An International Examination of the Influence of Context on Science Curricula Development and implementation* (pp. 301-312). Rotterdam: Sense Publishers.
- Joseph, D. & Nacu, D. C. (2003). Designing interesting learning environments when the medium isn't enough. *Convergence*, 9 (2), 84-115.
- Kakai, L. C. (2010). *School-based assessment of practical work in science education in Solomon Islands* (Unpublished dissertation of M Ed). University of Waikato, Hamilton, New Zealand.
- Kasanda, C. D. (2008). Improving science and mathematics teachers' subject knowledge in Namibia. In R. K. Coll & N. Taylor (eds), *Science Education in Context: An International Examination of the Influence of Context on Science Curricula Development and implementation* (pp. 199-209). Rotterdam: Sense Publishers.
- Klafki, W. (2000). Didaktik analysis as the core of the preparation of instruction. In I. Westbury, S. Hopmann, & K. Riquarts (eds.). *Teaching as a reflective practice. The German didaktik tradition* (pp. 139-160). London: Lawrence Erlbaum Associates.
- Lingbiao, G. & Watkins, D. (2001). Identifying and assessing the conceptions of teaching of secondary school physics teachers in China. *British Journal of Educational Psychology*, 71 (3), 443-469.
- Lloyd, J.K., Smith, R.G., Fay, C.L., Khang, G.N., Wah, L.L.K., & Sai, C.L., (1998). Subject knowledge for science teaching at primary level: A comparison of pre-

- service teachers in England and Singapore. *International Journal of Science Education*, 20 (5), 521-532.
- Lyons, T. (2006). Different countries, same science classes: Students' experiences of school science in their own words. *International Journal of Science Education*, 28 (6), 591-613.
- Maleque, A., Begum, M., Islam, F., & Riad, S. S. (2007). *Shikkha Bigyan O Bangladesha Shikkha*. Dhaka, Bangladesh: The University Grants Commission of Bangladesh.
- Meijer, P. C., Verloop, N., & Beijaard, D. (1999). Exploring language teachers' practical knowledge about teaching reading comprehension. *Teaching and Teacher Education*, 15 (1), 59-84.
- Millar, R. (2004). *The role of practical work in the teaching and learning of science. High school science laboratories: Role and vision*. National Academy of Sciences, Washington, DC. York: The University of York.
- Millar, R. & Abrahams, I. (2009). Practical work: making it more effective. *School Science Review*, 91 (334), 59-64.
- Ministry of Education [MoE]. (2011). *Education system in Bangladesh: Education structure*. Retrieved 20 July, 2011, from <http://www.moedu.gov.bd>
- National Curriculum and Textbook Board [NCTB]. (1996). *Curriculum and Syllabus, Secondary Level (Grades IX-X) (Report: Part 2)*. Dhaka: Ministry of Education, Government of Bangladesh.

- Nivalainen, V., Asikainen, M. A., Sormunen, K., & Hirvonen, P. E. (2010). Preservice and in-service teachers' challenges in the planning of practical work in physics. *Journal of Science Teacher Education, 21*(4), 393-409.
- Ranade, M. (2008). Science education in India. In R. K. Coll & N. Taylor (eds), *Science Education in Context: An International Examination of the Influence of Context on Science Curricula Development and implementation* (pp. 99-114). Rotterdam: Sense Publishers.
- Scanlon, E., Morris, E., Terry, D. P., & Cooper, M. (2002). Contemporary approaches to learning science: Technologically-mediated practical work. *Studies in Science Education, 38* (1), 73-114.
- Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57* (1), 1-22.
- Siddique, M. N. A. (2008). Ideas about science portrayed in the existing and proposed science curricula of grades IX and X in Bangladesh. *Asia-Pacific Forum on Science Learning and Teaching, 9* (2), 1-17.
- Swarat, S. L. (2009). *What makes science interesting? Investigating middle school students' interest in school science*. Published dissertation of PhD in Education. Northwestern University, USA.
- Taylor, J. A., & Dana, T. M. (2003). Secondary school physics teachers' conceptions of scientific evidence: An exploratory case study. *Journal of Research in Science Teaching, 40* (8), 721-736.

- Thair, M. & Treagust, D. F. (1999). Teacher training reforms in Indonesian secondary science: The importance of practical work in physics. *Journal of Research in Science Teaching*, 36(3), 357-371.
- Van Driel, J.H., Beijaard, D., & Verloop, N. (2001). Professional development and reform in science education: The role of teachers' practical knowledge. *Journal of Research in Science Teaching*, 38(2), 137-158.
- Van Driel, J. H., Verloop, N. & de Vos, W. (1998). Developing science teachers' pedagogical content knowledge. *Journal of Research in Science Teaching*, 35 (6), 673-695.
- Willis, J. W. (2008). *Qualitative research methods in education and educational technology*. Charlotte, NC: Information Age Publishing.
- Woodley, E. (2009). Practical work in school science- why is it important? *School Science Review*, 91 (335), 49-51.
- Yin, R. K. (2009). *Case study research: Design and methods* (4th ed.). California: Sage Publications.
- Zacharia, Z. (2003). Beliefs, attitudes, and intentions of science teachers regarding the educational use of computer simulations and inquiry-based experiments in physics. *Journal of Research in Science Teaching*, 40 (8), 792-823.

APPENDICES

APPENDIX A



HUMAN ETHICS COMMITTEE

Secretary, Lynda Griffioen
Email: human-ethics@canterbury.ac.nz

Ref: 2010/64/ERHEC

20 October 2010

Shaila Banu
8/45 Ilam Apartments
Homestead Lane
CHRISTCHURCH

Dear Shaila

Thank you for providing the revised documents in support of your application to the Educational Research Human Ethics Committee. I am very pleased to inform you that your research proposal "The role of practical work in teaching and learning physics at secondary level in Bangladesh" has been granted ethical approval.

Please note that should circumstances relevant to this current application change you are required to reapply for ethical approval.

If you have any questions regarding this approval please let me know.

We wish you well for your research.

Yours sincerely

pp 

Nicola Surtees
Chair
Educational Research HEC

Please note that Ethical Approval relates only to the ethical elements of the relationship between the researcher, research participants and other stakeholders. The granting of approval or clearance by the Educational Research Human Ethics Committee should not be interpreted as comment on the methodology, legality, value or any other matters relating to this research."

APPENDIX B

Government of the People's Republic of Bangladesh
Directorate of Secondary and Higher Education
Shikkha Bhaban, Dhaka-1000

The Chair
Educational Research Human Ethics Committee (ERHEC)
University of Canterbury, Christchurch, New Zealand

Subject: Permission for the Bangladeshi Teacher Educators studying for Master of Education at the University of Canterbury to conduct research on Bangladesh Education.


Dear Sir/Madam

The following 14 Bangladeshi Teacher Educators studying Master of Education at the University of Canterbury are hereby given permission to conduct research in the education sector of Bangladesh as a part of their Master of Education program.

Sl.No	Name and Designation
1	Mollah Mohammed Haroon- Ar-Rasheed, OSD (Lecturer, English), Directorate of Secondary and Higher Education, Dhaka, Bangladesh
2	Tania Afreen Khan, OSD (Lecturer, Guidance & Counselling), Directorate of Secondary and Higher Education, Dhaka, Bangladesh
3	Niger Sultana, OSD (Lecturer, Bangla), Directorate of Secondary and Higher Education, Dhaka, Bangladesh
4	Md. Ariful Haq Kabir (Lecturer, Sociology), IER, Dhaka University (on Education Leave)
5	Mohammad Ali, OSD (Assistant Professor, English), Directorate of Secondary and Higher Education, Dhaka, Bangladesh
6	Md. Ahasanul Arefin Chowdhury, OSD (Lecturer, Education), Directorate of Secondary and Higher Education, Dhaka, Bangladesh
7	Md. Safayet Alam, OSD (Assistant Professor, Physics), Directorate of Secondary and Higher Education, Dhaka, Bangladesh
8	Nazma Purvin, OSD (Lecturer, Mental Hygiene), Directorate of Secondary and Higher Education, Dhaka, Bangladesh
9	Muhammed Mahbubur Rahman, OSD (Lecturer, Education), Directorate of Secondary and Higher Education, Dhaka, Bangladesh
10	Abu Nayeem Mohammad Salauddin (Lecturer, Educational Administration), , IER, Dhaka University (on Education Leave)
11	Ranjit Podder, OSD (Assistant Professor, English), Directorate of Secondary and Higher Education, Dhaka, Bangladesh
12	Sanjoy Kumar Mazumder, OSD (Lecturer, English), Directorate of Secondary and Higher Education, Dhaka, Bangladesh
13	Mst. Shaila Banu, OSD (Lecturer, Physics), Directorate of Secondary and Higher Education, Dhaka, Bangladesh
14	Sheikh Mohammad Ali, OSD (Lecturer, Education), Directorate of Secondary and Higher Education, Dhaka, Bangladesh

It will be ensured that the researchers have their consent of participation before they start their research; guarantee confidentiality of data and individuals; avoid unnecessary deception; pose no risk to any participants; and their behaviour consistent with the Treaty of Waitangi obligations.

If any complications arise at any stage of the research, the ERHEC is advised to contact Mr. Md. Nazrul Islam, Joint Secretary & Project Director, TQI-SEP (Phone: 9562228, Email:nazrul@tqi-sep.org).


(Professor Md. Noman Ur Rashid)
Director General
Directorate of Secondary and Higher Education
Shikkha Bhaban. Dhaka-1000

APPENDIX C

Telephone: +64 3341 1500 Extn 52018, 008801715249959

E-mail: msb73@uclive.ac.nz, shlbn56@gmail.com

Date:



The role of practical work in teaching and learning physics at secondary level in Bangladesh

Information letter for Head Teachers (Principals)

Dear Head Teacher

My name is Mst. Shaila Banu (Lecturer, Officer on Special Duty, Directorate of Secondary and Higher Education, Bangladesh). I am currently studying for Masters of Education at the College of Education, University of Canterbury, New Zealand. As a part of my study, I am undertaking a project to investigate the role of practical work in teaching and learning physics at secondary level in Bangladesh. My supervisors for this research are Dr. Lindsey Conner, Associate Professor, Deputy Pro-Vice Chancellor, College of Education, and Dr. David Winter, Lecturer, School of Sciences and Physical Education, College of Education, University of Canterbury.

I would like to invite a teacher from your school to participate in this study. This will include the following:

- I will observe the teacher three times in his/her classroom teaching, and two times in practical classes. I would like to receive the lesson plans for each class.
- I will interview the teacher once after the first participant observation and once after the last participant observation. I will provide the teacher with probable interview questions before hand so that he/she will have enough time for thinking in order to give detailed information about the topic. Each interview will take approximately 30 minutes.

While observing, I will take some written notes. Both of the interviews will be recorded, and I will give the teacher a copy of the written transcript of both interviews, so that he/she will be able to add further comments or delete comments if he/she wishes.

I am interested in working with a teacher at your school because of the level of experience and expertise of the physics teaching staff, and comparatively better results in the Secondary School Certificate (SSC) examinations, as identified by the District Education Officer in response to my request for potential participants. Participation in the study is voluntary. If you agree to a teacher from your school participating, he/she will have the right to withdraw from the project at any time without penalty. If they withdraw, I will use my best endeavours to remove any of the information relating to them from the project, including any final publication, provided that this remains practically achievable.

I will take care to ensure the confidentiality of all data gathered for this study. The results of this study may be submitted for publication to national or international journals or presented at educational conferences. I will take care to ensure the anonymity of all teachers and the school involved in the study in all reports and publications of the findings. All participants and their Head Teacher will receive a copy of either the full report or a summary of the findings of the study. All raw data of this study will be securely stored in a password protected computer and/or locked storage for a minimum period of five years following completion of the project and then will be destroyed.

If you have any question about the study, you can contact me (details above). If you have any complaint about the study, you may contact the Chair of the Educational Research Human Ethics Committee, University of Canterbury, Private Bag 4800, Christchurch, Email: human-ethics@canterbury.ac.nz, or Mr Md. Nazrul Islam, Joint Secretary & Project Director, TQI-SEP (Ph: 9562228, nazrul@tqi-sep.org).

If you agree to allow a teacher from your school to participate in this study, please complete the attached consent form and return it to me in the addressed envelope provided.

With kind regards

Mst. Shaila Banu

APPENDIX D

Telephone: +64 3341 1500 Extn 52018, 008801715249959

Email: msb73@uclive.ac.nz, shlbn56@gmail.com

Date-



The role of practical work in teaching and learning physics at secondary level in Bangladesh

Information Letter for Teachers

Dear Participant

My name is Mst. Shaila Banu (Lecturer, Officer on Special Duty, Directorate of Secondary and Higher Education, Bangladesh). I am currently studying for Masters of Education at the College of Education, University of Canterbury, New Zealand. As a part of my study, I am undertaking a project to investigate the role of practical work in teaching and learning physics at secondary level in Bangladesh. My supervisors for this research are Dr. Lindsey Conner, Associate Professor, Deputy Pro-Vice Chancellor, College of Education, and Dr. David Winter, Lecturer, School of Sciences and Physical Education, College of Education, University of Canterbury.

I would like to invite you to participate in this study. This will include the following:

- I will observe you three times in your classroom teaching, and two times in practical classes. I would like to receive the lesson plans for your each class.
- I will interview you once after the first participant observation and once after the last participant observation. I will provide you with probable interview questions before hand so that you will have enough time for thinking in order to give detailed information about the topic. Each interview will take approximately 30 minutes.

While observing, I will take some written notes. Both of the interviews will be recorded, and I will give you a copy of the written transcript of both interviews, so that you will be able to add further comments or delete comments if you wish.

I am interested in working with you because your experience, skill and expertise in teaching physics have been identified by the District Education Officer in response to my request for possible participants. I hope that science education will be benefited from your rich experiences. Participation in the study is voluntary. If you participate, you will have the right to withdraw from the project at any time without penalty. If you choose to withdraw, I will use my best endeavours to remove any of the information relating to you from the project, including any final publication, provided that this remains practically achievable.

I will take care to ensure the confidentiality of all data gathered for this study. The results of this study may be submitted for publication to national or international journals or presented at educational conferences. I will take care to ensure your anonymity and that of your school in all reports and publications of the findings. All participants will receive a copy of either the full report or a summary of the findings of the study. All raw data of this study will be securely stored in a password protected computer and/or locked storage for a minimum period of five years following completion of the project and then will be destroyed.

If you have any question about the study, you can contact me (details above). If you have any complaint about the study, you may contact the Chair of the Educational Research Human Ethics Committee, University of Canterbury, Private Bag 4800, Christchurch, Email: human-ethics@canterbury.ac.nz, or Mr. Md. Nazrul Islam, Joint Secretary & Project Director, TQI-SEP (Ph: 9562228, nazrul@tqi-sep.org).

If you agree to participate in this study, please complete the attached consent form and return it to me in the addressed envelope provided. I am looking forward to working with you and thank you in advance for your contributions.

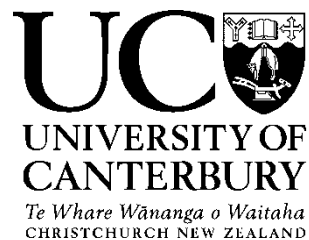
With kind regards

Mst. Shaila Banu

APPENDIX E

Telephone: 0064 3341 1500 Extn 52018,
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Email: msb73@uclive.ac.nz, shlbn56@gmail.com



The role of practical work in teaching and learning physics at secondary level in Bangladesh

Consent Form for Head Teachers (Principals)

I have been given a full explanation of the project and have been given an opportunity to ask questions about the project. I understand what will be required of me and of my physics teacher(s) if I allow the researcher to conduct the study here in my school and I also know that the participation of the teacher(s) is voluntary and they can withdraw themselves from the research at any stage without penalty.

I understand that any information or opinions my colleague(s) will provide, will be kept confidential to the researcher in a way that my school and colleague(s) will not be identified in any published and reported writing; and data collected for this study will be kept under lock and key in a secured place.

I understand that I will be sent a report on the findings of the study to my Email/postal address given below. If I require further information, I can contact the researcher Mst. Shaila Banu; and if I have any complaints, I can contact Mr. Md. Nazrul Islam, Joint Secretary & Project Director, TQI-SEP (Phone: 9562228, Email: nazrul@tqi-sep.org) or the Chair of the Educational Research Human Ethics Committee, University of Canterbury, Private Bag 4800, Christchurch, Email: human-ethics@canterbury.ac.nz.

By signing below, I agree this research to be conducted in my school.

Name:

Date:

Signature:

Cell/ Phone Number :

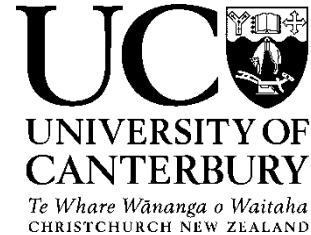
Email/Postal Address :

Please return this completed consent form to ----- in the envelope provided by 15/12/2010.

APPENDIX F

Telephone: 0064 3341 1500 Extn 52043,
008801715249959

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The role of practical work in teaching and learning physics at secondary level in Bangladesh

Consent Form for the participating teachers

I have been given a full explanation of the project and have been given an opportunity to ask questions about it. I understand what will be required of me if I agree to take part in the project. I understand that I will be observed while teaching in the classroom and also in practical classes; will be interviewed for around half an hour; and the documents related to my teaching will also be examined. I know that my participation is voluntary and I can withdraw myself at any stage of the research without any penalty.

I understand that any information or opinions I will provide, will be kept confidential to the researcher and to the people directly related to the study in a way that I will not be identified in any published and reported writing; and data collected for this study will be kept under lock and key in a secured place.

I understand that I will be sent a report on the findings of the study to my Email/postal address given below. If I require further information, I can contact the researcher, Mst. Shaila Banu; and if I have any complaints, I can contact Mr. Md. Nazrul Islam, Joint Secretary & Project Director, TQI-SEP (Phone: 9562228, Email: nazrul@tqi-sep.org) or the Chair of the Educational Research Human Ethics Committee, University of Canterbury, Private Bag 4800, Christchurch, Email: human-ethics@canterbury.ac.nz.

By signing below, I agree to take part in this research project.

Name:

Date:

Signature:

Cell/ Phone Number:

Email/ Postal Address :

Please return this completed consent form to ----- in the envelope provided by 15/12/2010.

APPENDIX G

Main interview questions

For my research, the secondary school physics teachers are the respondents. For the purpose of data collection, I will conduct semi-structured audio-taped interviews with the respondents. Here are the probable questions for the interview, which can be rearranged, or some new questions can also be added, if necessary. I will use around eight open-ended questions to consider their teaching, which will be supplemented by additional probing questions. The questions are as follows:

- 1) What do you understand by teaching and learning physics at secondary level?
- 2) What pedagogies do you use for teaching physics?
- 3) What kinds of activities do you provide for your students?
- 4) What is the role of practical activities in teaching and learning physics, according to you?
- 5) How often do you ask your students to conduct practical activities?
- 6) Can you give me some examples of the types of practical activities you or your students have done?
- 7) How important is it for the students to do practical activities themselves to help them learn physics concepts?
- 8) According to you, what factors enable you to teach well?
- 9) According to you,
 - a) What factors hinder teachers to conduct practical work?
 - b) What inhibits students to participate in practical work?

APPENDIX H

Probing questions

The main interview questions will be supplemented by the following probable questions:

- 1) Between the subject matter knowledge and the pedagogical knowledge, which one is the most important skill for teaching physics? Why?
- 2) Providing the content knowledge of physics using only the lecture method is enough for making students understand. Do you agree or disagree? Why?
- 3) Do you agree or disagree with that practical work makes physics teaching easier? Why?
- 4) Providing theoretical knowledge of physics along with practical activities can ensure effective learning of physics. Give your opinion.
- 5) How important is it for the students to do practical activities themselves to help them learn physics concepts? Why?
- 6) Inquiry-based knowledge is necessary for conducting practical class. Do you agree or disagree?
- 7) Practical work makes lessons interesting. What do you think?
- 8) Do you believe that practical activities increase students' motivation towards learning? Give reasons for your answer.
- 9) Does conducting practical work make it difficult to control the class? Why, or why not?
- 10) Do the teachers need training for effectively conducting practical work in school? Why?
- 11) How many physics classes do you take per week?

- 12) Do you take practical classes?
- 13) Are there laboratory assistants or demonstrators in your school for conducting physics practical classes?
- 14) How many practical classes do you or the demonstrators take per week?
- 15) Is there any specific laboratory for physics practical work in your school?
- 16) If no, then where do you conduct practical classes?
- 17) Are there adequate laboratory equipments in your school?
- 18) Do you or the demonstrators face any barrier to conduct practical classes?
- 19) If yes, then what are the barriers?
- 20) What are your suggestions to reduce these barriers?