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An Investigation of Pakistani University Teacher-educators' and Student-teachers' perceptions of the Role and Importance of Inquiry-based Pedagogy in their Professional Learning Experiences in Initial Teacher Education

By

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Abstract

This research is motivated by a paradigm shift in Initial Science Teacher Education in Pakistan, which places emphasis on the use of inquiry-based pedagogy as a key method for improving student-teachers' understanding of science. In the light of this key role for inquiry-based pedagogy, this study explores the perceptions of teacher-educators and student-teachers who are participating in an initial teacher education (ITE) program in a university in Pakistan. The main aims of the study are to explore (a) their perceptions about the components for inquiry-based pedagogy which are required to be undertaken properly in the classroom; (b) their perceptions of the role and importance of inquiry-based pedagogy and (c) their perceptions of the barriers that impede the practice of inquiry-based approaches.

The study uses a methodological triangulation to gather data from science teacher-educators and student-teachers, employing four research tools: a teacher-educators' questionnaire, a student-teachers' questionnaire, semi-structured interviews with 20 science teacher-educators, and two focus groups with small groups of science student-teachers. Though, the researcher's role as an insider helped in collecting robust and extensive data due to a personal familiarity with the native setting, it also brought challenges in conducting the teacher-educators' interviews. The analysis of data from both teacher-educators and student-teachers converged on the overarching themes of the role of inquiry-based pedagogy in ITE, the relationship between inquiry and science literacy and the barriers impeding the practice of inquiry-based pedagogy.

Overall, it became clear that the conceptualisation of inquiry-based learning with teacher-educators and student-teachers was rather limited. Nonetheless, the results of this study indicate that most teacher-educators were positive about the role and importance of inquiry-based pedagogy in ITE. The majority of teacher-educators appreciated their role as a facilitator of the learning process using inquiry and reported that they had developed an appreciation of the benefits of teaching science using inquiry-based pedagogy. Furthermore, teacher-educators strongly indicated an intention to use inquiry-based science teaching strategies in ITE in science though they tended to rely on questions as their main activity rather than using a range of inquiry-based instructional strategies. Moreover, the majority of teacher-educators reported that continued practice in teaching science courses and/or teaching method courses had contributed to their developing a fair understanding of inquiry-based pedagogy in science. The teacher-educators and student-teachers appreciated that inquiry-based pedagogy should be used in ITE because it helps in developing learning. The teacher-educators responded positively regarding the role of inquiry in developing

science literacy and in enhancing the procedural understanding of student-teachers in science. Though most of the findings were supported by student-teachers' responses from student-teachers' questionnaires and focus groups, a gap was noted between the teacher-educators' perceptions of the use of inquiry-base pedagogies and the student-teachers' perceptions of their actual experiences in the science classroom in the responses given in the student-teachers' focus groups.

The results indicate that a majority of teacher-educators and students reported several serious barriers to using inquiry-based pedagogy. These were exam-based assessment, text-based curriculum in science courses, insufficient time, a lack of resources and a lack of university support. Furthermore, the majority of teacher-educators reported that the curriculum allows only limited exposure to inquiry when teacher-educators are burdened with a large teaching load as well as a shortage of time, limited resources and big classes. The teacher-educators commented that assessment allows them little autonomy in assessing student-teachers' levels of science learning. Consequently, teacher-educators' lack of motivation regarding the process of inquiry-based strategies was reported, which resulted in the reduced use of inquiry-based strategies. Thus, teacher-educators' lack of motivation, difficulties in managing inquiry-based lessons and student-teachers' low levels of confidence in using inquiry were all reported as more minor barriers which could be removed with a continued practice of inquiry-based approaches.

Student-teachers' perceptions from their questionnaires' and focus groups' data support the teacher-educators' perceptions of the role and importance of inquiry-based pedagogy. Moreover, the majority of teacher-educators responded that student-teachers should be encouraged to develop an understanding of the process of inquiry. The emergent themes were discussed in the light of the existing literature in order to highlight similarities, as well as distinctive features in a Pakistani context. Finally, recommendations concerning the importance of inquiry-based pedagogy in science in ITE, the arrangement of resources, teacher-educators' professional development, and preparation for student-teachers are presented for the attention of teacher-educators, the University administration, and Higher Education Authorities.

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Author's Declaration

I declare that, except where explicit reference is made to the contribution of others, that this thesis is the result of my own work. This work has not been submitted for any other degree at the University of Glasgow or any other institution.

Signature _____

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Glossary

The glossary contains some of the terms used in this thesis. It is not exhaustive; rather, the purpose of the glossary is to remove any potential barriers to the reader's understanding by clarifying meanings which were intended by those involved in the study, particularly for readers less familiar with inquiry-based approaches to ITE in Pakistan. It is acknowledged that some of the following definitions will be contestable in other contexts and that there are contradictions evident between different (and even within some of the same) areas. In retrospect, it appears that this may have had the potential to send mixed messages to those involved; these issues have been raised in this thesis.

Terms or Acronyms	Meaning
Teacher-educators	Teachers who are teaching a science course including teaching methods of science courses or both in ITE programs at university of X. I call teachers or teacher-educators in my thesis. These terms are interchangeable.
Student-teachers	The prospective teachers and trainee students in the ITE program at the University of X. I call students or student-teachers in my thesis. These terms are interchangeable.
Inquiry-based Pedagogy	A way of teaching that helps student-teachers achieve scientific understanding by combining scientific knowledge with reasoning and thinking skills. The role of the teacher is to act more as a facilitator of learning than as an instructor.
IBL	Acronym for Inquiry-based Learning
ITE	Acronym for Initial Teacher Education in science
Professional Development	Also known as continuing professional development (CPD), the process by which development and training needs are identified and agreed. Effective PD is based on self-evaluation and personal reflection related to the relevant professional standards, involving high quality dialogue within a culture of improvement, alternative timescales for review, and evidence of impact on professional practice and pupil learning.
In-service Training	The training received by teacher-educators during their jobs in the context of ITE in Pakistan.
Science Literacy	Knowing and understanding scientific concepts and science processes so that student-teachers are equipped for personal decision making, participation in civic and cultural affairs, and economic productivity
Procedural Understanding	Describes the understanding of ideas about how the sciences gather evidence, which in turn underpins an understanding of how to proceed in scientific investigations.
Assessment	Assessment is the process of evaluating how effectively learning is occurring. This process may be undertaken internally by teachers, by learners, by learners and teachers collaboratively, or by learners in collaboration with one another; or, it may be conducted as part of an external process, for example for certification and qualifications or as part of a national monitoring system.
BT	A teacher-educator who teaches science and science method courses in ITE programs at the university of X in Pakistan.
ST	A teacher-educator who teaches only science courses in ITE programs at the university of X in Pakistan.

Chapter 1

Introduction and the Context for Investigation

1.1 Introduction

This study explores teacher-educators' and student-teachers' perceptions about the role and importance of inquiry-based pedagogy, in their professional learning experiences in ITE at a Pakistani University. This first chapter begins by presenting the motivations of the author which have emerged from my own personal, professional and academic life. These motivations have led me to wish to undertake this research. The second section of this chapter reflects on the research questions that underpin the study and explore why these research issues matter in the particular context of Pakistan. The chapter ends by setting out the organization of this thesis.

1.2 Personal, Professional and Academic Motivation

As a child, I was a keen student of science. Throughout my school life, this interest remained with me and when I left school, I studied science education at undergraduate and postgraduate levels. All the way through my schooling in Pakistan, I was taught traditionally, by a combination of lectures and teacher-led activities. Though these approaches to learning and teaching enabled me to memorise information and to pass my examinations, I always believed that my schooling did not develop a deep enough understanding of science concepts and thinking skills in me.

As a new graduate, I started teaching at university; when I spoke with my student-teachers about their own experiences of school science, I received a variety of responses. Their own reminiscences of learning science at their primary and high schools were mixed. For example, student-teachers who went to public sector schools were not confident about their learning experiences in science. They argued that this was because of a lack of opportunities to explore science in action and because of the dominant teaching styles adopted by their teacher-educators. The majority of student-teachers have never had any opportunity to take part in activities such as group learning, asking questions or making presentations in class. From my teaching experiences at a public sector university, I felt

that science in Pakistan was being taught by teacher-educators who were well intentioned but who had little or no training on how they might more actively involve pupils in teaching and learning in science, with the aims of encouraging student-teachers to think more deeply about science, to investigate scientific ideas or to engage independently with scientific problems. It appeared that the teacher-educators themselves had been taught in the same way as they themselves were teaching at present. This is because a majority of the teacher-educators currently teaching in public sector universities had themselves studied in public sector schools. Thus, the majority of science teacher-educators used traditional teaching methods and worked, in many respects, as stereotypical teacher-educators. These teacher-educators emphasised the teaching of knowledge and understanding in the content of text books; for various reasons, they paid little attention to how student-teachers learn. The student-teachers I spoke to recognised that their scientific understandings were often superficial. Many student-teachers, in fact, believed themselves to be scientifically illiterate. Here, science literacy is viewed from two perspectives: student-teachers' understanding of inquiry in science and the abilities that student-teachers should develop based on their experiences with inquiry (e.g. Anderson, 2000; Bybee, 1997).

Despite all these challenges, in my role as a university teacher-educator I tried hard to help my student-teachers to learn deeply in order that they might become more scientifically literate. This challenge was significant. As a teacher-educator determined to do her best by her student-teachers, I began to wonder if my Masters degree in Science Education was sufficient preparation for my teaching, if I really wanted to be an educator who was able to develop effective teacher-educators for the future.

I started my Masters at the University of Glasgow, in 2008, with these questions in mind. Seeking an opportunity to answer some of them, I started exploring the theoretical background of inquiry-based pedagogy and finally decided to explore inquiry-based pedagogy in ITE at a Pakistani university.

These experiences led me to the idea and inspiration that the teacher-educators' and student-teachers' perceptions should be explored, specifically, how they perceive the role and importance of inquiry-base pedagogy in their professional learning experiences and how they see themselves. This might lead them, in turn, to explore how they could implement inquiry-based pedagogies in science in their current practice. I realized that teacher-educators and student-teachers' views on 'how they teach and learn science

effectively as science becomes a process to understand rather than only a subject to teach' should also be explored. I thought that this would be likely to provide a baseline for researchers in Pakistan to investigate the teacher-educators' and student-teachers' perceptions. Until now, no prior study has researched inquiry-based pedagogy in ITE in Pakistan by exploring teacher-educators' as well as student-teachers' perceptions.

My approach to teaching, whereby student-teachers are central to learning, encouraged me to build a broader understanding of teaching, by illustrating the relationships between various aspects of teaching practice, both within and beyond the classroom. Another motivation to work on inquiry-based pedagogy in ITE is that teaching is considered a highly feminised profession in the Pakistani context. For the past couple of decades, females have increasingly joined the teaching profession, particularly in the private sector. Many studies have examined the high entrance of females into the teaching profession; they have also pointed out an increased number of female student-teachers enrolled in ITE in universities in Punjab (e.g., Khan and Saeed, 2009; Khan, 2012). I myself have been a female teacher-educator of science education in ITE in a university, so this was of great interest to me. I feel that teacher-led methods in ITE might influence the student-teachers' teaching practice in future. Thus, my own experiences from my school days, my post-graduate studies and my teaching all gave me a shared basis for understanding and an impetus to explore inquiry-based pedagogy.

1.2.1 Masters to Doctoral Journey

I completed an MSc Inter-disciplinary Science Education and Communication dissertation in 2009, on 'Problem Solving Teaching: A Study of Mathematics Teachers in Pakistani Schools' at the University of Glasgow, UK. Though the study was a small scale piece of research, based on a cross sectional survey of mathematics teachers, it provided me with a strong theoretical and research background as well as some useful findings in the local context of Pakistan. The teachers' perceptions indicated that they understood the fundamental elements of problem solving teaching methods in mathematics education; they also appreciated the value of these methods in their teaching. The teachers' views also indicated that they found difficulties in implementing problem solving pedagogies, however, because of a lack of training through the ITE programmes. Having been encouraged by the successful completion of my dissertation, I developed an interest in new and challenging pedagogies in ITE, for example, inquiry-based pedagogy. I decided to

explore inquiry-based pedagogy in teachers' and student-teachers' professional learning experiences at a doctoral level, and in doing so, to involve a large sample of teachers as well as student-teachers, spend extensive time doing field research and to employ questionnaires as well as interviews to explore teachers' and student-teachers' perceptions of inquiry-based pedagogy in science teacher education, and its role and importance in Pakistan.

1.3 Problems in Initial Teacher Education in Pakistani Context

In Pakistan, as with anywhere else in the world, initial teacher education (ITE) programmes are considered by teacher-educators to be a privileged opportunity to develop student-teachers in science. In recent years in Pakistan, more than 30% of the students after finishing their higher secondary school are likely to enter into the ITE programmes (Khan & Saeed, 2009; Ullah, 2010). This study explores the teacher-educators' and student-teachers' perceptions involved in ITE; therefore it is helpful to look at the key reasons for student-teachers to enter into ITE programmes in Pakistan. Firstly, teaching is becoming enormously popular as a profession. The reason for this is that the number of schools in the private sector has been steadily increasing. The teaching jobs are available in the private sector too, particularly for females. This makes the teaching profession a very common and a popular choice of career (Ali, 2008; Mohammed, 2008; Khan & Saeed, 2009).

Secondly, people believe that teaching does not require any special expertise or knowledge to begin with. The entry requirement to the private schools, especially, do not require teachers (entering into their early teaching) to have any professional training or qualification. Therefore, people can easily get a teaching job, especially as a primary teacher, due to the increasing numbers of private schools (Akhter, 2009; Khan, 2011). Though it is difficult to enter the public school system without any recognized training, anyone can get through easily enough if they have passed at least Secondary School with at least one year or more recognised teacher training qualification for example, B.Ed. (Mohammed, 2010). Thirdly, from my experiences as a teacher-educator in a Pakistani university, I can say that many students are just keen to go to university; not necessarily to become teachers.

Fourth, a large majority of those who do not qualify for professional universities or are low in merit (a high criterion is set by the professional universities for example, Science, Medicine, and Engineering) seek to study ITE, particularly on teacher education courses at

universities. Therefore, student-teachers with low academic achievement tend to enter teacher education programmes. In sum, all these reasons contributed into the demand for teachers which has also increased the number of ITE and teacher training institutes in the public sector as well as in the private sector.

This study has its roots in my work in a university in the Punjab province of Pakistan. In this university, teacher education courses are usually taught as a compulsory subject in each year of undergraduate studies. There are four reasons behind selecting a university that offers specialisation in teacher education: (a) I formerly taught in a university that offers teacher education programmes in each program of study, so the research will be likely to help me to understand and improve my teaching practices; (b) this university sponsored my study (M.Sc. and PhD) therefore my study will likely help to understand the processes of teacher education there; (c) the teachers and student-teachers at this university, in general, contribute more towards teaching and learning knowledge than any other universities because it is a specialist university in teacher education (Khan & Saeed, 2009); this university produces a high proportion of prospective science teachers in Punjab province; and (d) this university is located in the Punjab, a province of Pakistan which makes a large contribution to the country because the overall level of education in Punjab is higher than in other provinces.

Teacher education programs which have proven high up to standard of teaching and effective pedagogies can help graduates to contribute more effectively in their prospective teaching, as well as helping to develop pedagogy at universities. Though ITE programmes have been producing a large number of teachers, a difficult phenomenon for science teacher-educators as well as science student-teachers is that the transmission style of teaching science is not enough to help student-teachers to deepen their learning of science in ITE, particularly in Pakistan. Rather, this dominant style of teaching results in rote learning to pass the examination (Ali, 2008; Akhter, 2009).

In addition, the extent to which ITE in universities addresses the quality of teaching as well as quality of teacher education programmes is a prime topic for debate in Pakistan. The quality of teacher education, which must be considered to be a key factor in any education system, is poor in Pakistan (e.g., Khan, 2012; Mohammed, 2008). It suffers from the lack of adequate training programmes or professional development program, the weak emphasis on teaching practice and non-existence of any proper support or monitoring systems for student-teachers. In the absence of any accredited body to certify teachers, the mere acquisition of a degree in ITE is considered to be sufficient to apply for the teaching

profession in the public sector (Mohammed, 2008; Ahmed, 2011; Khan, 2012). However, the private sector is independent in most of their activities and more organised than that of the public sector (Akhter, 2009; Memmon, 2010)

Because of the acuteness of the problems discussed above, inquiry-based teaching methods have been recommended by professionals (NRC, 2000; Anderson, 2002; Khan, 2012) to help student-teachers to improve their learning in science education as well as to widen their interest in science and develop their personal scientific literacy. Inquiry-based approaches include open-ended practical activities in science, and are associated with the development of thinking skills, science literacy and positive learning outcomes. Thus, inquiry-based pedagogy is seen as being significant to overcome the obstacles which currently exist in learning and to convince student-teachers of the importance of learning science in a meaningful way.

1.4 Teaching Situation in Initial Teacher Education (ITE)

The history of developments in teacher education in Pakistan suggests a significant quantitative expansion in terms of the number of institutions which have been established over a period of time and a large number of teachers who have been trained at these institutions in Pakistan. Presently, nearly 300 institutions in the public and private sectors offer a variety of teacher education programmes, ranging from certificate courses to PhDs in teacher education (Government of Pakistan, 2009; USAID & UNESCO, 2009). This seems to be an impressive development. However, the quality of teaching and learning in this system has suffered from stagnation, for example, a continuous practice of transmission teaching style and poor performance of teachers has further deteriorated over a period of time (Akhter, 2009; Khan, 2012; Mohammed, 2008). A closer look at the challenges in teacher education suggests that the field has suffered mainly in terms of quality of teaching and teachers' performance. Moreover, various national surveys, studies and reports have indicated a wide range of problems, such as low resources, affecting teachers' performance and quality (Mahmood, 2006). The literature indicates a high level of correlation between the steady decline to the status of teaching profession, particularly poor quality of initial education (for example, transmission style of teaching that does not helpful in developing learning, and lack of teaching practices by students) resulted into teacher-educators and student-teacher into the poor learning outcomes which have been recorded over recent years in Pakistan (GOP, 2002: 2004b).

It is widely agreed that the ITE programmes which are offered at most of the public sector institutions in Pakistan are substandard in that the teachers are too rigid, only transmission styles of teaching with lengthy content, and their lessons lack of student-centred activities. The dominant pedagogy used in these programmes is characterized by chalk-and-talk, and this forces their students to memorize (Elaine, 2005; World Population Foundation, 2009). The motivation for teachers to undertake initial or in-service courses has mainly been in order to attain a certificate/degree or diploma (because of the benefits attached to it in terms of an increase in salary and the prospect of promotion to an upper salary scale). Teacher education programmes, therefore, do not emphasize the need for the personal and professional competencies and qualities which are widely deemed to be embodied in a good or an effective teacher (UNESCO, 2006). All the public and private sector teacher education institutions offer teacher education programmes which meet schools' demands and children's basic learning needs. However, and as a matter of fact, there is a potential for stronger links between teacher education and school needs which has not yet been realized (Mohammed, 2006).

Although teaching is disorganized in most ITE institutes in universities in Pakistan, there has been no serious effort by any government to address some of the critical questions about the relevance of teacher education (for example, teaching methods, curriculum, assessment, large teaching load) to the improvement of the quality of education. At a fundamental level, the necessary link between teacher education and school education remains absent from consideration. Teacher education has been treated as a mundane activity within the education system instead of using it as means to improve the quality of student-teachers' learning in schools. The kind of teaching and learning practice prevalent in the vast majority of public schools classrooms in Pakistan is a manifestation of the huge gap between teacher education at university and the school education system (Government of Pakistan, 2006b; 2004b). Therefore, the gaps between school teachers, university teachers underlying the critical gaps to improve teacher education in the country may be seen as being a failure of implementation of education policy evidence which, in turn, is linked to a serious lack of the will on behalf of the government.

From the above discussion of the situation of science teacher education in Pakistani universities, it can be summarised that teaching is chaotic (lengthy curriculum and large teaching load make teachers performance low) and is without recognised standards (Khan, 2012). Also, it is not surprising to note that inquiry has not yet become a characteristic of science practice and that "in classrooms where it does take place, confirmatory exercises

and structured inquiries are by far more common than guided or open inquiries" (Windschitl, 2002:115). Previous research has suggested that many teachers avoid teaching inquiry-based science because their own experiences have not stimulated their interest in science, and what science is taught in the primary schools is taught mainly through lectures and textbooks rather than through exploration and experimentation (Jarret, 1999). Therefore, it is assumed that the inquiry form of teaching and learning science is probably not practiced in most of the elementary schools today.

1.5 The Research Issues in terms of the Cultural Context

In contemporary teacher education in Pakistan, science teacher-educators do not seem to be assisting student-teachers' learning by using inquiry-based pedagogy for the teaching of science. Many challenges of traditional teaching within the classroom are currently encountered in the public education institutions in Pakistan. The public sector faces criticism from parents and the general public concerning the quality of teaching, poor learning and inadequate classroom environments. The criticisms are that these cannot meet learners' needs and the demands of professional teaching in the 21st century society; in addition, the teachers and students need to develop the importance of science literacy to the future generations in the population (Ali, 2008; Ahmed, 2011; Khan, 2011).

Moreover, there are complaints about current educational practices and university culture, raising questions about poor learning and reduced literacy on science phenomena by a dominant lecturing method, ultimately, preparing student-teachers who are less likely to employ critical thinking, be literate scientifically to understand the importance of science application as well as inquiry-based skills compared with teachers in other advanced countries. Such a situation tends to make student-teachers more passive and more likely to be rote learners because teachers take over the role of a sole knowledge distributor and most likely to stick with transmission style teaching (e.g. Mohammed, 2006; Ali, 2008). According to the current culture in Pakistani teaching, teachers and student-teachers lack the ability to implement inquiry-based pedagogies in ITE because of their limited understanding of the process of inquiry-based pedagogy (Khan, 2012; Varma, 2007). They also find themselves in an inappropriate environment to use inquiry and, therefore, do not develop the confidence, initiative, and abilities required to take part in inquiry-based approaches to learning.

As discussed above, the majority of teacher-educators are unfamiliar with the process of inquiry-based science instruction (Weiss et al., 2001). One reason which has been given for this is that efforts to date in science teacher preparation have centred more on teaching science concepts and principles and their hierarchy of organizing content in science than on learning through exploring (Smith, 2002). Additionally, the literature indicates that the requirements in training student-teachers in inquiry mainly present two challenges: firstly, problem solving pedagogies or inquiry has not been a prominent feature of science teacher preparation in ITE (e.g. Mohammed, 2006; Khan, 2012). Secondly, teacher-educators have never been exposed to effective inquiry-based instruction, and therefore, they do not necessarily understand it (Haefner & Zembal-Saul, 2004). Thus, student-teachers are not prepared to incorporate scientific inquiry into their teaching practices and they are also likely to have a limited personal understanding of the process of inquiry (Khan, 2012). Therefore, the literature suggests that most teacher educators and student-teachers are not confident enough to teach science, especially science through inquiry.

The research problem arises from the existing situation of teaching and culture in ITE in Pakistan. As inquiry is a contested term which has many different interpretations based on teachers-educators' and student-teachers' perceptions according to the contemporary trends in university culture, this research attempts to uncover a variety of the issues related to the problem of defining inquiry-based learning. This will help to refine the focus of the research.

1.6 Purpose/Aspects of the Investigation and the Research Questions

This research aims to explore teachers' and student-teachers' perceptions of inquiry-based pedagogy in the Pakistani educational context. It investigates teacher-educators' and student-teachers' perceptions of inquiry-based pedagogy in their professional learning experiences. Also, the research will examine the challenges faced by teacher-educators and student-teachers which arise from their existing culture and teaching situations. Furthermore, this study will outline and assess the challenges of the university support within the faculty of a university.

The purpose of this study is not to justify inquiry-based pedagogy (for example, to list the advantages and disadvantages of inquiry-based pedagogy). Neither, this study is an attempt to prove or disprove the theoretical basis of inquiry-based pedagogy. This study focuses specifically on two issues. Firstly, it explores teachers and students' perceptions of the role

and importance of inquiry-based pedagogy in ITE. Secondly, this study seeks to investigate teachers' and students' readiness to use inquiry-based pedagogy; for example, if they learn about using inquiry, how feasible inquiry is to teach or apply in ITE. Also, if teachers and students develop their experiences and classroom exposure, how does this enable them to do inquiry-based pedagogy?

The following research questions are addressed:

1 How do teacher-educators perceive the role of inquiry in science in ITE?

   (a) How do student-teachers perceive the role of inquiry in science in ITE?

2 How do teacher-educators understand the role and importance of inquiry in relation to scientific literacy?

   (a) How do student-teachers understand the role and importance of inquiry in relation to scientific literacy?

3 How do teacher-educators perceive the challenges that impede the practice of inquiry-based pedagogy?

   (a) How do student-teachers perceive the challenges that impede the practice of inquiry-based pedagogy in the classroom?

1.7 Aims of the Study

Based on the above, this study explores the following aims:

- To investigate teachers' and students' perceptions of inquiry and inquiry-based pedagogy
- To investigate teachers' and student-teachers' perceptions of the role and importance of inquiry and inquiry-based pedagogy in ITE.
- To identify the perceptions about the challenges that impede the practice of inquiry based pedagogy in ITE.

1. 8 Significance of the Study

This research mainly focuses on educators' and student-teachers' perceptions of the practices of inquiry- based approaches to teaching science through their professional learning experiences in ITE in Pakistan. It is anticipated that the outcomes of the research may contribute to, and provide recommendations for, improvements and further

development of teacher-educators' and student-teachers' learning experiences in ITE in Pakistani universities. This would allow a pedagogical design that helps student-teachers and teachers to develop a rich understanding of inquiry-pedagogy. The study will also investigate how teachers' pedagogical knowledge and practices develop student-teachers as effective teachers for the future.

This research is an innovative study in a university in Punjab (a province in Pakistan) that anticipates suggesting through teacher-educators' and student-teachers' perceptions how to overcome the obstacles in adopting inquiry-based pedagogy and significantly contribute to the development of pedagogy in ITE. As a new university in the Punjab province, it is in the process of instigating reforms and developing into maturity (University of X, 2012; Saeed, 2010), and low performances in teaching and poor learning at university give the researcher a push to research in different areas such as pedagogy, assessment and the curriculum. My focus in this study is to explore the teacher-educators' and student-teachers' perception of the role and importance of inquiry-based pedagogy in their professional experiences. The importance of the teachers' and student-teachers' understanding of inquiry-based pedagogy is developed in the light of the fact that the teacher-educators and student-teachers are likely to say that it is important to promote learning science through inquiry in science teacher education; however, there may be differences when it comes through teacher-educators' and student-teachers' perceptions to what is meant by inquiry in their practices.

1.9 Organization of the Thesis

This thesis is organized into eight chapters, as follows:

Chapter 1 presents a brief overview of the problem, the issues around it and the significance of the research, and sets out the research questions. Chapter 2 presents an overview of teacher education in Pakistan, policy and pedagogy, the practice of inquiry and the challenges of teacher education in Pakistan. Chapter 3 presents a discussion of the problems of defining inquiry, and a working definition of inquiry-based pedagogy is developed. Then the advantages and disadvantages of developing inquiry-based pedagogy are also discussed. Chapter 4 reviews the teaching methods which are used in the Pakistani teaching and learning context and teachers' and student-teachers' perspectives of inquiry-based pedagogy. This chapter also addresses how the cultural context shapes the approaches taken into the science classroom and how far teachers should go using inquiry-

based pedagogy. Chapter 5 outlines the research approaches, the development of the research tools, research participants' methodological steps; the difficulties and ethical issues faced, and the procedures involved in the data analysis. Chapter 6 presents the findings from the questionnaires. Chapter 7 has presented the teacher-educators' and student-teachers' perceptions, as captured through interviews and focus groups. Chapter 8 brings together the results from both questionnaires and the interviews and discusses the findings by returning to the main research questions and the literature. Chapter 9 presents the study's conclusions and recommendations.

Chapter 2

Initial Teacher Education in Pakistan

2.1 Introduction

This chapter presents a brief background of the policies in teacher education in Pakistan. It also addresses the opportunities and challenges presented by the educational policies in science teacher education in Pakistan. This chapter ends explicitly reviewing the situation of the research culture in Pakistani universities and what the expectations to pedagogy in teacher education are.

Before these issues are addressed, there is a need to offer a brief overview of teacher education in Pakistan where the empirical work of this study is placed.

2.2 A Brief overview of Teacher Education in Pakistan

Since Pakistan became an independent country on 14th August 1947, the two Muslim-majority wings in the eastern and north-western regions of British India were carved out. The West wing comprising four provinces: Punjab, Balochistan, Sind and Khyber Pakhtunkhwa (previously known as the North West Frontier Province) and East wing comprising East Bengal. The West and East wings were separated in 1971which created political disturbances in the country, especially, in East Pakistan. The West wing Pakistan came into existence, after a civil war in the distant East Pakistan and appearance of an independent Bangladesh (Ahmed, 2012; Ali, 2011).

Since the independence of Pakistan, a continued focus has been emphasized on the development of education as well as teacher education. Pakistan is made up of four provinces and teacher education and professional development is mainly recognized as a provincial responsibility (Ahmed, 2012). Pakistan's federal government is responsible for teacher education institutions that also play an important role through its Curriculum Wing. Each province has a distinct centralized organizational structure to prepare teachers for each level such as primary, middle and secondary. Currently, there are more than 300 teacher education institutes offering a variety of ITE programmes in Pakistan in the public and private sectors (MoE, 2009; USAID & UNESCO, 2009). A majority of these ITE institutions are situated in Lahore (Capital of Punjab). Figure 2.1 below show the location

of Lahore in the map of Pakistan; where Lahore is situated in the upper part (center) of province Punjab and contribute as one of the biggest economy in Pakistan.

Figure 2.1: Location of Lahore (http://www.infoplease.com/atlas/country/pakistan.html**)**

These teacher training institutes are under the administrative and curricular control of the Provincial Departments of Education. Primary school teachers seeking employment in government schools are trained in Government Colleges for Education (GCEs); Government Colleges for Teachers (GCETs) and Regional Institutes for Teacher Education (RITEs). Since 2004, the Directorate of Staff Development (DSD) has been liable for designing and implementing both initial and continuous professional development (CPD) programmes in all 35 Government Colleges of Teacher Education (GCTEs) in Punjab province in Pakistan (Directorate of Staff Development, 2004). In these programmes, a complete programme of ITE includes common courses, disciplinary courses, education specialization courses, and about one and a half months or more teaching practicum. Those who meet the programme requirements and pass the examination for teacher qualification obtain a diploma/degree. These courses prepare student-teachers to teach common subjects in primary (grade 1-5), secondary (grade 6-10) and post secondary (grade 11-12) schools. However this training is not for subject specialists (Khan & Saeed, 2009; Ali, 2011).

2.3 A Brief History of the Previous Education Policies in Pakistan

After independence, several education reforms were commenced in order to bring about qualitative and quantitative improvements in the education sector. Seven education policies along with five-year plans, ten-year prospective plans and Education Sector Reforms (ESRs) were formulated and implemented. A large number of policies and plans are due to the rise and fall of different governments and sudden political changes (Ahmed, 2012; Sadiqqui, 2007). Therefore, major changes to the education system have been recommended by government from time to time. Though some reforms have been implemented, the system tends to be resistant to change because tradition and customs has been so rigid in their essential aspects. However, these reforms did not improve situation considerably in the former ten years after independence for the reason that reforms were disorganized and uncoordinated due to the upset political conditions of the country (Ahmed, 2012).

National Commission was established in 1959, which recommended that education should be made compulsory up to primary level (years 1-5) by the year 1969 and up to middle level (years 6-8) by the year 1974. The first thorough analysis of education came in the Report of the Commission on National Education in 1959 which presented a realistic approach to the challenge of removing social, economic and political differences (MoE, 1977: 1). The Report put emphasis on quality in general education as well as in teacher education. Educational Extension Centres were established to improve the quality of teaching but failed to introduce new methods of teaching. However, the policy emphasised teacher education in accordance with changing trends and, therefore, the policy suggested establishment of Colleges of Teacher Educators. Unfortunately, the lack of immediate action, poor financial resources and the negative behaviour of different religious and secularist groups created many problems and prevented the implementation of the policy in 1960 (Ahmed, 2009: 2012). So the document remained unimplemented in Pakistani educational history because of the Commission's authoritarian approach and the lack of support on the part of public opinion.

The new Education Policy (1970) revealed that general curriculum dominates that the content of the existing teacher training and professional development programmes. With a view to ensuring adequate teacher preparation, policy proposed that the teachers for primary, middle and high schools should have at least Matriculation, Intermediate, and Graduate qualifications, respectively and have received professional development. Also, the policy suggests that comprehensive programme of professional development need to

begin for teachers to up-grade their qualifications. However, the announcement of the New Education Policy 1970 coincided with political instability in the country as conflict started between East Pakistan and West Pakistan.

Subsequently, a new education policy (1972-80) was introduced in the contemporary Pakistan. This policy aimed at equalizing education opportunities, arresting the decline in educational standards and correcting the growing imbalance between various levels of education like primary, secondary, etc. This policy also emphasised improvement of teaching methods, provision of instructional materials and teaching aids, particularly to primary schools (e.g. Ahmed, 2012; Kamarani, 2011).

The Ministry of Education instigated National Education Policy in 1992, and encouraged the Non-Governmental Organisations (NGOs) to set up resource centres for professional development of teachers. However, National Education Plan (1998-2010) was criticised in many areas, for example, an imbalance in teacher training programmes among the courses pertaining to academic knowledge of the subject, content of school curriculum, teaching methods, teaching practices and curricular activities. Moreover, this policy emphasised on teacher education and gave a comprehensive list of quality inputs, for example, merit based recruitment of teachers, initial teacher training and professional development, provision of career structure, and a system of incentives (Majeed, 2009; Ahmed, 2012). The policy also proposed revising the curricula of content and methodology, and upgrading the quality of initial teacher training programmes by introducing programmes of longer duration at post-secondary and undergraduate levels (MoE, 1998).

In order to strengthen the quality of teacher education, Government of Pakistan implemented teacher educations reform in 2001; also focused on curriculum reforms, improvement in teacher education and professional development (Majeed, 2009:2). In order to achieve all of these target, the Pakistani government took initiatives such as upgrading teacher qualification linked to their pay scales, professional development of teachers at all levels within the education system, continuous curriculum reviewing, updating in collaboration with provincial counterparts, and developing public-private partnerships (MoE, 2001). Finally, it can be noted that Education Policy (2009) accepted the need for curriculum development and assessment in order to face the challenges of globalisation and learning as a lifelong process.

2.4 Opportunities and Challenges by the Educational Policies in ITE

Policies are, in general, responsible for practices to examine the ways in ITE in which student-teachers are prepared to teach in their prospective teaching. Therefore, the role of educational policies on the contemporary teacher education focuses on how policies affect educational progress based on the current economic, social, and educational situation (Ahmed, 2012; Hunzai, 2009; Majeed, 2009).

The literature tells us that the policy documents in Pakistan were the result of extensive research but their implementation left much to be desired. Therefore, neither single policy was successful in achieving its declared goals nor the targets were set for realizing these goals (Ahmed, 2012; Khan, 2008). There were two reasons: Firstly, there was no genuine widespread ownership of policy goals by the majority of stakeholders. Secondly, the strategies and plans to achieve the policy goals were unrealistic and did not have the support of identified and dedicated resources required to achieve the targets (Ahmed, 2012). Thus, there was not any tailoring of goals to relate to the maximum resources available.

Moreover, all policies recommended providing the opportunities for professional development through a training programme to all teachers and training needs will be assessed on the basis of research and training programmes. The provincial governments aimed to draw upon resources from the private sector through public-private partnerships in the areas of teacher education and professional development programmes (MoE, 2009a). Additionally, the National Education Policy (2009a) recommended that the teacher education curriculum will be adjusted to the needs of the school curriculum and should comprise student-centered teaching and cross-curricular competencies. Thus, the education policy (2009) did not show any concrete measures, which have been taken, so far, to put the policy recommendations into action (Ahmed, 2012).

The literature suggests that there are two main factors in ITE determining improvement in teacher education; the level of general education of teachers in the system and the amount and kind of trainings that teachers have received (Beeby, 1977; Darling-Hammond, 2000). As the quality of the teaching is mainly estimated by the quality of initial teacher education the student-teachers receive, therefore, ITE programmes aim fundamentally training teachers to enable them to deliver quality teaching so that their student-teachers can produce high quality learning. So far, the National educational policies, theoretically, refer a direct relationship between the quality of education and the structure of initial

teacher education. As discussed above, all of the previous education policies can be noted conversing about the role of education as a social reform and social development but have been unable to significantly contribute through education and training (MoE, 2009a).

Moreover, the National Plan of Action NPA (1998-2010) recognized the importance of teacher education and acknowledged that "regular training" and continuous professional development was needed for teachers. The NPA (1998–2010) also aimed to increase the effectiveness of education system by institutionalizing the professional development of teachers, teacher trainers, and educational administrators through school clustering and other techniques (GoP, 1998). Lately, National Education Plan (1998-2010), emphasized higher education, technology education and science teacher education keep focusing on curriculum reforms and improvement in teacher education and training (MoE, 2001).

There are certain aspects to be developed by teachers in order to improve their skills and abilities in terms of becoming an effective teacher. The National Education Plan (GoP, 2009) suggests these requirements very clearly in the policy document: "The academic qualifications, knowledge of subject matter, competency, skills and commitment of the teachers have an effective impact on teacher education" (p. 41). By using innovative and creative methods, teachers enhance the quality of their teaching and improve the learning process within the classroom, thereby improving the overall educational infrastructure of the school. The policy indicates the main ingredient of effective teaching. However, Ahmed (2012) argues that the policy lacks guidance on the implementation and monitoring of the quality of teacher education. This makes it harder for student-teachers to get a quality education from an ordinary public or private school.

Unfortunately, all educational policies have been more unlikely to work effectively. Although, all policies have theoretically been focused on the quality of teacher education, those did not provide any guidance for implementation or monitoring of mechanisms. The current educational reforms emphasise teachers' professional development and change in the current practices and teaching situations from teacher-as-dictator to teacher-as-facilitator in Pakistan (Ahmed, 2012). It gives student-teachers a chance to participate in learning as well as get in line with the new ideas. Similarly, Darling-Hammond (1997) explains that the change in teachers' roles from their past practice requires them to incorporate improvisational skills in order to teach with flexibility and the ways in which they have never taught students before.

A critical review on the educational policies in Pakistan suggests that the educational system of Pakistan has been the target of experimentation in the form of policy packages during the past 64 years (Ahmed, 2012). The political instability of governments led to non-implementation of the major recommendations of the educational policies. For that reason, a number of education policy statements remained at the status of seminar recommendations and could never be implemented (Ahmed, 2012; Halai, 2010; Memmon, 2010). This indicates that there had been huge gaps between planning and implementation of education policies. Moreover, literature informs us that the most crucial causes of failure in effective implementation of policies are defective implementation methods, financial constraints, absence of public participation, lack of political commitment and absence of national vision (Ahmed, 2009; Ahmed, 2012; Majeed, 2009). Hence, the majority of government policies and reform efforts have clearly failed to address the economic, social and political dimensions of the problems facing the education system. Moreover, it is a concern of teachers' status and teacher preparation, scarcely any success was achieved (UNESCO & USAID, 2006). This indicates a gap between policy and practice in implementing policy on teacher education and teacher preparation.

2.5 The Structure of Initial Teacher Education (ITE) in Punjab (A Province in Pakistan)

Initial science teacher education programmes (B.Sc. B.Ed.) have been carried in universities and colleges of professional development since 1984 in the province, Punjab. The curricula and academic activities in science teacher education programmes generally include science courses and teacher education courses. Teacher education courses are compulsory component of the programme. Thus, teacher education courses aims to prepare the student-teachers as the prospective teachers for their early years of teaching. Therefore, science educators are required to equip themselves with science subject knowledge as well as pedagogical knowledge. Student-teachers and teacher-educators work collaboratively in implementing Science Teachers Education programmes at undergraduate and postgraduate level at the University of X. These programmes aimed at educating teachers at the tertiary level and integrate ITE and professional development programmes (University of X, 2010). B.Sc, B.Ed programme is of length of 3 years, divided into 6 semesters. In each semester, one or two courses of teacher education are offered.

In general, assessment in universities in Punjab is examination-based (Khan and Saeed, 2009). Assessment of student-teachers in the initial teacher programmes includes

summative test, therefore, student-teachers are required to sit in mid-term (20%) and final-term exam (60%) and (Continuous assessment: for example, projects, essays and fieldwork) assessment (20%) by teachers (University of X, 2012). Examination check/tests the knowledge presented by curriculum and to provide evidence of students' success or failure. Most teachers practising traditional teaching and students have to do rote-learning (Mohammed, 2006). However, textbooks are often criticised for not reflecting the curriculum up to considerable experiences and skill that covers the objectives (Jamil, 2009; Khan and Saeed, 2009; Sarwar et al., 2011). Therefore, all of the important and self-assessment questions or activities (especially the questions focused on inquiry-based skills) are consistently missing (Sarwar et al., 2011). In practice, however, there is little uniformity in the use of these books (Khan, 2011). Table 2.1 shows that detail of the ITE Programs and levels for which student-teachers are prepared as:

No	Program	Entry +Program Duration	Level for which prepared
1	BEd	14 years +1	Primary
2	BSc, BEd	12 year +3	Primary and secondary
3	MA Education	14 years +2	Secondary and Higher
4	MEd	B.Ed+1	Secondary and Higher
5	M.Phil	M.A Education+2	Higher Education
6	PhD	MPhil+3	Higher Education

Table 2.1: Structure of ITE Programmes in Pakistan

2.6 ITE in the Public and Private Sector

Teacher training institutes both public and private offer teacher education programs in Pakistan. Most of the ITE institutes and training colleges are owned by government of Pakistan. Particularly, these programs are not of the calibre and standard that can bring significant change in the level of knowledge and skill of teachers in the public sector (e.g. Ali, 2011; Mohammed, 2006; Iqbal, 2010). Ultimately, it does not bring a measurable impact on the student-teachers' learning and does not develop their interest in science education. Also, the curriculum of teacher education programs fails to develop the required pedagogical skills or subject knowledge that would make these ITE programs worthwhile and valuable (Khan and Saeed, 2009).

In Pakistan, research informs us that the dominant pedagogy used ITE is characterized by chalk-and-talk, memorization or lecture (Elaine, 2005; World Population Foundation, 2009). Also, it is generally perceived that in-service and ITE programmes offered at most of the public sector institutions are of substandard, for example, they are rigid, textbook

and examination-based. The teachers seeking to undertake initial or in-service courses mainly have been achieving a degree because of the benefits attached to it in terms of raise in salary and promotion to upper salary scales. Therefore, ITE in the public sector do not put emphasis on the need for such professional competencies and qualities that an effective teacher embodies.

In the recent years in Punjab, the private sector is increasingly contributing in teacher education. Although all of the public and private sector teacher education institutions in the country offer teacher education programmes, the private sector tends to commercialize teacher education (Gulzar et al., 2005). Therefore a few institutions in the private sector are recognized for designing and delivering quality initial teaching programs based on state-of-the-art knowledge of the practice and profession of teaching.

Moreover, teaching practices are more likely to promote teaching and learning practices in the classroom that make student-teachers participate and engage in the private sector. In private sector, teaching emphasizes in developing conceptual understanding, critical thinking, and problem solving skills in student-teachers (Saleem, 2009). Also, the private universities appreciate the fact that ITE contributes to the development of quality teachers and invests the huge funds on facilities and resources on their student-teachers. This enhances the popularity of the private sector among those who can afford an expensive education. The private sector is leading the public sector and leaves behind the public sector in quality of teaching and teacher education and availability of resources. Also, student-centered teaching approaches are used the private sector and tests them to develop quality learning and practices in teacher education. However, there has been lack of effort in the public sectors to learn from the work undertaken by the private sector.

Moreover, the public sector lacks a necessary link between teacher education and school education at the very fundamental level. Teacher education has been treated as mundane activities within the education system instead of using it as a mean in improving quality of student-teachers' learning in the schools. The kind of teaching and learning practice prevalent in the vast majority of the public schools classroom in Pakistan is a manifestation of the huge gap between teacher education and school education system (GoP, 2006b; UNESCO, 2002b).

2.7 Courses and Initial Science Teacher Education programs

Contemporary science teacher preparation programs in the universities (for example, B.Sc., B.Ed.) require prospective teachers to successfully complete a varying number of courses in sciences in addition to the core of professional courses which typically includes the foundations courses, the methods courses and practice teaching. The science methods course exposes inquiry form of instruction for student-teachers in ITE in Pakistani universities. Research suggests that teaching methods courses have the potential to shape the practice of initial teachers (Aaronson et al., 2007). However, even when science education methods course is required, it is not known how associated this course is with the inquiry-based science learning and instruction.

Research on teaching method courses usually seeks to explore what aspects of inquiry instruction seem to be working well and what aspects are not working well? What factors influence inquiry instruction? This teaching method course mainly deals with inquiry namely: (1) Definitions of inquiry; (2) Basic elements of inquiry-based pedagogy; (3) key features of inquiry, (4) students' learning outcomes using inquiry-based pedagogy (5) lesson planning using inquiry-based instruction or approaches (Prospectus of University of X, 2011). Therefore, this study seeks perceptions of both student-teachers and teacher-educators to look how science methods courses function in developing inquiry-based pedagogy.

Smith and Gess-Newsome (2004) suggest student- teachers to graduate with the understanding of the science as inquiry, it is important to know how the science education methods course syllabi are fulfilling aims of learning and teaching science through inquiry. The literature also indicates that most student- teachers are placed in schools where science is taught by generalists who are required to teach a number of subjects (Hussain, 2011; Mohammed, 2008). Therefore, teachers do not have time to develop or implement inquiry-based instruction for science or to develop innovative strategies to teach science. Thus, it is possible that pedagogy in classrooms might not provide adequate exposure to inquiry-based science for student-teachers (Abell, 2006; Anderson, 1997).

Research addresses inquiry-based learning in initial science teacher education (Newman et al., 2004) and generally points out that the supposed lack of teacher understanding and skills must be addressed in the methods course and that the potential challenges that face future teachers in inquiry teaching must be an explicit part of science methods instruction. Because of the multiple definitions for inquiry in science education literature and in the

classroom practice, examining how inquiry is taught in the science methods course and how the student-teachers respond and understand inquiry-based pedagogy is important in creating a successful teacher education program. However, inquiry-based approaches are not implemented uniformly in the science methods courses or science courses. Therefore, it is possible that inquiry is not uniformly implemented in teaching of all the courses. To date, no research exists that has examined from teacher-educators' and student-teachers' perceptions on the contribution to the science method methods course to developing their understanding of inquiry-based pedagogy in ITE in Pakistan and the development of their pedagogical strategies for teaching science.

2.8 Assessment: The Examination-based Assessment in Pakistan

Assessments are an integral part of pedagogy which determines the destiny of student-teachers and learning for their career. In ITE in Pakistani universities, assessment is greatly influenced by examinations. The examinations are to assess ability, achievement or present performance in a subject; also, examination-based assessment may be used for qualifying for entrance to professions and higher education (Ahmed, 2012; Rehmani, 2003). Since Pakistan came into existence, seven different education policies have been implemented in the country. A review on these educational polices shows that the main thrust of all these policies was to promote quality education and the improvement of pedagogy (Ahmed, 2012). However, the improvement in assessment has not been achieved and is quite unsatisfactory (Rizvi, 2000).

Assessment is used to evaluate the overall system efficiency as well as student-teachers' learning and performance. Also, it provides feedback for improvements at all tiers starting from changes in the classroom to improvements in the national systems (MoE, 2009: 41). In addition, keeping in view the crucial role in determining the impact of pedagogy, examinations in Pakistan have more demerits than merits (Rehmani, 2003). Moreover, modern assessment techniques are not being used to measure student-teachers' achievements and hence dependency on traditional learning processes yields a low quality of education yet, in ITE in Pakistan (Christie and Khushk, 2004; Khattak, 2012).

Firstly, assessments do not judge real competence or genuine educational accomplishment of the student-teachers in Pakistani universities. Instead, Pakistani educational system in universities still encourages those who can best reproduce what they have learnt during lessons and fails those who are unable to do that. It seems as if the whole system of

education revolves around examinations. Such types of assessment and evaluation are narrow in scope and hinder the use of a new pedagogy such as inquiry-based pedagogy (Khan, 2006). To be very specific, Rehmani (2003) identifies the problem that teachers teach for testing [checking students' knowledge], rather than for learning. Thus, the assessment system of examinations reinforces approaches to teaching that reward memorization. Therefore, the student-teachers reproduce more they score higher and better awarded by the examiners.

Research suggests that the current examination system absolutely ignores learners' learning outcomes. However, testing of memorization is measured extensively. Accordingly, it is apparent from the above excerpts that the assessment system suffers from multiple deficiencies such as fostering rote-learning, and not adopting critical or analytical approaches for assessing learners. However, the Ministry of Education (2009:41) has announced that student-teachers' performance should be based on assessing competence in a specialised area that requires skill set. Multiple assessment tools in addition to traditional examinations shall be explored, to ensure the right balance between the uses of formative assessment approaches combined with the summative approach. But implementation has not been taken yet (Ahmed, 2012; Khattak, 2012).

Assessments, particularly in Pakistan, in the form of examinations, mainly focus on easy, straight and very simple questions and they ignore high levels of cognition involved in such items as comprehension, analysis, synthesis and evaluation. Christie and Afzaal (2005) and Shah and Afzaal (2004) examined an increase in the incidence of the recurrence of questions and selected material is tested again and again in university examinations. This leads student-teachers toward memorising the selective content and they are more likely to show good performance in the examination. In this situation, the student-teachers keep focusing on retention and rote memorization as examination tactics. Thus, the quality of teaching in relation to assessment is not satisfactory and the worth of our output at this level is inadequate. Therefore, it needs to explore that skills are required for assessing the learning outcome.

Ahmad and Malik (2001:132) draw attention to the shortcomings of the examination and assessment system. They argue that the assessment system in Pakistan is defective due to the following reasons: firstly, No single body is responsible for assessment. This results in a lack of coordination among the working of these internal and external authorities. Also, exam of different subjects can be scheduled to be written at the same time. Moreover, results are not reliable because student-teachers use deceitful methods and indulging

malpractices in the examination. There is not any monitoring system and deficiencies in marking take places. Furthermore, Qureshi (2005) suggested that the more regularly the evaluations take places; the more will be the level of student-teachers' achievement. Although Education Policy (2009) theoretically valued the student-teachers performance based on specific skills that should be measured through multiple assessment techniques, there are not such assessment criteria in real practice (Khan, 2011).

In addition, research examines the decline in the examination system in Pakistan, its ineffectiveness, and unreliability in diagnosing student-teachers' weaknesses and in assessing their abilities. The design and content of the test papers is such that student-teachers only have to rely on their memories, and this does not have a beneficial effect, on syllabi and teaching practice. Above all, these paper tests lack validity and reliability and does not check students' learning in real (Ali and Reid, 2012; Khan, 2011). Similarly, Ahmad and Malik (2011) also point out that testing is not viewed as a vital component of teaching and is considered quite distinct from teaching and learning as well as practice. In terms of reliability and validity of assessment procedures, Rehmani (2003) pinpoints that reliability and validity of examination papers in terms of coverage of curriculum, selection of paper setters, and lack of training or otherwise of the paper setters and examiners, marking system and preparation of results, are considered uncertain. Moreover, Khan (2011), and Shah and Saleem (2010) also point-out that textbook materials are prescribed by the teacher for their learners to be learnt and explained word by word and sentence by sentence. Most of the time, it is confined to only one text book. Thus all of these practices do not contribute into students' learning; rather, student-teachers become passive recipients of prescribed content knowledge.

Moreover, Kamrani (2010: 7) examined the present assessment system and suggested that examinations need to be repaired at multiple levels such as introduction of a variety of assessment tools for evaluation of student-teachers' learning and for their capacity for further growth and development. Also, Gipps (1994) suggests that the major purpose of assessment is to support the teaching and learning process (Khattak, 2012; Rehmani, 2003). Nevertheless, It seems far from current practices in Pakistan and the main hurdle is that only a few teachers have had proper training in designing tests and variety of approaches to assessment in Pakistan (Mirza et al., 1999).

I think that assessment that promotes rote learning raise student-teachers unconcerned in developing a deep understanding of knowledge. Student-teachers particularly do not sit in classrooms to understand what they have learned but simply want to qualify for the next

grade with passing grades. Also, students are not interested in getting something after a year in one grade, but are eager to gain admission into the higher standard. Kamrani (2010) further explains that it is our classroom situation and assessment approach that reduces that students' motivation. It does not provide students an opportunity to build up innovative ideas, but simply puts the stress upon the students. Therefore, well-designed tests are essential elements of the learning process that strengthen inquiry based abilities and problem solving skills of student-teachers. In sum, Pakistani universities assessment system serves this purpose poorly, resulting in poorly designed test papers that discourage student-teachers those are motivated in using inquiry-based skills (Jamil, 2009).

2.9 Research Culture in Universities in Pakistan: Expectations and Paradigms

ITE programs are an integral part of the contextual cultures and traditions in Pakistan, and they reproduce them through their own acts. Also, ITE contributes to the understanding of how the established research culture is viewed by the teachers and student-teachers themselves. Although ITE programs in Pakistan seem to have no absolute objectives and contents, these are always culturally and socially influenced by the certain social and political situations (Ali, 2011).

Research indicates that Pakistani universities lack a strong research environment, so far, within educational institutions compared to the developed countries. There are two factors important to develop among faculty within universities: personal factors and institutional factors. For example, firstly, personal factors include a lack of understanding of the process of research, and fears of plagiarism that hinder their expansion in the research activities. Secondly, institutional factors involve a lack of incentives by the government, lack of support from university and lack of time in generating research publications (Lodhi, 2010; Mahmood and Shafeeq, 2010). Also, excessive teaching load is another problem that hinders teachers spending time on research activities. Hence teacher education has been facing challenges to strengthen both personal and institutional factors to improve research productivity. So these factors do not let teachers contribute to the research productivity of teacher educators within universities. Therefore, and unfortunately, teacher education in Pakistan is still far from a constructive research culture and not matched with the global trends in the educational research (Lodhi, 2010).

Research on Pakistani culture suggests that personal factors also offer many dilemmas to teachers. Teachers' lack of understanding of the research process hinders in developing a strong research culture as well as academia because both the senior and the young staff at university have not been updated themselves (Lodhi, 2010). They are still deprived of training on research process and the knowledge on how to generate research publications. Also, the lack of encouragement to contributing into research is another problem to faculty. Therefore, teachers feel lethargic in participating in research activities because of lack of time and large teaching load.

The second important factors are institutional factors that present a discouraging situation to engage faculty in research process. I noted through my experience of teacher-educator in a Pakistani university that lack of facilities is a major hurdle in productive research too. A number of researchers who wished to research in science complained that they did not have standardised laboratories and equipment. Teachers do not find any mentoring or collaboration to get support in research because of large teaching load and staff meetings on the organisational matter of university. Overall, it seems that universities do not encourage faculties to develop themselves as a researcher. Therefore, being disappointed from these fruitless efforts, teachers concentrate on earning money by teaching at private universities instead of contributing into research. Moreover, faculties and scholars blamed unreasonable payments and several other handicaps that impede the cultivation of research culture. Thus, there is no concern and appreciation of the research so far in the present regime in ITE in Pakistan (Lodhi, 2010).

Though ITE institutions receive substantial funds from governments to promote research, particularly the Departments of Education, unfortunately these funds are not utilized in a right way in promoting research within the institutes (Memon, 2007; Ahmed, 2012). Therefore, ITE in universities do not gain such status yet to become models of good practice within the area of research as well as academia. Thus, faculties in educational universities seem to fail in developing teacher education through quality research output and dissemination of the lessons learned.

As discussed above, ITE programmes in the universities of Pakistan suffer a number of discouraging personal and institutional factors which hinder strengthening research cultures and teachers as researchers. Moreover, research on teacher change and development indicates that problems producing complications to teachers in the classroom; do not exist in isolation; they are complexly interwoven (e.g. Rodrigues, 2010). Research

suggests that teachers' life and work are socially constructed and powerfully influenced by the choices and constraints of the larger society (e.g. Darling-Hammond, 1996; Hargreaves, 1997; Rodrigues, 2010). The literature suggests that the contextualized and personalized nature of teacher's knowledge influences teaching practices and teachers using ways of thinking and method of teaching inherited from their teachers and school experiences (Boyle et al., 2003). Studies conducted in Pakistan confirm the findings of similar studies from the international contexts, which found teachers as being the product of various influences of their socio-economic, religious and cultural structures (e.g., Ali, 2008; Bashiruddin, 2003; Halai, 2001; Rizvi, 2000). Therefore, research is necessary that emphasise the importance of broadening an approach to educational change.

Moreover, literature suggests that the teacher education system can be better understood in the light of particular culture and society; what happens outside the institute is more important than what happens inside. This underscores the need for recognizing the links between political, socio-economic contexts and pedagogy in teacher education. Thus, it necessitates exploring in-depth understanding of the factors, socio-cultural philosophy that shape the teacher education system, within which teachers are developed. Therefore the cultural dimensions are also important; pedagogy in teacher education must be addressed into the cultural contexts where teachers work (Lodhi, 2010). Thus, research culture needs to explore systemically and in depth in all of these dimensions.

Likewise, the literature suggests that the teachers' total personality is shaped by their prior life experiences and social circumstances in which they live and work (Hargreaves, 2003). Teacher‘s pedagogical beliefs, behaviours and practices are grounded in their unique personality. It can be argues that is teaching style simply a matter of personality. In this context, teacher education and development may be regarded as individual development. Also, it is affected by the social-cultural and political forces to a great extent (Hargreaves, 2003). Hence, it can be noted that education, political and social problems are inseparable to teacher education and their influence cannot be ignored. Training can play an effective role on developing teachers. Although, trainings to teachers can alter teacher to be an effective teacher, ITE programmes require attention to the political and social factors and other variations to promote new forms of practice in educational improvement (Ahmed, 2012).

Additionally, Pakistani universities are expected to play an effective role in both teaching and research in common with trends according to the rest of the world. Unfortunately, teacher education in Pakistan has distanced itself from the global trends in thinking about the teacher education reforms (Ali, 2011; Ahmed, 2012). Recently, departments of education within universities are under constant pressure to increase their research output as a result of recent reforms by the Higher Education Commission of Pakistan (Ahmed, 2012). In conjunction with this, a weak research culture with low engagement in research activities influences the skills, competency of educational researchers, quality of research and teaching carried out in the field of teacher education.

Moreover, research tells us that routine teaching could be considered a secure, convenient and compensated option for teachers due to an unsupportive culture to research activities. Mundane teaching activities can save teachers' time, stress, position and promotion in the school, although these activities do not enhance teachers' professional development or students' understanding of concepts (Lodhi, 2010). Also, it can be noted teacher educators are unlikely to achieve any improvement, if the culture works against the teachers' improvement (Mohammed, 2006). Thus, a poor research and teaching culture make the teachers' self esteem low. Given that such situation, teachers are unlikely to maximise their learning and teaching capacities particularly in using inquiry-based pedagogy.

Research suggests that strong research culture through high research output could cause developing pedagogy and quality of teaching in academia (Hemshely-Brown & Sharp, 2003). Regarding this, improving research within faculties in the Departments of Education should be a top priority for both Higher Education Commission and Universities. Through my experience as a teacher-educator, I agree that the successful development of a research culture largely depends upon the quality of teaching and teacher-educators' positive attitude towards research. It can be noted that a large number of teacher-educators have nothing to do with research or intellectual composition excluding achieving high degrees in education, thesis writing, and submitted for M.Phil and PhD degrees (Lodhi, 2010). As a matter of fact, many teacher educators are noted to close down their research practices, immediately after the completion of their doctoral research. However, they put their emphasis more on teaching in the private sector where they are highly paid being possessed a research degree (for example PhD professors are highly paid in the private sector universities). In conclusion, all these factors, for example, policies and educational plans influence research culture and the development of pedagogy in ITE in Pakistan.

2.10 Chapter Summary

This chapter started by indicating an overview of the educational policies and practices in initial science teacher education in Pakistan. The opportunities and challenges offered by the educational policies and their influence regarding Pakistani science teacher education were discussed. There are divisions of opinions in policy in Pakistani education system. The public schools lack expertise and resources to teach in the public sector institutions as compared to the private institutions. At the same time, the lack of adequate resources such as qualified teachers, appropriate teaching materials and models reduced the quality of learning in ITE in Pakistan especially at the public college and school level. However, quality of teaching in the private universities is far better in comparison with the public universities. Also, this chapter reviewed the situation of research culture in Pakistani universities in terms of expectations and paradigms of pedagogy in ITE. Therefore, government of Pakistan has been undertaking reforms to bring about the effective reforms in ITE in Pakistani universities so that the student-teachers can be developed good teachers and successful researchers. The next chapter addresses the problems in defining inquiry-based approaches and review the related research on advantages and disadvantages of inquiry-based approaches in ITE.

Chapter 3

Inquiry-based Approaches and the Related Literature

3.1 Introduction

This chapter begins by indicating the problems of defining inquiry-based approaches in science teacher education. Then, a working definition of inquiry emerges from the existing research that will later inform the questionnaires and the interview questions used for this research. This chapter also addresses the arguments for and against adopting an inquiry-based approach in science teacher education. This chapter concludes by establishing the focus on the perceptions of the teachers, and of student teachers, on the key aspects of inquiry-based pedagogy in a science teacher education programme.

3.2 The Problems of Defining Inquiry-based Approaches in Science Teacher Education

The meaning of inquiry in science teacher education varies as much as the methods of inquiry themselves (Abell et al., 2001; NRC, 2000; Newman et al., 2004). Though inquiry is generally considered as an approach to learning that involves a process of exploring the natural or material world, inquiry has been defined differently by its promoters and advocates, because everyone focuses on different characteristics of inquiry (Kuhn, 2011; National Research Council (NRC), 2000).

Inquiry-based instruction received considerable attention as a learner-centred approach in the mid-1990s (Blumenfeld et al., 1998), since the National Research Council published a key document guiding science education in the United States of America (NRC, 2000). Thus, inquiry as an activity to learn was long promoted by the NRC:

> Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations... using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results (NRC, 2000: p.12).

This definition of inquiry reflects an understanding of how science proceeds with inquiry and is independent of educational processes. The first part of the definition considers inquiry as being how scientists conduct science. This is commonly known as scientific inquiry. The second part of the definition considers inquiry as how student science teachers

learn science and how scientists work. The definitions of inquiry-based learning in science put the emphasis on science as inquiry; learning as inquiry; teaching as inquiry, or all of the above.

Inquiry as a method of science instruction is considered a frequent theme in science education (NRC, 2000; Bybee, 2000; Chiappetta & Adams, 2000). Thus, most definitions of inquiry illustrate the fundamental components of inquiry such as hands-on experiences, identify and collect appropriate evidence, present results systematically, analyse and interpret results, formulate conclusions, and evaluate the worth and importance of those conclusions where the student-teachers are central to the learning process. Moreover, Dewey's (1938) instructional approach was also based on the belief that learning occurs through diverse experiences and reflective thinking to synthesize those experiences. Dewey (cited in Tompkins, 2001: 32) highlighted the type of learning in inquiry:

> "What children know and what they want to learn are not just constraints on what can be taught, they are the very foundation for learning."

Bateman (1990) suggested that questioning has a fundamental importance in inquiry. The process of inquiry generally starts with questions. Therefore, most definitions of inquiry generally agree with formulating good questions as the core ingredients of inquiry (Lee, 2004; Kuhn, 2010). Moreover, Kahn and O'Rourke (2005) summarise some of the characteristics of inquiry-based learning as follows:

- Engagement with a complex problem or scenario, that is sufficiently open-ended to allow a variety of responses or solutions
- Students direct the lines of enquiry and the methods employed
- The enquiry requires students to draw on existing knowledge and identify their required learning needs
- Tasks stimulate curiosity in the students, encouraging them to actively explore and seek out new evidence
- Responsibility falls to the student for analysing and presenting that evidence in appropriate ways and in support of their own response to the problem

This broad understanding of inquiry makes it quite difficult to give a precise definition. Definitions which focus on the inquiry process match the described framework of an inquiry-based culture but are missing out on certain points which are also important if a full understanding of inquiry is desired. According to Colburn (2000) and Aaronson (2007), the most confusing thing about inquiry is its definition. NRC (2000) suggests "inquiry as questions generated from student teachers' experiences is the central strategy

for teaching science" (p.29). However, many educators have different understanding what is meant by inquiry, believing that the term applies to almost anything they do in the science classroom. Thus, there is a lack of agreement on the meaning of inquiry (Martin-Hauser, 2002). For example, Aaronson (2007) considers inquiry as a teaching strategy to teach skills, while Lederman (2003) equates inquiry with knowledge about investigation. Moreover, Aaronson (2007) defined inquiry as a teaching strategy to motivate learners, in both a hands-on and minds-on sense, manipulating materials to study particular phenomena and stimulate student-teachers by questioning.

In conclusion, inquiry-based learning is a contested term. Particularly in US English, the words 'inquiry' and 'enquiry' can be interchangeable, so that inquiry-based learning (IBL) is exactly the same as enquiry-based learning (EBL). The difference between the two is simply a matter of spelling (Watson, 2008). Additionally, substitute terms for inquiry or synonyms learning, discovery learning and critical thinking (Smith et al, 2007; Newman et al., 2004: Abell et al., 2001). Despite the different terms and differences within these terms, there is some consensus about what constitutes inquiry-based learning; learning itself happens in a similar way as in inquiry-based learning.

3.3 Working Definition of Inquiry-based Learning Compared to Other Approaches

Research provides some insights into defining inquiry, when compared with other approaches. However, the notion of inquiry is confused by equating it with investigative methods of science teaching, self-instructional teaching techniques, or open-ended teaching techniques. This has resulted in an improper use of inquiry as a paradigm on which to base an instructional strategy. Though Inquiry-based learning shares many characteristics with other learning approaches, for example open learning or discovery learning, all the activities in inquiry-based methods are systematised (Kuhn, 2010; Newman et al., 2004: Abell et al., 2001). Thus, inquiry is an approach to learning and method of instruction on its own.

Moreover, inquiry can be compared specifically to some other learning approaches. For example, open learning resembles a guided inquiry, as student-teachers formulate their own problems or pose questions to investigate (Gordon and Brayshaw, 2008). Thus, the common feature between inquiry and open learning is engaging students in science investigation. Moreover, student-teachers are encouraged in active learning to learn largely on their own, through active involvement with concepts and principles (Ausubel, 1969).

Correspondingly, students are encouraged to learn in inquiry-based learning by inquiring and with active engagement in essentially open-ended and student-centred hands-on activities.

In critical thinking, a learner plays a similar role as in inquiry, in terms of developing thinking. I believe that inquiry helps to make the thinking process visible, as in critical thinking, and also looks independently at the gaps or limits in learners' thinking. Baumfield (2007) suggested inquiry is an effective tenet to promote critical thinking. Critical thinking raises vital questions and problems, formulating them clearly and precisely. Inquiry and critical thinking possess a strong common feature in terms of raising questions. This indicates that the higher the level of learning, the higher the level of thinking and in-depth inquiry that a learner can achieve. Also, collaborative learning offers opportunities to discuss within a group or among peers that lead to difficult concepts being more easily discovered and understood (Cobb, 1994).

Moreover, inquiry-based learning is not entirely identical with problem-based learning (PBL) (Watson, 2008). Rather, problem based learning shares some aspects with IBL. Exactly where the boundary is set with PBL as a sub-set of IBL is not stable or clear. PBL tends to be structured around a problem which is given to the student teachers, whereas IBL can also encompass activities where students come up with the problem themselves. Definitions of PBL specify that students work in the form of groups to address science problem (e.g. Kahn et al., 2004), whereas IBL can also involve students working on their own as well as in the form of groups (Pawson et al., 2006). The diagram below shows that problem-based learning is a subset/group of inquiry-based learning, which is placed within active learning.

Figure 3.1 Relationship between IBL, PBL and Active learning (Smith et al., 2007:3).

Although the same statements could be made for some other learning strategies, inquiry-based learning is not matched entirely with any one of the other learner-centred approaches. In sum, inquiry learning may be considered an umbrella category that encompasses several other inductive teaching methods, such as problem-based learning, or may be a subset of some learning strategies, such as active learning (Lee, 2004). Lee suggested that inquiry is also consistent with interactive lecture, discussion, simulation, and independent study, and highlighted the commonalities between inquiry and other approaches as: "Probably the only strategy that is not consistent with inquiry-guided learning is the exclusive use of traditional lecturing" (p. 10). So, various concepts are interrelated; many characteristics of learning have been found to have much in common with other innovative learning approaches.

Finally, it is hard to establish an agreed definition of inquiry after looking at various definitions of inquiry from different perspectives. However, looking at the literature, resources and research, inquiry-based learning is not perfectly identical with the other approaches to learning, because inquiry has distinct features and has its own core ingredients (e.g. Lee, 2004). Therefore, I shall illustrate a working definition of inquiry-based learning on the grounds of these commonalities and differences, which inform my research thesis in the questionnaires and interviews (See Appendix A, B, C and D):

> A way of teaching that helps students achieve understanding in science by combining scientific knowledge with reasoning and thinking skills. The role of the teacher is to act more as a facilitator of learning than as an instructor.

Here, a summary is presented of the key features of inquiry that led to the definition of my research. Though inquiry is perceived as a disputed term, it still offers a broad understanding of the key aspects of inquiry in science teacher education. The process of inquiry-based learning usually starts with questions or a problem; a set of observations to be explained, and then solutions presented to peers. Inquiry-based learning shares many features with other inductive approaches; it covers several other inductive teaching methods, for example problem solving, and discovery approaches. Hence, inquiry teaching is defined differently by different promoters. However, the key feature is that it is a learning process that is driven by enquiry. In conclusion, a key definition of inquiry-based learning informed my research instruments with the features of inquiry, to help student-teachers achieve understanding of science, and to develop thinking skills.

The following section discusses the advantages and disadvantages of adopting inquiry-based learning in science teacher education and is based on a review of the literature.

3.4 Arguments For and Against Adopting an Inquiry-based Approach to ITE in Science

3.4.1 Advantages of Adopting an Inquiry-based Approach

This section reviews the advantages of inquiry-based approaches to teaching and learning. As discussed earlier, inquiry-based learning in science has been characterised in a variety of ways over the years (NRC, 2000; Newman et al., 2004: Abell et al., 2001; Bybee 2000). Moreover, the literature suggests that inquiry-based learning in science complements the nature of science instruction (NRC, 2000). Therefore, inquiry-based learning is more than just a teaching tool, and interconnects with a guiding set of principles and goals (Colburn, 2000). Thus, inquiry as a form of science instruction is advantageous in teaching the concepts and processes of science.

It is also noteworthy that most research on inquiry-based pedagogy in teacher education shed light on the benefits of inquiry, and promoted the use of inquiry-based approaches in science teaching (e.g., Abell et al., 2001; Anderson, 2002; NRC, 1996; Blumenfeld, et al., 1994; Krajcik, et al., 1994; Newman et al., 2004). Moreover, the nature, scope and importance of inquiry-based teaching have been promoted in various documents of the new National Curriculum for Science, particularly in Pakistan (GOP, 2006). In looking at the advantages of inquiry-based learning, there is a very strong tendency for authors to assert what it can do but rarely do they offer evidence. They simply assert that inquiry is better using various arguments. Most of the literature on inquiry-base learning is assertion and some of the arguments they propose are open to considerable questions.

The inquiry approach to learning is beneficial where student-teachers are central to the learning process (Tamir, 1990; Newman et al., 2004: Abell et al., 2001; Khan, 2012). Thus, the advantage of inquiry is that it cultivates the skills that help in the investigation and exploration of science (Hart, 2002; NRC, 2000; Anderson, 2000; Haefner & Zembal-Saul, 2004). Their deep learning is established when instruction builds directly on the student-teachers conceptual framework, and content is organised on the basis of broad conceptual themes common to all science disciplines. Research examining the outcomes of inquiry-based learning suggests that when students are engaged using inquiry, they describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, consider alternative explanations and develop deep learning (e.g. Anderson, 1998; NRC, 2002; Haefner & Zembal-Saul, 2004).

In conclusion, the literature asserts an immense emphasis on inquiry methods as a medium for the development of personal meaning and understanding that leads to students' higher achievement in science (Anderson, 2002).

Moreover, inquiry is useful in developing a responsibility in student-teachers to develop their own investigations. Scientific investigations are based on the principals of inquiry. In an inquiry-based process in science, the students formulate their own questions, create hypotheses, and design investigations which test these hypotheses and answer the questions. Orlich et al., (1990) also emphasised that inquiry experiences can provide valuable opportunities for student-teachers to improve their understanding of both science content and scientific practices; even more inquiry learning can also be applied to all disciplines. Also, Lee and Fradd (2001) established an inquiry matrix consisting of questioning, planning, implementation (carrying out the plan and recording), concluding (analysing data and drawing conclusions), repeating, and applying. They suggested that student-teachers using the inquiry matrix develop greater confidence in conducting scientific inquiry (using the four-question strategy mentioned above).

Literature on inquiry-based learning tells us that advocators of inquiry put emphasis on the importance of inquiry in various aspects of learning science. For example, inquiry-related teaching is effective in fostering science literacy and understanding of science processes (Linderg, 1990), conceptual understanding (Lloyd & Conteres, 1987), critical thinking (Narode et al., 1987), positive attitudes of science (Rakow, 1986), higher achievement in tests of procedural knowledge (Glasson, 1989) and construction of logical mathematical knowledge (Staver, 1986). Here, the procedural knowledge that informs my research questionnaires and interviews is defined as:

> Describes the understanding of ideas about how the sciences gather evidence, which underpins an understanding of how to proceed in scientific investigations. (Appendix 1 and 2)

Therefore, inquiry-based learning benefits science widely as a form of science learning. Moreover, Haury (1993) reviewed the research on inquiry-related teaching with respect to such outcomes as scientific literacy, science processes, vocabulary knowledge, conceptual understanding, critical thinking and attitudes toward science. Therefore, the effectiveness of inquiry teaching leads to a discussion of one's objectives for science education, including conceptual understanding of science principles, comprehension of the nature of scientific inquiry, and a grasp of applications of scientific knowledge to societal and personal issues (Flick, 1995). Hence, inquiry-based learning is advantageous, and student-

teachers can become more creative, more positive and more independent using inquiry-based learning (Kuhn, 2010).

3.4.1.1 Inquiry develops Deep Learning

Inquiry is valuable in science. Deep learning is developed as opposed to surface learning, and is regarded as one of the main goals of ITE. Marton and Säljö (1976) advocated surface learning as short term memorising, where the learner is focussed on content and superficial aspects. Surface learning is described as not real learning that develops deep understanding because surface learning is a high exercise in memory and replication of concepts. While Ramsden (1992) suggests deep learning as more long-term learning because deep learning happens when there is an understanding and internalisation, and possible application of concepts (Ramsden, 1992). Thus, inquiry-based learning is beneficial in providing the necessary context for deep learning, as it encourages the learner to engage with the subject through questioning, thinking for possible solutions, investigating answers and reflecting on the solution (Krajcik *et al.*, 1998). Additionally, the recent trends in science teacher education emphasise the importance of inquiry, because inquiry promotes meaningful and deep learning in science, rather than rote learning (NRC, 2000). The student teachers' prior knowledge and ideas are accessed and addressed in order to build new and deeper scientific understanding through inquiry. Inquiry-based learning is often contrasted with a pedagogical perspective, with more traditional methods, and reflects the constructivist model of learning.

Ausubel (1969) was an influential figure in meaningful learning. Ausubel (1969) suggested the advance organiser to be used in the following two cases: Firstly, when the material is new and the learner does not possess the appropriate relevant information to relate to it. Secondly, when the relevant information does exist in the learner's cognitive structure but that information is not developed adequately and is not likely to be recognised effectively and associated with the new information. Thus, advance organizers are used to provide support for new information.

Moreover, the function of an advance organiser is to facilitate meaningful learning, and the advance organiser itself has to be meaningful to the learner for this purpose. Any type of advance organiser cannot possibly function if the learner does not possess the relevant concepts to associate with the new material to be learned (Novak, 1993). According to

Ausubel (1969), the cognitive structure is hierarchically organised and logically structured, which means that the less inclusive or less comprehensive sub-concepts and details of specific records are organised under the most inclusive concepts.

However, Ausubel's great contribution was to separate very clearly between the reception-discovery dimension of learning and the rote-meaningful dimension of learning. In other words, if meaningful learning is the goal than it can be achieved using reception or discovery learning. His diagram is shown as figure 3.2, with the possible location of inquiry-based 5plearning shown on it.

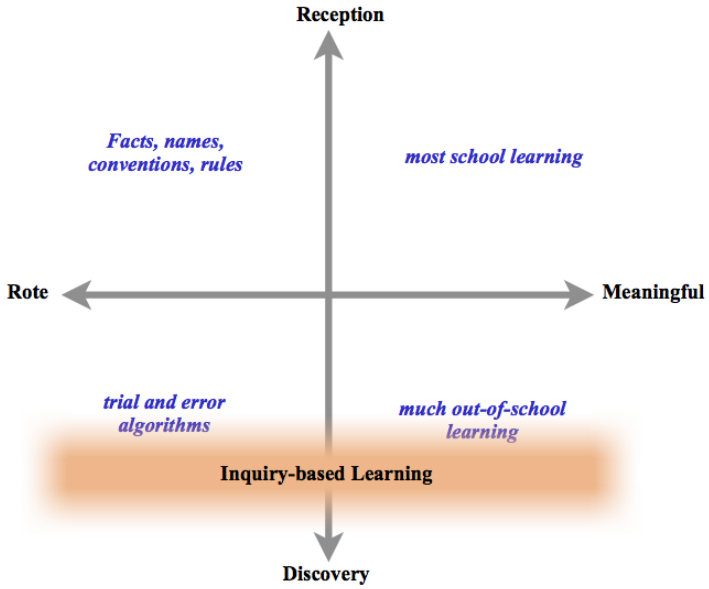


Figure 3.2 Inquiry and Ausubel Meaningful Learning

Inquiry in science learning has been a recurring theme in science teacher education (Bybee 2000; DeBoer, 1991). The foundation is that in order to provide experiences where students are central to the learning process (Tamir, 1990). Therefore, research is influencing educators to provide teacher education programs that help student-teachers develop inquiry-based pedagogical practices and beliefs that are consistent with the current education reform (Hart, 1996).

Moreover, inquiry provides opportunities for student-teachers to find solutions to problems by asking and refining questions, designing and conducting investigations, gathering and analysing information, making interpretations, and drawing conclusions (Kahn and O'Rourke, 2005; Krajcik et al., 1994). So, inquiry places a clear focus on the process, understanding of science and self-directed learning skills, with the aim of fostering the development of interest, social competences and openness for inquiry, to prepare the

student-teachers both for lifelong learning and uncertain future. Hence, inquiry-based learning is a way of assuring that student-teachers become actively involved in what they are learning, particularly in science (Kahn and O'Rourke, 2005). Thus, the process of learning in inquiry occurs in a similar way to the process of scientific investigation (NRC, 2000; Krajcik *et al*., 1994; Crockett, 2002).

Previous research on science investigations, particularly in Pakistan, provides some insight into inquiry-based teaching approaches. The literature examining inquiry-based teaching in the Pakistani context suggests that inquiry supports student teachers' performances and achieving learning outcomes (Nazir, 2006; Khan, 2012; Ullah, 2010). Khan (2012) examined the outcomes of the inquiry-oriented and traditional methods of teaching science at the 8^{th} grade. He found that student-teachers' achievement using inquiry is significantly higher than those exposed to the traditional methods of teaching science.

Moreover, Bybee (2000) asserts that "science as inquiry" as comprising three main elements: (1) skills of scientific inquiry (2) knowledge about scientific inquiry and (3) a pedagogical approach for teaching science content. I believe that each phase of inquiry supports the process of learning in science teacher education through a variety of sources, such as from the teachers, from curriculum materials, from technology, and from peers within and outside the classroom. Anderson (2002) also suggests that inquiry enables learners to understand a deeper meaning of knowledge, as well as to develop higher-level thinking skills. Hence, inquiry nurtures learning and understanding in science (Blumenfeld et al., 1994).

3.4.1.2 Inquiry-based Learning and Social Constructivist Perspectives

Social constructivism draws directly on the work of Vygotsky, who viewed learning as moving from a social context to individual knowledge construction (Vygotsky, 1978). According to Vygotsky, a learner is introduced to new ideas in a social context or "social plane" through interaction with other people, including talking, gestures, writing and exploration. In constructivist learning, learning is seen as the process by which individuals are introduced to a culture of more skilled members (Driver et al., 1994). In an educational setting, the social constructive activities consist of interactions among student-teachers and teachers that become the tools for the individual student teacher's sense-making and "internalisation" of the ideas explored in the social context (Scott et al., 2007:44). This indicates that student-teachers are responsible for their own learning, in the sense that they must direct their attention to learning tasks, and draw on their present knowledge to

construct understanding from them (Brooks & Brooks, 1993; NRC, 1996; Thompson, 2006).

Subsequently, inquiry reflects the constructivist model of learning from a pedagogical perspective, in which learners construct knowledge themselves and become involved as active learners. According to Bybee (1997), the constructivist view assumes a "Dynamic and interactionist conception of human learning in which student-teachers bring to the learning experience their current explanations, attitudes, and skills" (p.167). Thus, the constructivist approaches develop meaningful interactions between the student-teachers and teachers and their environment; they redefine, replace, and reorganize their initial explanations, attitudes, and skills.

Research from social constructivist theory suggests that teaching and learning science through inquiry is grounded in the constructivism that learning is constructed by the learner (Bybee, 1997). The constructivist view assumes a "dynamic and interactionist conception of human learning in which student-teachers bring to the learning experience their current explanations, attitudes, and skills. Through meaningful interactions between themselves and their environment, which includes other student-teachers and teachers, they redefine, replace, and reorganize their initial explanations, attitudes, and skills" (Codding et al., 2009). Thus, constructivist learning theory supports inquiry by placing the focus of learning on the student teachers' ideas, questions and understanding, and not on teacher-led teaching (Fosnot, 1996).

3.4.1.3 Inquiry-based Learning Promotes Critical Thinking

Critical thinking is defined as an "*engine*" that drives how we decide what to do or believe in a given context. Dewey (1909) in his book *How We Think*, defined critical thinking as "reflective thought", to suspend judgment, maintain a healthy scepticism, and exercise an open mind. So, these activities called for the active, persistent, and careful consideration of any belief in light of the ground that supports it. Dewey (1933) suggests that critical thinking has both an intellectual and an emotional component, and develops intellectual ability in learners to go beyond the known. Thus, critical thinking involves student-teachers in questioning; probing and thinking about the things they could do, in reflecting and evaluating teachers' feedback. Smith (2002) illustrated the connection between inquiry and critical thinking as: "Inquiry in its most simplistic form is to ask others to make their thinking process visible and asking for help in seeing any gaps or limits in our thinking".

Research suggests that critical thinking raises vital questions and problems; in formulating them clearly and precisely, it assesses relevant information, comes to well-reasoned conclusions and solutions, testing them against the relevant criteria and standards, thinking open-mindedly within alternative systems of thought and practical consequences. The academic and personal benefits of inquiry in developing critical thinking in academic achievements were fairly considered; student-teachers tend to perform with personal reasoning (United States Department of Education, 1990; National Academy of Sciences, 2005). Therefore, effective teachers cultivate critical thinking using inquiry at every stage of learning, including the initial period (Hooks, 1994). Kyle (1980) suggested that inquiry in science is a systematic and investigative process incorporating uninhibited thinking capability after a person has acquired a broad, critical knowledge of the particular subject matter through formal teaching processes. Therefore, it needs to explore more about that critical thinking and reflection in the classroom could be achieved using inquiry-based approach.

3.4.1.4 Inquiry and Science Literacy

Inquiry as a goal for scientific literacy for all was first articulated in the NSES (NRC, 1996). The NSES provides guidance on what science student-teachers should knows; how teachers are to teach science, and how teachers are to assess student teachers. Inquiry in relation to science literacy is viewed from two perspectives: what student-teachers should understand about inquiry-based approaches in science, and the abilities that student-teachers should develop, based on their experiences with inquiry in science.

Also, inquiry is encouraged as a combination of science processes with scientific knowledge, reasoning and critical thinking, so student-teachers can develop a richer, deeper understanding of science (NRC, 2000; Bybee, 1997).

Thus, in light of the literature on inquiry and science literacy, scientific literacy is defined in my research questionnaires and interviews as:

> "Knowing and understanding scientific concepts and science processes so that student-teachers are equipped for personal decision making, participation in civic and cultural affairs, and economic productivity". (Appendix A and B)

The overall picture of the possible nature of science literacy is shown in figure 3.3.

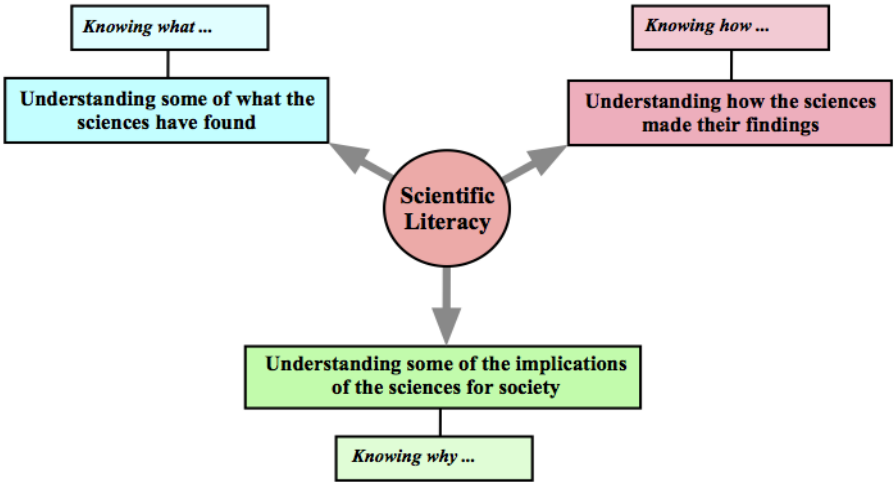


Figure 3.3 Inquiries and Science Literacy

The literature suggests the importance of inquiry in relation to science literacy (NRC, 1996; Anderson, 2000). It is emphasised that all young people, not just those intending to follow careers in science, must be scientifically literate. They need to have a good knowledge and understanding of science and scientific ways of thinking in order to function effectively in an evolving global technological society. Moreover, research on the instructional practices suggests that inquiry teaching methods attain the over-arching goal of science teacher education and preparation of scientifically literate citizens (Millar, 2004). Hence, inquiry-based teaching methods are the best ways to achieve scientific literacy, because they provide student-teachers with the opportunity to discuss and debate scientific ideas (American Association for the Advancement of Science, 2002).

Furthermore, Hogan & Maglienti (2001) point out that inquiry is valuable and one of the primary ways for scientists to evaluate scientific ideas and conclusions. However, most studies of the effect of inquiry instruction on science literacy have focused only on measuring gains in scientific knowledge. Norris, Phillips and Corpan (2003) illustrate this type of science literacy as fundamentally only focusing on recall of scientific principles. The NSES also encourage combining scientific processes with scientific knowledge, reasoning and critical thinking, so that student-teachers can develop a rich and deep understanding of science (NRC, 1996; Bybee, 1997). Hence, research suggests that it is little understood how student-teachers perceive inquiry-based approaches, and how they find them useful in developing science literacy as compared to traditional instruction.

However, the literature sheds light in a statistical sense on how learning in an inquiry-based learning framework differs from the traditional teaching approaches (e.g., Justice et

al., 2007b; Berg et al., 2003). Several quantitative research studies measure the advantages of inquiry, corresponding to terms of inquiry-based learning producing learning in science, student teachers' engagement, academic achievement and higher order learning outcomes (e.g. Prince and Felder, 2006). This indicates a lack of research into inquiry-based approaches and activities using qualitative research methods. Science teachers and student-teachers have difficulties and challenges adjusting to this approach when inquiry-based learning is adopted (e.g. Plowright and Watkins, 2004). The following section reviews the arguments against adopting inquiry-based pedagogy and sheds light on the disadvantages of inquiry.

3.4.2 Disadvantages of Adopting Inquiry-based Pedagogy

Despite the fact that the arguments in favour of inquiry-based learning indicate that inquiry is a beneficial approach in various aspects, inquiry is the only one form of pedagogy that can be used to teach science. There are cases where inquiry is not very useful, or not the best way of learning. This section reviews the disadvantages of inquiry, on two bases: inquiry is not the only way of learning, and while inquiry is a good way of learning, it may not be workable. Firstly, I present the review through some examples and studies on inquiry not being the only way of learning science in science teacher education.

Inquiry-based pedagogy does not exist in isolation; it interrelates with the curriculum and assessment. It cannot be implemented in isolation without looking at the curriculum, and at how the learning outcome is assessed. It should be noted at which stage it is suitable to teach using inquiry, or when not. For example, inquiry appears not to work when student-teachers need to introduce complex and abstract ideas in science through the experience of developing understanding, their own thinking and reasoning having many benefits for student-teachers which are not obtained in other ways (Saltiel, 2006; Fibonacci, 2012). In addition, research suggests that some of the content of the science curriculum are not suitable for teaching using inquiry-based approaches (Plevyak, 2007; Ross et al., 2010). Subsequently, Eltinge and Roberts (1993) suggested possible reasons why inquiry is not used: firstly, for curriculum putting emphasis on content. Secondly, where content is easier to access. Thirdly, textbooks put emphasis on science as a body of knowledge. Thus, inquiry is disadvantaged in such circumstances, because it cannot cover all the textbooks or areas of curriculum of science.

Moreover, inquiry is perceived as a demanding and challenging approach to the teaching of science, which can present difficulties when it is implemented in science classes. For example, the literature indicates that student-teachers have difficulties conducting systematic scientific investigations (e.g., Schauble et al., 1995; Kraijcik et al., 1998). Moreover, Blumenfeld et al. (1994) explains that scientific investigation techniques such as data collection and analysis are complicated, and typically require a level of precision that student-teachers generally do not exhibit, using inquiry-based practises. Student-teachers cannot conduct investigations that yield meaningful results if they are unable to master these skills using inquiry-based pedagogy. Thus, inquiry's presenting challenges to learners and teachers in acquiring skills across the diversity of abilities and prior experience is another significant disadvantage (Soloway et al., 1994).

Nonetheless, there were no significant differences in content achievement between groups, although these were not focusing on content as the main outcomes measured (Kirschner et al., 2006). It has been noticed that inquiry is beneficial for achieving one or more non-content goals, focuses on the conceptual understanding; whereas, simultaneously, not impeding student teachers' content achievement. There are two major reasons for this deficiency of inquiry-based teaching. Firstly, there is a widespread persuasion in favour of a textbook approach in some countries, where the textbook is viewed as the authority, that student-teachers are required to master. Secondly, there can be frustration and difficulty encountered in implementing inquiry-based teaching (Weiss et al., 2003).

The literature on the practices of the inquiry-based approach to teaching informs us that inquiry can be problematic for teachers in classroom management, with teachers frequently having difficulties interacting with student-teachers and engaging them in classroom inquiries (Abell et al., 2001; Newman et al., 2004). Therefore, teachers may be concerned about how far they can teach using inquiry in initial teacher education (e.g., Newman et al., 2004). Lotter (2004) has discussed how does the teachers often display inadequate classroom management, and feel a loss of control. However, research suggests that inquiry is central to learning science, so it is expected to be prominent in the teaching of science (Anderson, 200; NRC, 2000). Moreover, Hayes (2002) maintains teachers' uneasiness at letting go of their authority to control and direct student teachers' science learning experiences, and their struggle to adopt a form of classroom relationship that is new to them. Conversely, the importance of inquiry does not imply that all teachers should pursue a single approach to teaching science.

This can be a notable concern; does the inquiry approach always turn into success? The literature suggests that inquiry-based approaches to teaching show positive, but relatively modest gains (Hayes, 2002; Anderson, 2000). Some studies in inquiry-oriented curriculum programs found various quantitative measures, including cognitive achievement, process skills and attitude to science; for example, Wise and Okey (1983) found an average effect size of 0.4 standard deviations in favour of inquiry-discovery teaching for cognitive outcomes. Thus, it can be noted from the previous studies that inquiry-based teaching in science shows relatively the modest gains over the other traditional approaches.

The literature indicates another disadvantage of inquiry-based pedagogy, because it does not become a characteristic of science practice, yet "in classrooms where it does take place, confirmatory exercises and structured inquiries are, by far, more common than guided or open inquiries" (Windschitl, 2001:115). For example, U.S. Department of Education National Centre for Education Statistics (1995) on student-teacher work and teaching practices in the American schools indicates that 69% of 12th graders surveyed had "never" or "hardly ever" designed and carried out their own investigation. 37% and 32% of the student-teachers surveyed in grades 8 and 12, respectively, reported that they did not conduct science investigations that took more than a week. Additionally, the literature on the use of inquiry in other parts of the world indicates that the inquiry form of teaching and learning science is generally not used in most elementary schools at present (Fibonacci, 2010).

Subsequently, inquiry can be seen as one of the best methods of teaching, but not necessarily the only best one. I argue that inquiry may be a good way of learning but it may not be workable. The literature informs us that inquiry does not seem to be workable in the presence of several dilemmas that teachers and student-teachers face in science teacher education (Weiss et al., 2003; Varma, 2007). Though learners enjoy active and independent learning within the process of inquiry, Kane (2000:5) has reported that a 'Passive countenance needn't reflect an inactive brain'. This indicates that inquiry-based learning cannot happen without physical demonstration i.e. works through collaboration, group work, hands-on activities, questioning and discussions. This does not seem possible in Pakistani classrooms with limited resources, large number of students and small classroom size (Khan, 2012; Halai, 2010; Mohammed, 2006).

Having given lectures myself as a 'teacher-educator', and also from my experience as a student teacher in different universities, I have unfortunately come across the silence which I think occurred because student-teachers were not prepared to answer questions in big

classes, especially when not used to attending a class with such an interactive structure. Thus, inquiry seems impractical when student-teachers have to attend such a class; they hesitate to participate in inquiry-based lessons. Inquiry-based learning does not seem workable when student-teachers and teachers lack motivation. The challenging and extended nature of inquiry requires a higher level of motivation on the part of learners than is demanded by most traditional educational activities. Research suggests that student-teachers either fail to participate in inquiry activities, or participate in them in a disengaged manner that does not support learning when they are not sufficiently motivated or they are not motivated by legitimate interest (Soloway et al., 1994; Khan, 2012).

The literature indicates a concern that most student-teachers have not engaged in learning science as inquiry or been exposed to inquiry-based instruction in their previous schooling (Llewellyn, 2002; Mohammed, 2006; Khan, 2012). Also, teachers do not receive adequate preparation in theoretical knowledge and practice of inquiry (Radford, 1998). Student-teachers initially feel resistant to the learning technique, citing concerns about the lack of guidance, and no clear inquiry-based course content (Newman et al., 2004). Additionally, research indicates that most teachers avoid teaching inquiry-based science, because their own experiences did not motivate their interest in science, and they were never taught using inquiry in their own schooling (Jarret, 1999). They can perceive disadvantage and risks in adopting inquiry-based learning. Thus, teachers do not make the effort to implement inquiry because of their personal situation, lack of motivation or other barriers (Anderson, 2002; Newman et al., 2004). Therefore, the presence of these dilemmas discourages student-teachers and teachers to implement inquiry.

Teaching using inquiry is more complex than a traditional lecture. When student-teachers observe their educators, and how they are teaching, they unintentionally remember their style, and follow that teaching style when they become practicing teachers. Nasmser (2001) suggested that a teacher's own schooling typically influences ITE programmes. Therefore, the prospective teachers start developing their own teaching styles based on how they were taught in their own school. Ross et al. (2010) suggested that the influence of teachers' own schooling has a powerful impact on their development as teachers, acting as a filter during their teacher education programs, and having an impact on what they are able to learn. Thus, inquiry-based teaching seems impractical in ITE, where ITE programs do not substantially affect developing student-teacher teaching style, and student-teachers still follow the traditional teaching style of their own teaching (Mohammed, 2006; Ahmed, 2012; Khan, 2012).

Another disadvantage of inquiry that makes it unproductive is limited understanding of process and the basic components of inquiry in science teacher education (e.g. Crockett, 2002; Anderson, 2002; Newman et al., 2004: Abell et al., 2001). The literature informs us that, while teaching is a difficult task in itself, implementation of inquiry in the classroom presents its own challenges (Hayes, 2002; Newman et al., 2004: Abell et al., 2001). For example, teachers' limited conceptions of the nature of science, and of inquiry-based practices and a subsequent restriction in their teaching repertoires, can combine with content knowledge (Harris et al., 2005), inexperience with the range of inquiry-based approaches (Anderson, 2002), and an inadequate understanding of inquiry (Keys and Bryan, 2001). Moreover, research in Pakistani science teacher education indicates that use of inquiry is limited to questioning about the previous knowledge in science content and structured activities led by teachers (e.g. Khan, 2012; Mohammed, 2006). It is generally understood that the process of inquiry begins with questions made by either teachers or student-teachers. It is generally assumed that, if teachers use questioning in any way, this means that inquiry-based teaching is practised. Therefore, inquiry-based learning encourages student-teachers to create knowledge by questioning. However, does inquiry only encourage seeking the answers for questions, not the understanding of content? Thus, inquiry is disadvantaged, problematic and impracticable, because of limited understanding of the process of inquiry-based approach.

Moreover, another challenging aspect of inquiry to student-teachers and teacher-educators is that it is a more time-consuming approach (e.g. Anderson, 2002; Newman et al., 2004). Therefore, the majority of teachers are not familiar with the process of inquiry, and do not devote much time to teaching science (Weiss et al., 2001). Research on inquiry-based approaches to teaching suggests that the perceived higher workload associated with inquiry-based learning stops inquiry being a workable approach to teaching (e.g. Justice et al., 2002; Newman et al., 2004).

Furthermore, Bovill et al. (2010) point out that inquiry-based learning being more time consuming and involving more work discourages teachers from using it. Also, teachers fear is being reported for performing a poor job in class if student-teachers are not sufficiently disciplined when practising inquiry-based lessons and an administrator may notices it. Bonwell & Eison (1991) discussed the element of risk involved when implementing inquiry-based learning strategies in the university classroom; risk that the tutor will not feel in control of the class and its direction. Moreover, Welch et al. (1981) examined how teachers and student-teachers became frustrated by their limited preparation

when using inquiry, including management, lack of time, limited available materials, lack of support, emphasis only on content, and difficulty in teaching. Thus, teachers may also fear the risk that student-teachers will not be receptive to a change in the learning and teaching style. Hence, the most significant challenges, and all of the risks in the implementation of inquiry-based learning, demonstrate that these challenges can prevent student-teachers from successfully engaging in meaningful investigations, and therefore, undermine learning.

It is argued that all inquiry-based learning is constructivist learning. However, as Ausubel (1962) has demonstrated (see figure 3.2), that need not be the case. Constructivism has its central tenet that learners construct their own understanding, and that these may not be the same as those provided by the teachers. The literature on the constructivist approaches to teaching suggests that we can teach in a constructivist way to all learners. The problem with this argument is that constructivism describes what *learners do* as they seek to understand. It does *not* describe what teachers do.

There is nothing a teacher can do to encourage learners to construct their understandings or not construct their understandings, other than, perhaps, directing learners not to seek to understand, but simply to memorise (e.g. Reid, 2012; Kirschner et al., 2006). However, teachers can take steps to encourage the learners to develop understandings which are similar to those held by the teachers. In essence, this is really what constructivist teaching means. It means taking steps so that the understandings constructed by the learners (a natural process which will always occur) are more likely to be those held by the teacher. Thus, teaching constructivistically (as often used in the literature) is meaningless, in that constructing understanding takes place *inside* the head of each learner, inaccessible to the teacher. The point is that constructivism is an excellent description of what goes on naturally. So constructivism has little predictive value and cannot directly lead to better teaching, simply because what happens overtly in the classroom has no direct bearing on a process which takes place naturally inside the head of each learner. The review of Kirchner et al. (2006) offers useful insights on this while Reid (2013) has developed the theme further.

In addition to the discussion above, it can be argued whether every aspect of learning is inquiry, because inquiry-based learning demands the active participation of the learner. The argument about inquiry learning is basically the same as the constructivist argument, that all learning is constructed (e.g. Mayer, 2004; Kim, 2005). Moreover, the constructivist theory of learning has been criticised in that learner must produce better learning outcome

in the guided instructions, rather in minimal guided instructions. Furthermore, Shulman & Hutchings (1999) suggested that less guided approaches fail in integrating the content expertise and pedagogical skill. Thus, this discussion pinpoints the dilemmas that teachers face in adopting an inquiry approach to science teaching.

Moreover, Kirschner et al. (2006) considers inquiry-based learning as one of the fashionable approaches that have gained a currency among certain educators. The point is not that inquiry is, in itself, inadequate. Indeed, inquiry-based approaches to teaching and learning have long been promoted, as there are many positive features to inquiry-based learning. As Kirschner et al. (2006) point out, each set of advocates for unguided approaches seemed either unaware of or uninterested in the previous evidence that unguided approaches have not been shown to be more effective in terms of generating learner understanding. Indeed, inquiry is not always workable. For success, it depends on how inquiry-based approaches to learning are implemented. For example, if they are implemented with the limitations of working memory capacity in mind, they may achieve better learning (Reid, 2013). If they generate increased cognitive loads, then learning may well be hindered (Kirschner et al.). Thus, inquiry could be one of the effective approaches to learning, but it depends how inquiry is implemented.

3.5 The Focus of This Research is on Establishing Student Teachers' and Teacher-Educators' Perceptions on the Key Aspects of Inquiry

This chapter began by representing the problems of defining inquiry-based approaches in science teacher education. The different definitions of inquiry were reviewed over the various roles of inquiry in learning and teaching of science and the different aspects of inquiry by the promoters of inquiry-based learning. Then a working definition of the key aspects of inquiry from the existing research was developed that helped to develop questionnaires and the interviews used in this research. The arguments, in favour of and against adopting inquiry-based learning, were examined mainly through the literature. Though research tells us that inquiry brings positive results in learning, it does not guarantee them by itself. It is argued that inquiry is good to use but it is not workable all the time with the entire curriculum and with all student teachers. Inquiry bears the disadvantages of being un-workable because of the teachers and student-teachers lacking understanding of the process of inquiry in science teacher education. One of the issues from the literature also highlights teachers and student-teachers having different perceptions of inquiry-based approaches. This section illustrates a key aspect of this

research, that is, through teachers' and students' perceptions of inquiry-based learning.

3.5.1 Teachers' Perspectives on Their Role using inquiry-based Pedagogy in ITE

The literature suggests that teachers' appropriate conceptions and supportive environments for teaching are the prerequisite to sustaining teachers' inquiry-based practices (Leonard, 2009). Moreover, Fecho (2000) stated that educators need to think beyond the traditional structures of teacher education and consider ways of bridging their previous educational experiences to their practices of teaching. Furthermore, there is a gap in knowledge in association with teachers' own schooling, learning experiences and inquiry approach to learning, which has been little explored in ITE in Pakistan.

The literature on teacher education in Pakistan identifies a few critical gaps in the understanding and practices of teachers in ITE. It can be noted a considerable shift in teachers' essential role in teaching and their thinking about educational improvement in science classroom (Ahmed, 2011; Khan and Saeed, 2009; Andrabi, 2010). Nietfeld and Cao (2003) stated that the effectiveness of teacher education programmes in changing teachers' and student-teachers' attitude and ensuring a deep understanding of pedagogical knowledge is mixed. Therefore, teachers must have both basic knowledge of teaching and the ability to teach under real time constraints. Lacking either, the teachers are considered ill-prepared for their job (Williams & Alawity, 2001). This can be rarely considered in teachers' preparation and inquiry-based activities in ITE in Pakistan. Hence, it is little known on the teachers' preparation for inquiry-based activities in ITE in Pakistan.

In sum, teachers who have the beliefs, values, and goals that support their teaching and implementation of inquiry in science classroom can be at odds with those who support inquiry (Volkmann et al., 2005). Therefore, lack of class time to implement inquiry, lack of organizational support to implement inquiry and the increased extent of time to prepare inquiry-based lessons hinder implementing this approach (Mayer, 2004; Varma, 2007). However, in the Pakistani context, no research study to date has examined teachers' and student teachers' understandings and perceptions of the challenges in inquiry-based pedagogy to implementation in science teacher education.

Literature on the outcome of inquiry-based studies suggests that teachers who have positive perceptions of instructional programs often have greater job satisfaction (Reference). Also, those teachers are more likely to utilise inquiry-based instruction to further the learning gains (Dawson, 2007). However, Lipka et al. (2005:382) have discussed how teachers' perceptions of inquiry-based learning are due in part to "the long-

term positive relationship between teacher and student-teachers that contribute to a classroom environment in which trust and mutuality were constructed". Thus, there has been little work done by previous research on teachers' perceptions of inquiry-based learning about open communication, student teacher motivation in the classroom, and their job satisfaction when inquiry-based instruction is undertaken.

Moreover, many researchers suggest that if inquiry-based instruction continues to be more effective than the traditional teacher-directed methodologies, even when employed by teachers opposing the implementation of initiatives supporting inquiry-based learning (Taylor et al., 2011; Barnett and Mahony, 2007). However, there is further need to know teacher-educators' perspectives on when inquiry-based methods are initiated in class by teachers in their early careers in ITE.

Also, it is important to find out how long teachers should necessarily teach using inquiry in science teacher education. I think that the teacher should ascertain the nature of the teaching work, particularly, when inquiry is practised. If teacher education supports the learning that teachers require to undertake, this will result in greater success. This assumption can influence more current policy and practice, perhaps because the ideas are so embedded in our culture through the classroom system. It is necessary to know teachers' perceptions on the use of inquiry all the time, with all student teachers, and with the entire curriculum.

Despite widespread agreement on the advantages of inquiry-based learning, most teachers are still reluctant to use this pedagogical approach in their science classrooms for a variety of reasons. Some feel it is only appropriate for advanced student teachers; others feel inadequately prepared for this type of instruction; still others are concerned about "managing" an inquiry-based classroom, in which some would say that student-teachers may be disruptive, pay less attention, socialise, or simply not participate. Looking at the arguments for and against inquiry-based approaches (Section 3.4.1 and 3.4.2), it indicates that there is theoretically an agreement that it is important to promote inquiry in science teacher education. However this may mean different things, by teachers' and students' perceptions and experiences if teaching in the classroom. Thus, the review on teachers' perspectives on adopting an inquiry-based approach to teaching suggests a gap between their perceptions and practices in inquiry-based pedagogy.

3.5.2 The Student-teachers' Perspectives of Inquiry in ITE in Science

It is believed that one of the most important contributions a teacher can make to student-teachers' future success in education is to provide them with ample opportunities to learn and use inquiry-based skills in science (NRC, 1996). Inquiry-based instructions are considered as the creation of a classroom where student-teachers are engaged in essentially student-centred, hands-on activities (Colburn, 2000). Additionally, NSES recommends that "teachers guide, focus, challenge, and encourage student-teachers' learning at all stages of inquiry" (NRC, 1996:3). Thus, it is critical to know about student teachers' perspectives on the process of inquiry in initial science teacher education.

Research suggests that student-teachers themselves have opportunities to participate in inquiry-based science learning and must experience a learning environment to maximise their learning (Lederman, 2003; Taylor et al., 2011; Varma, 2007). However, the literature indicates serious deficiencies in the preparation of student-teachers to teach science (Weiss et. al., 2001; 2000; Wilson et al., 2001). Regarding science teacher education programs for student-teachers' preparation as inadequate in both content and pedagogical strategies (Weiss et. al., 2001; NRC, 2000; Duran et al., 2004), problems in the preparation of student-teachers as prospective teachers lead to an important concern of student-teachers in developing an understanding of inquiry, which encourages effective science teaching consistent with the vision of school science (McLoughlin & Dana, 1999; NRC, 2000).

Moreover, the literature points out that many education graduates lack expertise in both science content and pedagogical content, and consequently do not feel confident to teach science (McLoughlin & Dana, 1999; Varma, 2007). For example, when student teachers' perspectives on learning about inquiry-based approaches in science were examined, it was found that student-teachers engaged in inquiry supported their development on an understanding of science and scientific inquiry (Varma, 2007). Inquiry-based learning made them more accepting of approaches to teaching science that encourages learners' questions about scientific phenomena (Haefner & Zembal-Saul, 2004). Thus, it is necessary to explore student teachers' perspectives on initial science teacher education programs in their preparation of pedagogical practices using inquiry-based instruction.

Most studies of the effectiveness of inquiry investigated student teachers' perspectives on achievement through acquisition of content knowledge, conceptual understanding, and overcoming misconceptions. Using these variables, studies have demonstrated an increase in student teachers' achievement in inquiry-based laboratories (Luckie et al., 2004).

However, research suggests that inquiry instruction results in improved learning (Krajcik et al., 2002; Berg et al., 2003; Varma, 2007), it is not known whether increasing inquiry instruction can significantly change students' attitude toward science. There is a lack o f evidence in the literature on examining student-teachers' achievement in laboratory using inquiry have not discovered statistically significant differences (Berg et al., 2003).

Moreover, research suggests that most student teachers' perspectives about inquiry-based learning also come from their experiences as undergraduates in initial science teacher education (Grossmann et al., 1989). Generally, they are not unlike the confirmatory laboratory experiences found in their high school or college. Trumbull and Kerr (1993) examined a typical undergraduate biology laboratory class, which was highly scripted and tightly controlled. Student-teachers were given questions, and the methods to answer them. They also examined whether student-teachers lack the necessary focus to carry out inquiry-based approaches, for example, the reasons for collecting data. In addition to the problem of being subjected to the models of highly structured inquiry, student-teachers are rarely exposed to discussions about science as a discipline in ITE, and do not participate in discussions of how new knowledge is brought into the field (Bowen & Roth, 1998).

Literature indicates a little about student teachers' perspectives on their knowledge of the process of inquiry, and their motivations for undertaking difficult-to-manage forms of instruction. Keys and Bryan (2000: 2) argue that "the conceptions of inquiry are tied to beliefs about what science is and about what kinds of knowledge and skills are worth teaching in science classrooms". For the effective practice of inquiry, student-teachers should be told exactly how to do it, as well as understand how to work on it. Thus, the literature indicates a fundamental need for research on student teachers' perceptions of their knowledge about the process of inquiry.

Moreover, student-teachers follow the teaching style of the teachers they have observed in their schools. According to Darling-Hammond et al. (2001:37), "teachers are probably teaching in the manner that they themselves were taught". Thus, student-teachers avoid adopting new and challenging teaching methods, and the teaching styles are followed as a tradition. Windschitl (2003) pointed out that the previous experiences are powerful influences on teachers' classroom behaviours, providing novice teachers with training on the use of a guided-inquiry curriculum; a community-based internship would enhance their inquiry-based teaching in early childhood and elementary classrooms. Ultimately, there is little known about student teachers' own pedagogical development using inquiry-based teaching in ITE in Pakistan.

The literature suggests that inquiry-based learning engages student-teachers in learning, and that student-teachers have fun in inquiry-based lessons. Cai (1997) examined how college student teachers' reactions to teaching styles were influenced by the subject matter of the class in which they were enrolled. Boyce (1992) examined in a study on undergraduates while the style of instruction was superior for skill acquisition, over 50% of the student-teachers reported not liking the learning environment. The previous research on student-teachers engagement using inquiry indicates that a little is known about their perspectives on the various aspects of inquiry-based pedagogy in ITE; particularly, fun, likeness, interest, and motivation attached to the environment in inquiry-based lessons (Varma, 2007; Hayes, 2006).

Additionally, student-teachers react differently to various teaching strategies used by the teacher within the classroom and teachers' activities may influence the student-teachers' attitude and perspectives. Vaughn et al. (1993:108) suggest that "*students are actively shaping the classroom with their preferences and act..., and these preferences likely influence teaching procedure*". Thus, there is little known about students' responses and attitudes to teachers' planning and changes in their teaching strategies using inquiry-based approaches.

In sum, there is a range of experiences that can influence student teachers' perspectives of inquiry-based learning. They range from their own experiences, to work in science laboratory settings, to coursework in science teacher education, their previous schooling, and teachers' actions. Shapiro (1996) conducted a study with an elementary science methods class and found that 90% of her student-teachers had never experienced science as an investigation, and that most of those who had, did so in school science fairs. She found that student-teachers appreciated the need to make changes in the design of the investigation in order to solve the problem, and stressed the importance of perseverance, as well as skills in communicating results with others. Thus, student teachers' perspectives are likely to alter their image of inquiry as they are to enhance it, and to develop robust understanding of science practices.

3.6 Chapter Summary

Thus, in my study, I shall be focusing on teachers' and student teachers' perceptions of the role and importance of inquiry-based approaches in ITE in Pakistan. In conclusion from the literature, the teachers' and student teachers' perspectives of inquiry-based pedagogy is reviewed, in light of the fact that everyone is likely to say that it is important to promote inquiry in science teacher education; however, inquiry is perceived very differently through the practice of teaching in science teacher education programs. The next chapter presents an overview of teaching methods in ITE in Pakistan. The implications for teachers using inquiry, and the opportunities and challenges facing the teachers and student-teachers in science teacher education in Pakistan will be reviewed.

Chapter 4

Teaching Approaches in Pakistan

4.1 Introduction

This chapter presents a review of the teaching methods in science in initial teacher education (ITE) in Pakistan. This also sheds light the opportunities and challenges to the teacher-educators and student-teachers in the initial science teacher education. At the end, this chapter addresses implications to the teacher-educators' perspectives on their practices, professional development in ITE, the teachers' understanding of their practices and any contradictions between their perceptions and those of their student-teachers.

4.2 ITE in Pakistan: the Opportunities and Challenges

A comparative overview of the literature on teacher education in Pakistan and international context recognizes some critical gaps in the understanding and practices of teacher education in Pakistan. In Pakistan, in recognition of teachers' essential role in the reforms, which has been consistently recognized throughout consecutive National Education Policies, teacher education has been considered a key area of the reforms. Therefore, government recognize teachers' central role in teacher education and emphasize efforts to enhance the status of teachers and teaching profession at large (Ahmed, 2012).

Moreover, science teacher education tends to stress upon the technical aspect of teaching, which involves subject knowledge and a fixed set of skills required to transfer that knowledge to student-teachers (Ali, 2008; Ahmed, 2012; Memon, 2010; Sarwar, 2006; Saeed, 2010). Literature has emphasised that other critical dimensions of teacher education including personal, social, and moral are believed to have received little or no attention (Mohammed, 2006). Also, the literature on teacher education in Pakistan emphasised the traditional transmission paradigm of teacher education aiming at the transmission of knowledge (Cole & Knowles, 2000). It can be noted from these paradigms that teaching is a technical activity and the role of a teacher as a technician is to equip herself with the necessary knowledge and skills required by the teaching task (e.g. Cocheran-Smith & Fires, 2001).

Quality or competence of the teacher is determined largely by the quality of initial and in-service education the teacher receives. Literature suggests that the quality of teaching is determined by the level of professional competencies which is inclusive of knowledge, understanding, skills, and attitudes he or she brings to the teaching profession (Cocheran-Smith & Fires, 2001). However, teachers lacking the required level of professional competence are attributed to the dysfunctional teacher education system in the country (Aga Khan Foundation Pakistan, 1998; DIFSD & USAID, 2008). The Education Policy (2009) alludes to a direct relationship between the deteriorating quality of education and obsolete ITE structure and inadequate professional development system.

There are numerous factors which are responsible for the poor quality of education, especially in the public sector in Pakistan (Ahmed, 2009; 2012). The poor quality reflected in student-teachers' learning is being attributed largely to the poor quality of teachers/teaching serving to them. The notion of poor quality of education is concerned with the ways in which children are made to learn information through rote memorization with inadequate rationale of replicating it in the examinations (Hayes, 1996; Jaffer, 2005). The environment within classroom pedagogies do not encourage students to engage in in-depth cognitive learning and use their own judgment and exercise their critical abilities in efforts to understand what it all means to learn what is presented to them in the school (Government of Pakistan, 2006c, 2002a; Sultana, 2001; World Bank 2006). Thus, it seems that teacher education, as a fundamental part of education system, has failed to respond to issues related to the improvement of the quality of education system in Pakistan.

The existing literature on teacher education in Pakistan explains a wide array of issues, tensions, and challenges at both international and national levels meeting teacher education in Pakistan (Ahmed, 2012; Barber, 2010; Government of Pakistan, 2002b; Jamil, 2004; UNESCO, 2006c: 2008). However, the corrective measures proposed do not provide comprehensive policy guidelines that are needed to interpret the problems of teacher education. The literature illustrated those issues onto the status of teacher education and suggested a clear lack of efforts in understanding the dynamics of teacher education and its relationship with school education from the perspectives of the knowledge originating from research in the local and international context.

Although, Schools and initial teacher education (ITE) institutions have radically different purposes, the nature of their key activities reflects the criteria which the members of each context use to judge their effectiveness. Student-teachers have to move between the two contexts and have to learn to negotiate the different sorts of criteria. ITE courses are

explicitly critical of practice and produce agents of change and tensions between school and ITE. For example, Rosaen and Schram (1998) suggest one role of ITE should be to produce 'transformative intellectuals' who will reform, rather than just shape the existing teaching practices. Such a view of teacher education is likely to focus on the acquisition of teaching skills required to deal with routines or predictable situations inside the classroom. Likewise, Dewey (1964: 38) has also stressed:

> Education programmes should produce students of teaching who are thoughtful about educational theory and principles rather than skilled only in the routines, mere technician, copiers, and followers of tradition and example.

The literature constituted by Government reports and policy documents identifies the gaps that apparently exist in the current discourse on science teacher education in Pakistan (Ahmed, 2012; DIFSD & USAID, 2008). The literature also reflects a broader consensus on the issues and problems that impede improvement in teacher education in Pakistan. However, this view fails to recognize the dynamics and complex realities of the classroom, and teachers' personal make-up (Ahmed, 2012; Halai et al., 2004). Whereas Valli (1990:38) argues that life in classroom is dynamic and uncertain, that answers to teaching problems are not a simple process of rule application, and that teachers must exercise wisdom of practice for their development and learning of student-teachers.

4.3 Challenges in Initial Teacher Education in Pakistan

As discussed above, teacher education is unable to show the performance in improving the quality of education system in Pakistan, up till now, that was required. Therefore, the quality of education in general and the public-sector schools, in particular, are being criticized widely (Ahmed, 2009; GOP, 2005). Thus, a number of factors can be seen responsible for the poor quality of education, especially in the public sector universities. Thus the challenges influencing ITE in Pakistani public sector universities are, for example, lack of professional development, insufficient implementation of training programmes, and instability of educational policies due to the political instability in the country, etc.

As discussed in Chapter 2, teacher education in Pakistan has its fundamental roots in the serious lack of will of political leadership to reform the whole education system which has brought about the huge gap between policies and actual implementation of policies. Moreover, educational policies have been affected by many other forces, for example,

political instability. Likewise, the increasing roles of politicians in the recent years in Pakistan have influenced teacher education. Unfortunately most decisions on policies and educational plans generally in education are political at one level or the other (Ahmed, 2012). They shape the policies of Pakistan to their own benefits and not been for the progress of education (Shami, 2005). In fact, numerous policies and plans have been considered but discarded because of the change in government ruling party (e.g. Ahsan, 2003; Memon, 2007; Sadiqqui, 2005). The most destructive impact is that the teacher education sector is controlled by provincial government which suffers from much political interference in Pakistan (MoE, 2007).

Additionally, a concern is noted on teacher quality on the process of teacher appointment. The teachers' appointment is subject to interference from political parties seeking to place teachers of their own choice and interest within their population (Ahsan, 2003). Therefore, these teachers cannot be supposed to produce a quality teaching. Sadiqqui (2009) also criticized that there are thousands of '*trained teachers'* in Pakistan who got degrees in teaching, the majority of whom have just passed their exams by cramming the contents. It can be noted that there is a need a shift from teacher dominancy to student-centred approach in teaching as well as attitudes towards methods of teaching (e.g. Sadiqqui, 2009; Hunzai, 2009). Hence, such teachers' appointments are also a cause of decline of quality in teaching and development of pedagogy in Pakistan (e.g. Sadiqqui, 2009).

Moreover, the professional development of teachers is a keystone for quality in teacher education. Research on Pakistani teacher education suggest that there is a less focus on teacher performance and quality in terms of professional development in Pakistan instead, more emphasis is on the following factors when teacher enters into teaching profession in universities (1) the educational qualification of the teacher, (2) recruitment on merit, (3) an adequate teacher performance monitoring system, (4) incentives, (5) the up-grading of teachers' skills, and (6) a growth-oriented career structure (World Bank, 2006). Nonetheless, each stage of education is under-development and shortages of teacher are the key issues, and there is a large room to improve the quality of teaching (OECD, 2004).

Another issue with teachers training and monitoring of these training can be noted. Despite the fact that, above 90 % of teachers working in the public-sector schools in Pakistan are trained (Academy of Educational Planning and Management, 2009), these trainings are not relevant to teaching and remain inapplicable. Hence, the impact of teacher training both through initial and in-service programmes is not seen on student-teachers' achievement. Although teacher education and training in Pakistan have been much criticized, it has been

supplying a massive trained human resource in spite of the limited and insufficient resources. However, education ministries supervised teacher-training workshops in order to improve teaching skills, incentives are severely lacking because of the shortage of financial support to education that reduced the teachers' participation (Ahmed, 2012). Therefore, only a small number of teachers are concerned with their professional development.

Moreover, another pertinent issue facing both of the public and private sector is that teachers are often sent to professional development without their willingness and interest. Most of them who attend development courses are just there to participate and to fill up a vacancy. It is of also concern to note that there are no particular options on the variety of courses available for teachers (Ali, 2009; Mohammed, 2010).

The methodology of teaching in ITE is essential for imparting the basic knowledge and skills to student-teachers. Literature suggests that development in ITE cannot be sustained if a country does not have competent and capable teachers to teach using an effective pedagogy (Mohammed, 2006). Unfortunately in Pakistan universities, educational plans and policies have been less emphasising in developing teachers' pedagogical knowledge. Nonetheless, most plans in Pakistan have been focused on teachers' recruitment and on developing new pathways to teaching rather than pedagogy. Moreover, teaching in the public sector educational institutes is characterized as rote learning to be reproducing on examinations. Some of the student-centred methods such as inquiry-based pedagogy to learning in science might be the aim of curriculum designers but not seriously implemented practically, until now (Mohammed, 2004).

Within ITE programmes, another issue is the lack of coordination and direct collaborations about teaching methods between staff. This has resulted into non-standardized and deficient teaching and failed to provide acceptable levels of teacher education. Thus, there is no single ruling authority to provide guidance and direction to these institutions to maximize their efficiency and to monitor their product quality (Mohammed, 2006; UNESCO & USAID, 2006).

Fundamentally, it is student-teachers' concern about the ways in which they are made to learn information through the rote memorization with a limited purpose of reproducing it in the examinations (Hayes, 2002; Jaffer, 2005). The situation within university and classroom pedagogies do not encourage children to in-depth cognitive learning and to use their own judgment and exercise their critical abilities in efforts to understand what it all

means to learn what is presented to them in the school (Halai et al., 2004; Shah, 2000; Sultana, 2001). Therefore, Pakistan's educational situation reflects that the government education system possibly seems not helping learners to learn effectively.

There is a general understanding in Pakistan that teachers need fewer academic and professional qualifications to teach in their early years. Science education is, therefore, suffering from a shortage of qualified teachers (Mahmood, 2008; Memmon, 2010) skilled in pedagogical knowledge. Iqbal & Mahmood (2000) maintained that many teachers lack desired knowledge, competences, skills and scientific attitude. Also, teachers' demonstration to an inquiry directed experiments seldom find their way into classroom and laboratory. Sadiqqui (2009) suggested that teacher education should not be rather a mechanical sort of activity but it should be organized with live experiences.

It is agreed that teachers are pressurised with several challenges and problems in teacher education, particularly, in Pakistani system and traditional teaching methods are usually followed by teachers. In such circumstances, things could be imbalanced even though teachers have not proper understanding of inquiry approach to practice and background knowledge. Ali (2008:2) explained as:

> The traditional tendency is to emphasise the correct conduct of taught procedures in order to gain 'right' answers and, of course, the importance of being able to 'do' mathematics correctly cannot be underestimated.

In teacher education in Pakistan, the teaching staffs in government colleges are poorly trained and under-motivated, use inappropriate methods of teaching and do not supervise the teaching practice of student-teachers in a way likely to enhance teaching skills (Ali, 2008; Khan and Saeed, 2009, Iqbal, 2010, Memmon et al., 2010, Ahmed, 2012). Assessment of the prospective teachers depends entirely on the rote learning. Hussain (2003) examines the teachers of training colleges mostly use the writing board and charts as audio-visual aids while projects, multimedia until now and computers are not used at all. Hence, lecture and didactic methods are mostly used in teacher education. This suggests knowing student-teachers' inquiry practices and their beliefs about inquiry in initial science teacher education. However, it needs to explore what is known about teachers' and student-teachers' views about their current practices of teaching and inquiry in Pakistani contexts.

Furthermore, the quality of teaching in ITE is hindered by the problems in current teaching practices interrelated with curriculum and assessment system in Pakistan. Zia (2003) discussed the contemporary situation regarding examination and curriculum in Pakistan

that the teachers lack either the confidence or the structure that a curriculum can provide. Consequently, the quality of teaching drops. Also, the quality of instruction in teachers' preparation programme still needs improvement at a great deal.

In the current system of Pakistan, the majority of teachers do not seem to meet the recommendations of teaching of science (Halai, 2010; Mohammed, 2006). It has to be recognized that teachers have a little hold over curricula, assessment system and resources. It is, therefore, unfair to criticize the teachers for not taking up better approaches. Therefore, research influences educators to provide teacher education programs that help student-teachers to develop pedagogical practices and dispositions (Hart, 2002) and that preparation of primary and middle school science teachers. Additionally, Weiss et al. (2001) suggests that coursework in science education should also include the balanced conceptual content among natural resources and environmental science. Thus, long-term professional development programs are needed to achieve lasting changes in teachers' practical knowledge (Van Driel et al., 2001).

Moreover, the educational reforms have not been successful to make a real progress in education system. Although, the statistical reports show a quantitative progress in education, overall quality of education provided by the public sector in Pakistan has been poor (Rizvi and Elliot, 2005). According to Rizvi and Elliot (2005:36), "Quantitatively, Pakistan's education system has shown significant progress since 1947". It seems that education is progressing in terms of increase in number of institutes in Pakistan.

> Teachers in many government primary schools in Pakistan are still struggling alone in their classrooms to cover content with large groups of learners (Rizvi and Elliot, 2005:37).

However Rizvi and Elliot (2005) argued, that teachers are still anxious because When efforts have been made to the reforms in educational structure and curriculum in accordance with moral and cultural values, development budget allocation for the social sector has been very low (Mohammed, 2006). Also, all efforts have often been unsuccessful in the past because they failed to take teachers' existing knowledge, and attitudes into account (Van Driel et al., 2001). Hence, the biggest dilemma in teacher education in Pakistan is that a very few efforts have been undertaken at both provincial and national levels; therefore, teacher education has been at disadvantages.

4.4 Teaching Approaches in ITE in Pakistani Universities

The following methods to teaching are generally used in ITE in Pakistani classrooms.

4.4.1 Lecture Method

The lecture is highly top rated and most used teaching method in Pakistan (Ahmed, 2012; Halai; 2009; Memmon; 2009; khan, 2012). Generally, a lecture is a talk or verbal presentation given by a lecturer, trainer or speaker to an audience. With all the advancement of training systems and computer technology, lecture method is still widely used in teaching and training at higher level of education. This method is economical, can be used for a large number of student-teachers, material can be covered in a structured manner and the teacher has a great control of time and material. Traditional teaching approaches allow teachers to dominate throughout the process of learning in the classroom. Kim (2005) suggests that traditional teaching approach undertook the following steps: 1) introduction; 2) development; 3) review. Thus, using this approach, teachers usually dictate student-teachers without considering whether learning happens or not.

Kim (2005) discusses the typical classroom situation as follows: Firstly, teachers often disseminate knowledge and expect student-teachers to identify the facts of the knowledge presented. Secondly, most teachers rely heavily on textbooks. Often, the information the teachers disseminate to student-teachers is directly aligned with the view of the textbook. Thirdly, most classrooms encourage competition among student-teachers, structurally discourage cooperation and require student-teachers to work in relative isolation on tasks that require low level thinking, rather than high-order thinking. The similar teaching practices happened in most of Pakistani classroom. Also, it can be noted that student-teachers' independent thoughts are devalued in most classrooms in lecture settings. When student-teachers are asked questions, most teachers seek to enable student-teachers to know the "right" answer instead of motivating them think through complicated issues (Mohamed, 2006). Thus, teachers' perspectives in ITE in Pakistan need to be known how teacher-led education is a way to engage student-teachers and lead them to the best possible outcomes.

Literature suggests that student-teachers may place greater emphasis on lecture material than on textbooks. Lecturing is not simply a matter of standing in front of a class and reciting what you know. The classroom lecture is a special form of communication in which voice, gesture, movement, facial expression, and eye contact can either complement

or detract from the content (Davis, 1993). Moreover, McCarthy (1992) found in a study that that most of the student-teachers considered lecture as the best method because according to opinion of student-teachers; it creates new ideas, it is good for large class, develops creativity among student-teachers, teacher is experienced and has mastery on subject, explain all points and can answer all questions by student-teachers. Likewise, Sullivan & McIntosh (1996) said that the lecture can be a highly effective and interactive method for transferring knowledge to student-teachers with planning and effective presentation techniques. Moreover, lecture gives the pupils training in listening and taking rapid notes. Therefore, the majority of student-teachers usually rate lecture method as the best teaching method. Because the teachers take the responsibility of all information delivered to students-teachers; this makes student-teachers take notes and save their time. Thus, the lectures are the efficient and inexpensive of teaching because lectures can be an effective way of transmitting a huge volume of educational content in science to an even large number of learners.

Rizvi and Elliot (2005: 37) suggest that inquiry-based pedagogy is mostly not workable in Pakistani teaching training institutes becomes "teachers are probably teaching in the manner that they themselves were taught". The majority of enrolled teachers and student-teachers in teacher education programme have studied in the public sector schools (Ali, 2008). Therefore, they mainly teach using traditional lecture method. Most teacher-educators in the teacher preparation institutions use the lecture method and even dictate their notes to the student-teachers in Pakistani classroom. Freire's (1970) narrated the concept of banking education about the role of teachers in teacher- led approaches. According to Freire's banking concept of education, teacher handover knowledge to students, therefore, student-teachers behave like passive listener. Therefore, the students do not participate in the learning process. Freire (1970) also make known to problem-posing education in the classroom where teachers and students interact with each other. Hence, ITE in Pakistan strongly needs a change from dominant teaching to problem-posing teaching.

The teachers using the traditional teaching approach are usually inadequately trained. Therefore, they are more likely dominate student-teachers' learning in the classroom with excessive use of the textbooks (e.g. Mohammed, 2006). I agree that teachers usually teach in a way that they themselves observed their teachers or were taught by their own teachers when they were pupils. Also, lecture method is highly criticised because it develops the rote learning rather than deep learning (Mohammed, 2004; 2006). Additionally, the present

education system in Pakistan offers only minimal curricular resources for student-teachers. Therefore, teacher educators have limited knowledge about technology and innovations they could use with their student-teachers. Nevertheless, inquiry-based pedagogy suggests a role of facilitator to the teachers contrary to the teacher-dominated approaches. The pursuit of student-teacher questioning and participation in classroom activities is valued in inquiry-based classroom. The student-teachers are viewed as thinkers and the teachers generally behave in an interactive manner, and mediate the learning environment for student-teachers.

4.4.2 Discussion Method

The discussion approach is another used teaching approach in ITE in Pakistani classroom. In Pakistan, most teachers like to use lecture approaches to teaching through which they can control the class well. Most of the time, discussion is one of the strategies teacher choose to use in classroom (Ahmed, 2012). Discussion is a free verbal exchange of ideas between group members or teacher and student-teachers. Also, student-teachers should have prior knowledge and information about the topic to be discussed. McCarthy (1992) suggested strengths of class discussion as; pools ideas and experiences from group, and allows everyone to participate in an active process. Kochhar (2000, p.347) defined that a problem, an issue or a situation in which there is a difference of opinion, is suitable for discussion method of teaching. Group discussion method by giving reasons that firstly, it has more participation of student-teachers, the student-teachers do not have to rely on the rote learning. Secondly, every student-teacher can share opinions, and this method develops creativity among student-teachers (Kochhar, 2000).

Discussions usually occur among student-teachers in the form of small groups, or whole class and are teacher-led or student-led. Also, teachers frequently involve students in discussion of a written text, though discussion can also focus on a problem, issue, or topic that has its basis in a "text" in the larger sense of the term. In ITE in Pakistani classroom, small group discussions are often used rather than a whole class discussion (Khan and Saeed, 2009). From my experience of teacher-educator in a university in Punjab (Pakistan), I can say that discussion method encourages students-teachers to give their own views through open participation with freedom, particularly, where there are no resources in classroom. Student-teachers are divided into small groups of, four, five, or six, and given the questions to discuss and then report back and student-teachers share with peers and present in classrooms. Therefore, discussion method allow student to interact with teacher-

educators and peers and work collaboratively.

Given that the lack of resources in classroom and insufficient laboratory equipment, these problems hinder in doing open-ended science investigations or hands-on activities. In such circumstances, it does not seem possible to use inquiry-based approaches all the time. Therefore, group discussions can better engage student-teachers in solving problems/questions.

4.5 Teachers' Perspectives on their Practices and Professional Development in ITE

Teachers are the most crucial component of any system of teacher education, how well they teach depends on their qualification, experience, and training, not the least of these being the environment and management structures within which they perform their role (Kane, 2011). Teaching has been seen in many different ways having parallel conception between teaching and learning since last centuries. Kember (1997) examined teaching as a continuum from the transmission of knowledge to the facilitation of learning at one end. While, at the other end, learning has a broader concept that offers aim of education is to make the learners develop learning, and their own thinking. Following on from this, it is then important how teachers' professional development and practices play a role in fulfilling this aim of education in ITE. Therefore, this section presents a brief overview on the teacher's perspectives on professional development and practicalities of teaching and then of their students.

ITE programmes aim to prepare competent, thoughtful, reflective and innovative teachers for their prospective teaching, who are committed to provide high quality teaching and learning for all pupils (GOP, 2009). Therefore, the teachers' development is not only the result of the initial training that the teachers receive before or upon entry into teaching, it is also a product of the continuous struggles on their daily experiences inside and outside the classroom. Therefore, teachers' thinking, beliefs and practices influence teachers learning and development in relation to student-teachers, pedagogy, classroom processes and structures. The connection between teachers' perspectives and values and their classroom practices is apparent. For example, Maor and Taylor (1995) suggested that teachers' epistemology is an important intervening influence on how student-teachers' learning in inquiry in science. It can be noted that teachers' and student-teachers' understanding of inquiry and learning as inquiry are fundamental.

The process of becoming a teacher is appearing simply learning to teach (Levine, 2006). The literature on teacher education in Pakistan suggests that the traditional transmission paradigm of teacher education and development regards teaching as centered, culturally and socially neutral kind of activity aiming at the transmission of an individual knowledge (Ali, 2008; Cole & Knowles, 2000; Mohammed, 2008). Thus, this considers teachers' perspectives on teaching as a technical activity, and the role of the teacher as a technician is to equip them with the necessary knowledge and skills required by the teaching task (Cochrane-Smith & Fires, 2001).

The aim of education in Pakistan is perceived as a process of 'getting through' and passing examinations. It is not about the personal journey a learner goes on and the experiences they have along the way. Caprio (2001) suggests that teacher must comfortable with inquiry to be able to help their student-teachers because inquiry-based approaches require significant amount of time and level of competence. Thus, it can be noted that an important perspective of teachers is that inquiry focuses upon single process skills (Lederman, 2004).

Inquiry-based approaches present teacher' practices in ITE as a facilitator but it challenges to teachers many ways. The teacher's role as a facilitator to student-teachers includes teachers' efficiency in class, interaction with student-teachers, peers support and democratic style of teaching with student-teachers (e.g. Hanson and Moser, 2003). Teachers' perspectives on their role as facilitators generate a discussion different from the other interactions after analysing student-teachers' work samples. Hence, role of the teacher in an inquiry-based learning is different from that during the traditional style of teaching.

In ITE, teachers are required to raise student-teachers' awareness about the teachers' wider role beyond subject teaching, through contributing to the culture of university. In the complexity of a live classroom, the direction can be more than one of actions leading directly to outcomes (Brophy, 1992). In addition, the teachers are supposed to work with student-teachers when they need help and address class-wide problems when necessary. Therefore, teachers' practices as facilitator can be modified and should not be used to describe the work done by a competent and qualified teacher. Moreover, the teachers' practices should be based on learners' needs. Through my experiences of teacher-educator, I can say that teaching staff is recruited as a lecturer at fundamental level/ start of their career in Pakistani universities (see Chapter 2). Therefore, teachers come with assumption they are going to lecture the class not with the thought they would be facilitators or more than the lecturers. Though teacher as a facilitator promote discussion through question,

encourage student-teachers to reflect on their learning experiences, a lecturer still develop something new and somewhat valuable to the learning. Thus, it is little known in the previous research that what teachers as a facilitator make certain about achieving the intended learning outcomes of inquiry-based learning.

Effective teachers continually practice opportunities that challenge student-teachers and promote inquiry-based learning by asking questions and other various activities in the science classroom (NRC, 1996:3). However, Downing & Filer (1999) argued that only teachers who have themselves mastered inquiry-related skills can successfully teach their student-teachers using inquiry. Thus, the teachers' perspectives being weak/limited in their own understanding of science processes and do not feel confident to facilitate the conceptual development in their student-teachers.

Literature suggests that complexities emerged when teacher-educators and student-teachers learned to use the process of inquiry in their practice (Hayes, 2002). Several tensions were identified from teachers' and student-teachers' perspectives, these tensions are similar for both of them. At times, the teacher-educators and student-teachers themselves expressed frustration with the lack of accessibility toward and understanding of a critical inquiry. Hayes (2002) examined the apprehensions and concerns of teachers regarding the implementation of inquiry-based science in their classrooms in the United States. He looked at how teachers engaged in productive struggles to understand and implement an inquiry teaching unit in their field-placement setting. Hayes also found that the teachers struggled with their emerging identities and roles as facilitators, spoken their concern about removing themselves out of the traditional authoritarian role as a teacher within the classroom.

Research suggests that professional development opportunities for teachers were an important contributing factor to the implementation of inquiry-based instruction in the present situation of teaching (Kazempour, 2009). Thus, the teachers as planners a can perform an essential part of inquiry-based instruction in guiding students' curiosity. Thus, teacher (even lecturer) is not merely a facilitator but work with the students and helps developing their understandings during the whole learning process. Thus, the teachers perspectives on their practices indicate them as facilitators in the process but avoid simply providing solutions or being prescriptive in approaches to teach (Gordon and Brayshaw, 2008).

4.6 Chapter Summary

This chapter reviews the situation of in initial science teacher education and the teaching methods used in science teacher education in Pakistan. The most used and highly rated teaching methods are lecture methods and discussion in which teachers usually encourage the rote learning to their student-teachers. This chapter also addresses the teachers' perspectives on their practices and professional development and reviews teachers' understanding of their practices and any contradictions between their perceptions and their student-teachers. It can be noted that the teachers are an important agents in the process of social transformation and educational change, the teachers can modify their practices and experiences according to learners' needs. To sum up, the literature on science teacher education in Pakistan reflects a narrow focus on the structural and organizational issues in ITE. The next chapter narrates the research methods and methodology used in the current study.

Chapter 5

Methodology

5.1 Introduction

This chapter presents the research design and methodology employed in the present study, which has aimed to investigate Pakistani university student-teachers' and teacher-educators' perceptions of the role and importance of inquiry-based pedagogy in ITE. This study takes a mixed method approach because of the nature of the problem, and research questionnaires, semi-structured interviews and focus groups were the sources of data collection. Though the questionnaire included mainstream questions in order to seek teacher-educators' and student-teachers' perceptions of inquiry-based pedagogy, care has also been taken to give due share to the qualitative approach through in-depth interviews to confirm the contemporary research trends in the field of science teacher education. Therefore, further interviews explored and provided further insight into the questionnaire's themes. The present chapter outlines mixed method design, explains why it was applicable and how the research tools, i.e. questionnaires, semi-structured interviews and focus groups were developed. An account is also given of the research participants, the difficulties and considerations related to the research methods, how the study was actually delivered to the target participants, ethical issues encountered, and the methods for data analysis.

5.2 Aims of the study

- To investigate the teacher-educators' and student-teachers' perceptions of the fundamental elements of inquiry;
- To investigate the teacher-educators' and student-teachers' perceptions of the role and importance of inquiry and inquiry-based pedagogy in ITE;
- To identify the challenges those impede the practice of inquiry-based pedagogy in ITE.

5.3 Research Questions

This study seeks to provide an answer to the following research questions:

1 How do teacher-educators perceive the role of inquiry in science in ITE?

   (a) How do student-teachers perceive the role of inquiry in science in ITE?

2 How do teacher-educators understand the role and importance of inquiry in relation to scientific literacy?

   (a) How do student-teachers perceive the role and importance of inquiry in relation to scientific literacy?

3. How do teacher-educators perceive the challenges that impede the practice of inquiry-based pedagogy?

   (a) How do student-teachers perceive the challenges when inquiry-base pedagogy is practices?

5.4 Research Methodology

5.4.1 Quantitative and qualitative approaches

This study has elements of both quantitative and qualitative approaches and these terms represent a well known distinction in research methodology. They are not simply the exploitation of figures versus qualitative data; rather, this division declares two different philosophical approaches to the exploration of the world and the construction of meaning (Cohen et al., 2007; Creswell, 2008). The terms quantitative and qualitative explain the respective manners of theory construction, methods of data collection and analysis, and general ideological orientation present in this study. Both quantitative and qualitative data were collected in this study to carry out an in-depth investigation of student-teachers' and teacher-educators' perceptions of the role and importance of inquiry-based pedagogy in ITE in Pakistan.

5.4.2 Quantitative Approaches

Quantitative research was initiated in response to the progress of natural science in its science investigations in the 19th century. The development of scientific methods and statistics in the 19th century encouraged the use of quantitative methodology in the area of social development. At this time, the social sciences attained a maturity and were able to research human beings scientifically at both individual and social levels (Cohen et al., 2007). Since 1970, the role of questionnaires in the field of science education has been significant. Research suggests that more than eighty percent of research papers published have been quantitative in recent years. This shows the dominance of quantitative research over other forms. Reid (2006) explains that research into attitudes can be analysed as (1) survey studies (2) factor analytical studies (3) correlation studies and (4) studies using structural equation modelling. Usually data has been collected through questionnaires, using a quantifiable scale and a close-ended form. The responses have been analysed statistically (Reid, 2006). This positivist approach has advantages, such as (a) It is precise; (b) it produces reliable and replicable data; and (c) statistically significant results are generalisable (Creswell, 2013; Cohen et al., 2007).

5.4.3 Qualitative Approaches

Qualitative research is part of social science. Unlike quantitative research, qualitative research is difficult to define precisely because researchers are of the opinion that qualitative research is perceived differently by different people and it is non-systematic and non-rigorous. Qualitative approaches are based on the participants rather than the researcher's explanation or choices, without holding a pre-conceived hypothesis (Ball, 2005; Creswell, 2008; Cohen et al., 2007; Rodrigues, 2010). However, recent years have witnessed interest in qualitative research in all disciplines of the social sciences. Quantitative research methodologies have sometimes been used in science education, but the importance of qualitative research has been increasing in the field of science teacher education over many years (see e.g. Varma, 2007; Rodrigues, 2010).

This research has recognised that a major aspect of teacher-educators' and student-teachers' perception of inquiries, the nature of science education, is something which can elaborate upon such influences. The frequency of published qualitative research studies is however comparatively lower than quantitative research in Pakistan (Ahmed, 2012). From my experience of teacher-educator in a university in Punjab (Pakistan), I can say that most research conducted in science teacher education, particularly pedagogy and practice in

science and science teacher education, has been carried out using quantitative methods for example, surveys and statistical analysis of quantitative data. Accordingly, use of the qualitative approaches like interview, focus groups and observations are less common. Therefore, this study contributes into research on pedagogy, particularly in ITE in Pakistan, used the qualitative approaches such as semi-structured interviews and focus groups to research the perceptions of teacher-educators and student-teachers in ITE.

5.4.4 Mixed Method Approach

After considering the nature of the study, a mixed methods design was selected for its interpretive function, its flexibility, depth and detail in studying the selected issues. This study aims to explore teacher-educators' and student-teachers' perceptions of the role and importance of inquiry and inquiry-based pedagogy in science in ITE in Pakistan. Mixed methods were, therefore, chosen because a combination of approaches can offer a balancing strength rather than using a single approach (e.g. Cohen et al, 2007; Muijs, 2004). Yin (1984:92) elucidated the benefits of combined approaches in research as being that: "the combining of several approaches helps to overcome the weakness, biases and limitation of using a single approach". Furthermore, according to Cohen et al. (2007: 233), "the usage of a mix of research approaches helps in collecting more comprehensive and vigorous data, and helps to make the researcher more confident that findings are valid".

The rationale for choosing a mixed methods study was that during my Masters degree I carried out questionnaires to teacher-educators on their perception of problem solving approaches in mathematics education. Questionnaires data did not provide in-depth understanding of teacher-educators in the Pakistani context as a sole method. Moreover, the questionnaire was tightly focused and did not allow participants to give their views with freedom but the questionnaires needs not to structure this way. Based on this, I decided on a new interview tool for my PhD project so that richer data could be collected. The data analysis in mixed methods gives a more confident understanding of the phenomenon being studied (Creswell, 2008).

Also, another reason for choosing mixed research methods within this study was the distinctive contribution that each particular approach could offer to the investigation of the research questions. As it was anticipated that there would be some dissimilarities between what participants reported in questionnaires and what they would articulate in interviews and focus groups, the tools should be able to reconcile this. Moreover, the benefit of

collecting data from multiple sources is that it allowed the researcher to carefully check and validate whether the researcher's interpretation of data is correct. According to Glaser and Strauss (1999), the replication of data is the best means for validating facts. Thus, a mixed methods design in this study provided sensible advantages in exploring the research questions.

Also, the mixed method design in this study employed a methodological triangulation that involves using more than one method to gather data, i.e. interviews, focus groups and questionnaires. Thus, triangulation helps in increasing the credibility and validity of the results. According to O'Donoghue and Punch (2003), triangulation is a "method of cross-checking data from multiple sources to search for regularities in the research data". Thus, triangulation testifies as to the consistency of findings obtained through different instruments and then is used to confirm findings within the study (e.g. Creswell, 2013; Cohen et al., 2007).

There are a variety of ways to combine quantitative and qualitative research, such as multi-methodological, mixed model, interrelating quantitative and qualitative research. Using mixed methods is advantageous in practical terms as it helps to understand the construct's meaning (Bell, 2005; Patton, 2003; Creswell, 2008). In addition, mixed methods allow data to be compared, which can give interesting results (Bell, 2005; Lau, 2009).

5.5 Research Tools

A research design is a detailed plan that includes guidelines for all the research related activities (Cohen et al., 2007; Creswell, 2008). It specifies what needs to be done, with whom, when, where and why. Because the primary research is all about the data, the central aspects of my research design were intended to provide the specifications of the data to gather and to describe how the data would then be processed and analysed.

As mentioned above, mixed methods were chosen as the main mechanism for data collection and analysis processes, with questionnaires and semi-structured interviews used as the main tools for gathering a mixed data (see Section 4.1). It was anticipated that there would be some differences between what participants in each of the different tools, and these tools should be able to gather this. The tools which were employed are presented as follows:

5.5.1 Questionnaire

In this study, firstly, questionnaires were used to seek teacher-educators' and student-teacher-educators' views of the role and importance of inquiry-based pedagogy in ITE (see Section 5.3). Questionnaires constitute an important and popular technique that is widely used to study the attitudes, opinions, perceptions and preferences in the field of educational research (e.g. Muijs, 2004; Reid, 2006). Oppenheim (1992: 100) described questionnaires as: "The questionnaire is an important instrument of research, a tool for data collection. It is considered a set of questions arranged in a certain order and constructed according to specially selected rules". Also, the questionnaire in the present study is characterised by its advantages. For example, (1) the questions were the same for all respondents, (2) anonymity of the participants was respected, (3) it was a relatively economical method in terms of both cost and time, and (4) it allowed time to carefully check the content of the questions that are likely to yield more accurate information. Moreover, (5) questionnaires were particularly chosen as a method because of its adaptability and flexibility to compare the data collected (Cohen at al., 2007: Reid, 2006).

Questionnaires may give three types of data about respondents, which are: (1) Factual (2) Behavioural and (3) Attitudinal (Cohen et al., 2007; Creswell, 2008; Reid, 2006). I outline each of these below.

(1) Factual questions: these are used to find out about who the respondents are. These questions generally cover demographic characteristics; for example, age, gender type of school and socioeconomic status, level of education as well as any relevant information useful to interpreting the findings of the survey.

(2) Behavioural questions: these are used to find out what the respondents are doing or have done in the past. These questions seek information on participants' actions, experiences, lifestyles, and habits.

(3) Attitudinal questions: these are used to find out what people think. This is a broad category that concerns attitudes, opinions, beliefs, interests and values.

I used elements from all of the categories as mentioned above, asking the participants what they thought and what their views were, and about their perceptions of inquiry-based pedagogy. At the start of the teacher-educator's and student-teacher's questionnaire, both of them were required to provide factual information.

The background items of the questionnaire were regarded as independent variables of the study. The total number of questions in teacher-educators' questionnaires and student-teachers' questionnaires were 65 and 72, respectively. This time allocation for completion of full questionnaire was decided after the pilot study, so the time allocated for completion of the questionnaires was 30-35 minutes. In this study, I used closed-ended questionnaire items because these are objective items and are the most commonly used types in the quantitative studies (Ball, 2005; Cohen et al., 2007; Reid, 2006). The major advantage of closed questions is that their coding and tabulation is straightforward (Reid, 2006). Therefore, I provided the respondents with ready-made response options to choose from and asked them to give an appropriate grade from 1 to 4 (4-Likert Scale).

5.5.1.1 Construction of Questionnaires

Questionnaires, however, do have some disadvantages, such as a potentially low response rate. I administrated questionnaires in person and this resulted in a high response rate as the participants were offered an explanation if they had any difficulties in answering any of the questions. Finally, taking all of these factors into account, questionnaires were chosen as the research instrument for quantitative data. To uphold ethics and ensure no bias, the questionnaires were thoroughly planned and carefully worded, with thorough discussion regarding the interpretation of the questions.

Questionnaires for teacher-educators' and for student-teachers' were constructed by the researcher. All the questions were closed and offered a 4-Likert scale. A 4-Likert scale without a midpoint was preferred in both questionnaires. Some studies have concluded that the optimal number of scale categories is content specific and a function of the conditions of measurement (Friedman et al., 2000). Also, a social desirability bias, arising from responses giving perceptions in relation to potentially socially unacceptable answers, can be minimised by eliminating the mid-point (for example, not sure or uncertain, etc.) category from the Likert scales. The closed questions offered a fixed range of responses to cover what the respondents think. Also, questions were easy and quick to answer. As Cohen et al. (2007) reported, "Closed questions prescribed the range of responses from which the respondents may choose" (p.321). Moreover, closed questions are useful in that they can generate frequencies of responses amendable to statistical treatment and analysis.

The questionnaires aimed to explore teacher-educators' and student-teachers' perceptions of the role and importance of inquiry and inquiry-based pedagogy in ITE. In order to

explore these concerns and aims as deeply as possible, questions were constructed which covered particular areas of inquiry-based pedagogy and difficulties when inquiry is used, derived from existing theories in the literature of inquiry-based pedagogy context. They were also based on the researcher's personal knowledge as a university science educator in Pakistan and the researcher's personal familiarity with the teaching and learning situations in Pakistan. The main questions were developed for the teacher-educators' and student-teachers' questionnaires to explore the following aims: (1) the participants' perceptions of the role and importance of inquiry and inquiry-based pedagogy in learning science; (2) their perceptions of inquiry-based pedagogy in relation to science literacy and 3) the difficulties encountered when inquiry is practised in ITE.

5.5.1.2 Likert Scale Questions

Likert scale items/questions consist of a series of statements, all of which are related to a particular target (an individual person, group of people, an institution or concept), and respondents are asked to indicate the extent to which they agree or disagree with these items by marking one of the responses ranging from 'strongly agree' to 'strongly disagree' (Cohen et al., 2007; Creswell, 2003; Reid, 2006). After the scale has been administered, each response option is assigned a number for scoring purposes (Reid, 2006). Some researchers prefer using an even number of response options because of the concern that certain respondents might use the middle category (neither agree nor disagree or not sure or neutral) to avoid making a real choice (ibid, 2006). Therefore I preferred a 4-Likert scale. I used number as (e.g., strongly agree=4, agree=3, disagree=2; strongly disagree=1).

5.5.1.3 Presentation of Teacher-educators' Questionnaire

This section provides details on the construction of the teacher-educators' questionnaire. The teacher-educator questionnaire was distributed in four parts. The questionnaire contained fifteen questions comprising various aspects of inquiry and inquiry-based pedagogy. Questionnaire was started explaining the goals and significance of the study, the rights of the participants, and some instructions on how to answer the questions. This was followed by questions on demographic information such as gender, the courses they taught, years of experience, highest level of education and training received. Following the first six questions, in Questions from 7-13, all items were measured by using a 4-Likert scale response system.

The second part was divided into 3 main questions: (7) views about learning of science; (8) views about their own teaching experiences of science; (9) aims of ITE using inquiry-based pedagogy. Part 3 started with three ways of thinking of inquiry-based pedagogy, i.e. definitions of inquiry-based pedagogy, science literacy and procedural understanding. Part 3 includes two questions focused on (10) views on Inquiry-based Pedagogy in science in Initial Science Teacher Education and (11) views on teaching and student-teachers' learning. This part looks for the answer to RQ 1, i.e. the perceptions of teacher-educators about the role and importance of inquiry-based pedagogy (see Section 5.3).

Finally, part 4 includes three questions as follows. (12) teacher-educators' views of their teaching and of inquiry based pedagogy in relation to science literacy. This part explores the perceptions of teacher-educators about the role and importance of inquiry-based pedagogy in relation to science literacy. This part looks for the answer to RQ 2 (see Section 5.3). Question (13) is about teacher-educators views on the key barriers in implementing inquiry-based pedagogy. This part seeks the perceptions of teacher-educators about the key barriers to implementing inquiry-based pedagogy. This part looks for the answer to RQ 3 (see Section 5.3). Finally, in Question (14) teacher-educators were asked to provide their contact details to be involved in interviews.

5.5.1.4 Presentation of Student-teachers' Questionnaire

This section provides details on the construction of the student-teachers' questionnaire. This questionnaire contained fourteen main questions covering the various aspects of inquiry-based learning approaches including advantages and disadvantages of inquiry. Student-teacher questionnaire was organised into four parts. Part 1 includes the questions on the demographic information such as gender, type of school, medium of instruction at school, courses studied and their year of study. Following the first five questions, questions from (6-14) is measured using a 4-Likert scale.

Part 2 starts with the explanation of three ways of thinking about inquiry-based pedagogy, i.e. definitions of inquiry-based pedagogy, science literacy and procedural understandings. Then, part 2 is further divided into 3 main questions: 6) views about the learning of science 7) views about teacher-educators' teaching 8) the aims of learning science. Then, part 3 includes three questions; focused on 9) views on Inquiry-based Pedagogy's help in learning science; 10) views on the role of Inquiry-based pedagogy in science in developing scientific literacy, and 11) views on the importance of inquiry-based pedagogy. This part

looks for answering RQ 1 (see Section 5.3). Finally, part 4 includes three questions, on: 12) views on the practicalities of teaching in science. This part looks at the perceptions of teacher-educators about the role of inquiry-based pedagogy in relation to science literacy. This part looks for answering RQ 2 (see Section 5.3). In item 13) views were invited on the key barriers to implementing an inquiry-based approach. This part looks for answering RQ 3 (see Section 5.3). Finally, in question 14), student-teachers were asked to provide their contact details to be involved in focus group interviews.

In both teacher-educator and student-teacher questionnaires, the language used in the set of questions was intentionally simple and clear. Also, the language was checked by a couple of science teacher-educators. The font size of the questionnaire was adequate to help student-teachers and teacher-educators in easily reading them. Finally, the draft questionnaire was assessed by supervisors and minor amendments were incorporated before applying for the Ethical Approval.

5.5.1.5 Piloting the Questionnaire

Piloting the questionnaire aimed to achieve three goals: firstly, to ensure that the questionnaire was suitable for its aims, i.e. eliciting the perceptions of the teacher-educators and student-teachers about inquiry-based pedagogy. Secondly, the clarity of questions is assessed to identify whether any ambiguities arose. Thirdly, the administration procedure is ensured to be effective. Oppenheim (1992: 48) remarked that "everything about the questionnaire should be piloted; nothing should be excluded, not even the type face or the quality of the paper". The pilot study provided very beneficial feedback before implementation, suggesting that the questionnaire required (on average) 30 minutes for completion. In addition, instructions needed to be provided with an example of how to respond. Furthermore, the layout of the questionnaire needed to be revised in terms of ensuring consistency of font size and box size, and to identify the average time required for completing the questionnaire. Finally, the study showed that the level of the questionnaire language was suitable as the participants responded without any difficulty to all the questions.

Number of Teacher-educators	Number of Student-teachers	Month
30	50	March, 2011

Table 5.1: Sample size in the pilot study

The wording of a questionnaire is of paramount importance to its effectiveness and pre-testing is crucial to success. A pilot has several functions, principally to increase the reliability and validity of the questionnaire (Cohen et al., 2007; Reid, 2006). Therefore, the piloting of the questionnaires helped me to check the clarity of the questionnaire items, instructions and layout and also to gain feedback on the validity of the questionnaire items. Piloting helped me in removing ambiguities or difficulties in wording of the questionnaire and also helped to identify omissions, and redundant and irrelevant items. I also identified any misunderstood or non-completed items and tried out the coding system for data analysis.

5.5.1.6 Account of the Administration of the Questionnaire

There are different ways of administering questionnaires: a pencil and paper questionnaire, a telephone interview, face to face, a postal questionnaire, or online and e-mail questionnaires (Cohen et al., 2007). However, a pencil and paper questionnaire form was adopted in this study, for its merits. Firstly, this form was familiar to the student-teacher-educators and teacher-educators, as they were likely to have completed a number of questionnaires. Secondly, this type of questionnaire allows some time to think about the answers. Official approval was already obtained. An appropriate time was arranged to administer the questionnaire. The questionnaire was distributed to the targeted samples between the end of March and the end of April 2011.

I distributed the questionnaire in person to all of the student-teachers and teacher-educators instead of mailing it to them. This method was preferred in order to answer any enquiries from the teacher-educators and student-teachers during the completion of the questionnaire. In addition, the aims were to: (a) explain the goals of the study; (b) clarify the instructions for answering; and (c) obtain a good return rate and accurate data.

During the administration of questionnaire, one teacher-educator helped as a gatekeeper to provide me with the required assistance to administer the teacher-educators' questionnaire. This questionnaire was distributed to the teacher-educators at the same time as the distribution of the questionnaire to the student-teachers. The procedure to administer the questionnaires was implemented in order to obtain a good return rate and valid data, and also to abide by the ethical codes of educational research.

5.5.1.8 Return Rate of Questionnaires

The return rate of the student-teachers' questionnaire was found to be high. 580 out of 600 participants responded to the questionnaire, giving a return rate of 95.8%. Only 20 questionnaires were excluded, as they were not returned. Therefore, the overall return rate of the student-teachers' questionnaires and the teacher-educators' questionnaires were about 96%.

Questionnaires	Questionnaires Distributed	Returned	%
Teacher-educators	100	50	50
Student-teachers	600	580	96

Table 5.2: The number of the questionnaires distributed and received

I distributed 50 questionnaires to teacher-educators; 30 out of the 50 teacher-educators did not return their questionnaires; 20 replied the first time. So I distributed questionnaires to 50 new participants' again to get the maximum possible return. Finally, regard to the teacher-educators' questionnaires, 50 out of 100 questionnaires were returned, producing a return rate of 50%. Thus, the methodology employed for distributing the questionnaire eventually resulted in a good return rate. The table above describes the total number of questionnaires distributed and the number of questionnaires returned to the researcher.

5.5.1.9 Reliability and Validity of Questionnaires

Reliability is an important issue in conducting survey on attitude in educational research (Reid, 2006). Reliability is concerned with ensuring that the instrument of data collection is consistent and yields approximately the same results in different settings and at different points in time (Reid, 2006). Krippendorff (2004) identified reliability as the degree to which the same scores can be produced when the same objects are measured repeatedly. Reid (2006) also shows that genuine reliability can be achieved with good samples and controlled use of surveys. The questionnaire was carefully constructed and was administered under circumstances where respondents were able to be honest in answering. Moreover, the sample size was large enough (teacher-educators (N=50) and students-teacher (N=580) to draw clear conclusions. Reid (2006) suggests that test-retest reliability is important in conducting surveys in educational research. In this study data collection was started with piloting questionnaire with teacher-educators (N=30) and students-teacher (N=50) before administering the main study. However, the sample of teachers and students in the pilot study was different than that of the main study. After pilot study, a small

number of amendments were made in both of the questionnaires; almost the same questionnaires were used in the main study (see Section 5.6.1.5). In the main study, questionnaires were conducted with a large sample of teacher-educators (N=50) and students-teacher (N=580). According to these traits, the reliability of teacher-educator's and student-teacher's questionnaire is likely to be good (e.g. Reid, 2006).

Cronbach's alpha is often employed to indicate a measure of reliability. In fact, Cronbach's alpha is a measure of internal consistency. It gives an indication of the overall extent to which positive (or otherwise) responses in the entire questionnaire occur in all the questions. However, in the questionnaires used here, 65 items were used with teachers and 72 with students and each item aimed to measure a different aspect. There is no advantage whatsoever for it being '*desirable'* those responses are similarly positive across all the items. If it was so, then the questionnaire could have been reduced to a much smaller number of items and, indeed, ideally to one item.

Thus, Cronbach's alpha is a measure that brings together all the inter-item correlations into one number. Alpha simply measures the uni-dimensionality or one dimensional set of items (Tavakol & Dennick, 2011). Cronbach's alpha is not a very helpful statistic here simply because the questionnaires are highly multi-dimensional, reflecting a range of areas of enquiry related to inquiry-based learning. Although Cronbach's alpha is simply a measure of internal consistency, it does not say anything about test-retest reliability or reliability (Reid, 2006).

Reid (2006: 17) defines validity as "validity is simply the extent to which the measurement actually measures what is intended". Also, Oppenheim (1992) describes validity of a measuring instrument can be referred to as the extent to which the instrument measures what the researcher wants it to measure. In this study, all the questions in both of the questionnaires which were designed to measure a particular trait are, indeed, measuring the same trait (e.g. Reid, 2006). In both teacher-educator and student-teacher questionnaires, the language used in the set of questions was intentionally clear and checked by a couple of science teacher-educators from the same area and experience. Those teacher-educators know the students language and understand the terms used in the questionnaires. Though, those teachers did not participate in the main study. Since all of the important aspects of inquiry-based pedagogy in the questionnaires were covered with clear definitions of the construct and its component. Therefore, the content validity of the questionnaire was ensured in this study.

5.5.2 Semi-Structured Interviews

Structured questionnaires were used in this study. However, one disadvantage of such questions is to restrict the respondents, as participants do not have adequate freedom to express their opinion in their own words (e.g. Cohen et al., 2007; Rodrigues, 2010). Thus, an interview offers an alternative to give more freedom and choice to both the interviewer and the interviewee to express their opinion freely and fully (e.g. Bell, 2005; Cohen et al., 2007). Also, Newby (2010:340) maintains that semi-structured interviews provide a robust shape between the questionnaire and the evolving interview which although it has known goals does not have any expected end points. Also, the semi-structured interview is suitable in conditions when the researcher has a good understanding of the phenomenon or domain in question and is able to develop wide questions about the topic prior to conducting the interview (ibid, 2007).

I used qualitative interviewing because of its suitability for research, in that interviews can be considered more helpful and powerful in collecting in-depth data, although they are time-consuming and it can be difficult to summarise the data to give precise conclusions (e.g. Bell, 2005). One reason is that people are more willing to talk than to write. The interviewer gains rapport or establishes a friendly and secure relationship with the interviewee, to give a certain type of confidential information (Rodrigues, 2010; Smith, et al. 1998: 218). Another reason to choose interviews is that an interview has a dual role. Firstly, I interviewed to explore the perceptions of understanding inquiry and inquiry-based pedagogy (see Section 4.3). In other data collection/gathering instruments, it is hard to explicitly explain the purpose but in interviews, the interviewer can explain their purpose (before the formal proceedings begin) and can answer the interviewees' queries (Cohen et al., 2007).

Secondly, interviews assisted me in developing conversational relationships about the participants' understanding of the meaning of inquiry-based pedagogy. Consequently, the interview has been deemed to be the appropriate method after using questionnaires because a qualitative interviewing method gave freedom and choice to interviewees to express their opinions freely and entirely.

5.5.3 Focus Groups: Process and Reflection

Using the questionnaires, student-teachers found that they did not have adequate freedom to express their opinion in detail (e.g. Cohen et al., 2007). To capture the student-teachers' full perceptions regarding their understanding of inquiry-based pedagogy in science, focus groups were organized. Focus group interviews with a small group of student-teachers were chosen to gather in-depth data because it was required to know how student-teachers thought in detail. Thus, an important part of this research design was to have student-teachers sharing their reflections and perceptions about inquiry-based pedagogy and to comment on each others' understanding. Two focus groups were conducted, with 4 science student-teachers per each focus group. They were selected by convenient sampling (Cohen et al., 2007; Ball, 2005) as this allows for the selection of a representative sample of the group being studied. Focus groups allow for diversity of composition and interaction between teacher-educators and student-teachers, which broadens the views on, and understanding of, the issue (e.g. Ritchie and Lewis, 2003). Thus, the triangulation of the research methods has helped in developing a better understanding of the research problem in this study than any single method used (e.g. Cohen et al., 2007; Creswell, 2008).

The intention of the focus group sessions was to stimulate discussions and reflections among the student-teachers about their understanding of the role and importance of inquiry-based pedagogy in ITE. The reflective discussions of the student-teacher-educators were audio-taped and later transcribed. Student-teachers in each focus group were assigned a number to keep track of their responses. Whenever a response was made, the number of the respondent was noted down. In this manner, responses were coded by group number and respondent number, e.g. G1-S1 represents student-teacher 1 in group 1. Similarly, G2-S4 represents student-teacher 4 in group 2. Transcripts from the focus groups served as the data source to provide deeper insight to the teacher-educators' responses.

5.6 Reliability and Validity in Interviews

Best and Kahn (1998: 17) defined that reliability is the degree of consistency that a tool or data collection procedure demonstrates, while validity relates to the quality of the data collection procedure that enables it to measure what it is intended to measure. In, this study, validity is guaranteed keeping congruence between the explanations offered of the phenomena and honest answer by the participants because the participants have more freedom to elaborate than that of survey (e.g. Reid, 2006). Denzin and Lincoln (2000: 117)

explained that the issues of validity and reliability in qualitative research correspond to the criteria of truthfulness, credibility, and internal validity.

In this study, I tried to ensure reliability and trustworthiness by following best practice for the interview process, such as the necessary reflexivity to clarify my position as a researcher. The study's data gathering validity, for example, to a certain extent depends on the time available, and the rapport between interviewer and interviewee (e.g. Rodrigues, 2010; Ritchie and Lewis, 2003). Also, Conway et al. (1995) point out that achieving reliability is challenging because each interview is unique in some way. Therefore, I prepared all the interview questions properly before interviews were carried out and made a rehearsal with a couple of colleagues who have been science teacher-educator. A one-to-one interview has therefore been chosen in order to maintain high reliability as Conway et al. (1995) suggested that one-to-one semi-structured interviews appear to have the highest reliability.

Nightingale and Cromby (1999: 28) showed that reflexivity "requires an awareness of the researcher's contribution to the construction of meanings throughout the research process". Therefore, this research considered the issue of positionality in designing interviews protocols for collecting data (see Section 5.8).

5.7 The Research Participants of Interviews

Cohen et al. (2007) state that the quality of a piece of research not only stands or falls by the appropriateness of its methodology and instrumentation but also by the suitability of its sampling strategy. The participants represent in this study a diversity of areas and social backgrounds. The participants were selected by convenience sampling at the University of X in Pakistan. Cohen et al. (2007) give a rule of thumb that the larger the sample size, the more structured, closed and numerical a questionnaire may have to be. Cohen (2007: 88) justifies the importance of convenience sampling as being that: "captive audience such as pupils and teacher-educators often serve as respondents in questionnaires based upon convenience sampling". This study employed questionnaires with 580 student-teacher-educators and 50 teacher-educators. Moreover, the study also involved interviews with 20 science teacher-educators and two focus groups each including 4 science student-teacher-educators from B.Sc. B.Ed. programme (this is a combination of B.Sc. and B.Ed. of 3-year length) in ITE at the University of X. The selection of interview participants was restricted to the research design and its purpose (see Section 5.2). Thus, a convenient sample

approach was used to select participants. Within the selection process, the categories of the teacher-educators for the interviews were determined. I considered the easiest way to categorise teacher-educators by course/s; they have been teaching as shown by Table 5.4.

No. of Teacher-educators	Courses taught
6	**Botany**
9	**Chemistry**
2	**Zoology**
3	**Physics**
5 (within 20 teacher-educators above)	**Teaching Science Method**

Table 5.3: Categories of teacher-educators by courses

I interviewed a sample of 20 teacher-educators whom I perceived had varied teaching experiences. Table 5.5, below, shows some details of the participants' profiles with gender, degrees, years of experience, and the courses they taught.

Coded Names	Gender	Teacher Qualification	Years of Experience	Courses Taught
T1	M	M.Sc., Ph.D.	More than 10	Botany
T 2	M	M.Sc., Ph.D.	More than 10	Chemistry, TSM
T 3	M	M.Sc., Ph.D.	More than 10	Chemistry
T 4	M	M.Sc., Ph.D.	More than 10	Botany
T 5	M	M.Sc., Ph.D.	More than 10	Chemistry, TSM
T 6	M	M.Sc., Ph.D.	More than 10	Botany
T 7	M	M.Sc., Ph.D.	More than 10	Mathematics
T 8	M	M.Sc., Ph.D.	More than 10	Zoology
T 9	M	M.Sc., Ph.D.	More than 10	Botany
T 10	F	M.Sc.	More than 10	Botany
T 11	M	M.Sc.	Less than a year	Chemistry
T 12	F	M.Sc.	More than 10	Physics, TSM
T 13	F	M.Sc.	More than 10	Botany
T 14	F	M.Sc.	5-10 years	Botany, TSM
T 15	M	M.Sc., Ph.D.	1-5 years	Zoology
T 16	F	M.Sc.	5-10 years	Chemistry
T 17	M	M.Sc.	1-5 years	Chemistry
T 18	M	M.Sc.	Less than a year	Chemistry
T 19	F	M.Sc.	1-5 years	Chemistry
T 20	F	M.Sc.	More than 10	Chemistry, TSM

Table 5.4: Information on the teacher-educators who participated in interviews

Table 5.5 shows that the anonymity of teacher-educators was assured by coding their responses on the interview transcripts as T1, T2…etc. the table also shows that the range of teacher-educators covers different age groups, years of experience and that they teach a variety of courses in ITE programs.

5.8 Consideration of other Research Tools

At first sight, it may seem more appropriate to have used only a quantitative approach. However, my research aimed at looking at the perceptions of teacher-educators and student-teachers; these were likely to vary to the extent that, if I had used only a quantitative approach, whereby people give answers on the 4-Likert scale of one to four or tick YES/NO boxes, it would not actually have captured the details of variation that the research wanted to explore. This study, therefore, needed to interview participants to thoroughly explore their views. However, science teacher-educators in Pakistani universities were unfamiliar with this kind of research and as I did not have access to other universities, I felt I could overcome the cultural challenges to the research better by initiating a questionnaire. I, therefore, concluded that if I started interviewing teacher-educators who have strong cultural influences and poor research experiences, some people may be suspicious of what they are doing. In other words, I considered quantitative and qualitative research tools with an idea of what was culturally appropriate for conducting this research.

I also decided that, for this research, classroom observation would not be useful, as it was much better to ask the teacher-educators and student-teachers to interpret what they understood in terms of the importance of inquiry and inquiry-based pedagogy in ITE. The teacher-educators would, therefore, be more comfortable because then they would be articulating their responses rather than demonstrating them. In short, if I observed the classes, I would not know what I was going to see. Also, I knew that, according to Pakistani culture, it may be very difficult for teacher-educators to accept someone observing their classes or asking questions, particularly teacher-educators of different ages and genders (see Section 5.8). Finally, the details of why triangulation of different methods (using a mixed method approach) was needed are provided as follows:

Firstly, with regard to the teacher-educators' questionnaire; these questionnaires were specifically constructed by the researcher to explore their perceptions of the role and importance of inquiry and inquiry-based pedagogy in science in ITE (see Section 5.2). Secondly, a student-teachers' questionnaire was used because it was required to know how student-teachers thought of the role and importance inquiry and inquiry-based pedagogy in science in ITE.

Thirdly, science teacher-educators' interviews and science student-teachers' focus groups, were used. This study initially used questionnaires, as it was necessary to know how

interviews and focus groups could elaborate participants' perceptions in detail. Thus, the credibility of themes emerging from the interview data was confirmed through the triangulation of data from multiple sources such as teacher-educators' and student-teachers' responses in the questionnaires. Thus, the triangulation of methods in this study provided a more balanced, in-depth and detailed picture than being used a single method.

5.9 Data Collection

This stage came after I applied for and received ethical approval from the University of Glasgow to collect my data through questionnaires and semi-structured interviews. I then travelled to Lahore, the biggest city in Punjab (a province in Pakistan), where the University of X is situated, as it is the chosen place for my data collection. Before I started inviting participants, I applied for and received the University of X's approval to invite volunteers from their Science Department. I then started presenting my plain language statement and consent form to the volunteer teacher-educators and student-teachers, and ensured that they understood the purpose of their optional participation. After that, I started collecting data from the teacher-educators and student-teachers inside the university. Finally, the process of data collection took about 8 weeks.

5.10 Ethical Issues

Research involving human beings has serious ethical implications that must not be ignored (Cohen *et al.*, 2007). Ethical standards embedded in the initial stages of the research design help to avoid or mitigate moral complications that may arise in later stages of the fieldwork. According to Tobin (2002: 113), "an ethical dilemma occurs when a researcher encounters a situation in which he or she is not sure how to act to protect and promote the interest of all participants in a study". When dealing with human subjects, therefore, some potential issues relating to ethics in this research were carefully considered both before and during the actual research itself.

Administering questionnaires and conducting in-depth interviews involves close interaction between the researcher and the participants (e.g. Rodrigues, 2010). Their relationship may influence the way the interviews are held and the quality of data gathered (Ritchie and Lewis, 2003; Cohen et al., 2007). I believe that the researcher should be open and honest with participants and that the participants should be treated with dignity and

respect. Therefore, the participants were given a written informed consent form about their voluntary participation and were assured of their anonymity, provided along with information on the purpose of the research and usage of the findings. In order to protect the rights and welfare of the participants, it is also worthwhile to become familiar with ethical guidelines of the institution where the researcher as well as the research participant is based so that ethical procedures can be complied with (e.g. Cohen *et al.*, 2007). I therefore got a permission letter to access my research participants from the university where the data was to be collected (see Appendix E).

Since research ethics is still considered to be a foreign phenomenon in Pakistan, approval to collect data was therefore a difficult task. I had to send emails several times to the administration offices to try to get university approval to collect data from the teacher-educators and student-teachers. Furthermore, the process of getting ethical approval at the University of Glasgow also deserves close attention and time-taken.

I planned questionnaires and interviews ahead of time. So, an application for ethical approval was written and submitted to the School of Education at the University of Glasgow far in advance to get an approval for data collection for a Pilot and the main study. The purpose of the research, methodology and ethical considerations were explained to the ethics committee. A list of interview questions, a plain language statement and a consent form were attached for their review and approval. Roughly four weeks after submission, I received approval from the committee.

5.11 Research Culture in Pakistan and Researcher Positionality

The existing structure of the universities in Pakistan is not supportive to research activities because of a number of constraints; for example, teaching load, and no clear allocation of time for doing research activities, etc. (e.g. Lodhi, 2012). In addition, a limited access to the latest literature and a lack of necessary resources such as computer and technical support are also major constraints for teacher-educators at Pakistani universities. Therefore, they are lacking in resources to take part in research activities in the social sciences, particularly in education. As the research culture, particularly in science teacher education, has not yet taken root, which is why teacher-educators have low levels of research experiences in Pakistani public sector universities (Lodhi, 2012). They, therefore, lack understanding of the importance and usefulness of qualitative methods in educational research (e.g. Rodrigues, 2010).

It is important to note that most studies in Pakistani universities in PhDs have traditionally been based on survey analysis. Also, research participants in educational research have been used to be highly involved in filling in questionnaires. My idea to use interviews, particularly with the science-educators and the science student-teachers was therefore unusual for them. A different focus using qualitative methods might mean participants were afraid of and suspicious of what will happen when they respond in interviews. They felt that 1) they are not ready to participate in interviews 2) an interview might waste their time, 3) they might not be able to generate ideas to answer questions in interviews.

Furthermore, educational research in English speaking countries is becoming more perceptive and interpretive, particularly in the UK universities. This shows how the research culture differs between the UK universities and Pakistani universities. Even though I understood the cultural differences, there was still the issue of how participants viewed me as an educational researcher coming from a foreign university to collect data from them that might cause them social and professional problems by participating in this research (e.g. Rodrigues, 2010).

These facts indicate a concern about the acceptance of research culture in the public universities of Pakistan, and there is a plenty to be done to shift the focus of faculty members in the universities of Pakistan from dominant teaching traditions to a strong research culture. Thus, stability is required between the two main activities of academics; teaching and research (Rodrigues, 2010).

5.12 Main Study Data Collection: Process and Reflection

The present study is a piece of 'insider research' based on my experiences of using the medium, collated data gathered from the University of X, where I resided on a short-term basis. I undertook research into teacher-educators and student-teachers at university. Being familiar with the local culture and customs and having already established a relationship provided the opportunity to access participants easily and to be privy to 'insider' information that would not be trusted to a stranger (e.g. Anderson & Sangster, 2010; Smith et al., 1998). To find potential participants, I relied heavily upon my own personal extensive local network. I have been in contact with the Campus Director at the University of X (who is also a science specialist). She performed the role of gatekeeper. Thus, teacher-educators teaching science courses and the student-teachers enrolled in the B.Sc. B.Ed. program could be contacted by me. The next step was to get an agreement from the

participant to meet and give me a chance to discuss the purpose of the interview. Through their contact details from the questionnaire, we mutually agreed upon the time and place, and then we met face-to-face. Interviewees had no problem with giving their written consent for the recorded interviews. Finally, I successfully interviewed a total of 20 interviewees; consist of 7 females and 13 males.

Another aspect to be considered was cultural sensitivity. Cultural sensitivity can provide a means to overcoming initial concerns, allowing for participation and open information exchange (e.g. Bauer et al., 2005). Before starting data collection, I was familiar with the correct 'cultural' protocol when approaching potential participants from different backgrounds and the local community at university, particularly that the senior teacher-educators must be approached before the younger ones. This helped in making free discussion which participants felt was unproblematic and easy, though it took a long time to get to what I was looking for. I consider that teacher-educators trusted me as an 'insider,' i.e. as a member of the university staff, rather than a researcher arriving there from outside, collecting information, leaving the university and publishing a research paper. This helped me overcome the difficulty in data collection (see Section 4.8).

In the interviews, I started with a question about what they thought of learning science in the classroom and how they involved their student-teachers in learning science subjects. My next question was on the role and importance of inquiry based learning in science. The rest were follow-up questions, which proceeded smoothly. I did not take lots of notes/memos during the conversation because of fear of losing eye contact with my interviewee and instead relied on my voice-recorder (Rodrigues, 2010;). I got good quality tape recordings that helped me to sum up the main points and details of the interview. Each interview usually took approximately 30-40 minutes. I believe I played the role of an active listener. I concluded that in most cases the interview had been engaging for both of us (e.g. Cohen et al., 2007; Rodrigues, 2010). We also shared an interest in the problem, which made it possible to build trust to discuss sensitive issues such as the challenges when inquiry is practiced.

As an insider, someone might ask how I avoided regenerating the ideas and thoughts I had as an insider in using a single method where you are aware of the local setting. Therefore, the mixed methods used in this research (see Section 5.3) allowed the researcher to avoid the regeneration of thoughts/interpretations from the local setting (Anderson & Sangster, 2010).

I realised that sometimes among the locals, the 'insider' relationship is a disadvantageous one. For example, some teacher-educators spent a long time before deciding to participate in this research, and some refused to participate at the last minute because they found out that another particular person was participating. Also, many teacher-educators asked me questions, such as "who took part in your research?" "Did that particular teacher-educators' interview go well?" Particularly, many female teacher-educators who were approached declined the invitation to be interviewed. I realised that they were doubtful about participating in interviews.

5.13 Data Analysis

This section presents the detail of the analysis of the quantitative and qualitative data gathered. Firstly, the questionnaires generated a large amount of quantitative data. Spreadsheets were developed using SPSS version 19. As it was not possible to identify all the data within one dataset of teacher-educators, a second dataset containing the same characteristics was obtained for student-teachers but with anonymised practice codes. Questionnaire data is most usable if it is stored within a computer file for coding for analysis. Cohen et al. (2000) suggest that it is important to check the questionnaire to identify and eliminate any errors made by the respondents prior to coding or data reduction. In the datasets, the responses from the questionnaires on the 4-point Likert scale were converted into a numerical scale and were then entered into two spreadsheets (Teacher-educators dataset and student-teachers dataset) using SPSS. I checked the SPSS file, cleaned up the data, calculated the frequencies and generated graphs.

Moreover, the missing data was handled using SPSS. SPSS gives average scores to missing data which helps in conducting further analysis (Pryce, 2005). The initial data file always contain mistakes so it is important to perform data cleaning in order to: (1) correct impossible data (2) correct incorrectly entered values (3) correct contradicting data and (4) examine implausible data. The data was cleaned when I calculated frequencies. The graphs showed numerical errors in few columns (Reid, 2006). I checked the SPSS files again and cleaned the data and again calculated the frequencies which gave correct figures. The missing data was also handled by using SPSS analyse option then handling the missing data. The SPSS gives average mean scores to the missing data which helps to conduct further analyses. After that, data was analysed by applying suitable analysis techniques/ statistics such as percentages, cross tabulation, chi-squares and correlations to explore the associations/relationships between variables.

The data was coded in the SPSS. For the first part of questionnaire, the same codes from 1-4 were given. For the background questions codes were given, for example, gender: Female = 1; Male = 2

The data for the Likert items are ordinal in nature. Background questions gave nominal data. Each response to an item was assigned a number from 1-4 in the SPSS spreadsheets. The quantitative analysis which was carried out involved a number of steps. The first step in the quantitative analysis focused on providing descriptive statistics and establishing statistically significant relationships between the variables. Descriptive statistics present data through tabular description, summary statistics and graphical displays (Reid, 2006; Howitt & Cramer, 2008). Using descriptive summaries and cross-tabulations, I investigated the relationships between individual teachers' and student-teachers' characteristics, as per the information provided in their returned questionnaires. Additionally, I used cross tabulation, Chi-square and Kendal Tau_b correlations to compare teachers' and student-teachers' responses across demographic/independent variables and report these where appropriate within themes (side by side within themes or sub-themes). For all statistical tests, I have provided measures of the statistical significance of the results. The following statistical tests were performed:

Test	Research Question
Descriptive Statistics	RQ1, RQ2 and RQ3
Pearson Chi-Square	RQ1, RQ2 and RQ3
Kendal Tau_b Correlation	RQ1, RQ2 and RQ3

Table 5.5: Statistical Response to Research Questions

Secondly, I transcribed all the interviews into text. The interviews were transcribed verbatim using NVivo. The transcripts were fully translated into English (not word by word but reflecting the sense of what was said) (Rodrigues, 2010). Therefore, the transcription of the interviews was a two-phase process, of transcription and translation. Some translated scripts were shared with colleagues; their first language was Urdu and they have excellent fluency of translating into the English language too. Feedback on the quality of translation was obtained and a contact was made for assistance with a college of languages in Lahore in case of doubt during the process of translation. In this way, the quality of transcripts was assured and made ready to analyze. NVivo was used to transcribe interviews and focus group tapes. After that, teacher-educators' interviews and student-teachers' focus group transcripts generated text in word processing files.

The process of indentifying themes from the gathered data is presented. Interview transcripts were read and re-read. Also, the percentages of each response from the questionnaires were calculated. In identifying recurring themes, the teacher-educators' interview data helped, as primary data. Interview and focus group transcripts were coded to merge themes and subthemes. Then, word processed documents for themes from interview and focus group were developed. Common phrases and common sentences were pointed out after repeated readings of the interview transcripts. To get repeated confirmations of the pertinent themes, a comparison was done between data from multiple sources such as teacher-educators' and student-teachers' responses to the questionnaires, interview and focus group data. The comparison of the data collected through multiple sources helped demonstrate that themes were grounded in the data (Hatch, 2002) and the reliability of the emerging themes. The data analysis begins with the teacher-educators' and students-teachers findings from the questionnaires and then their responses in their interviews. Then, the focus group data were used to develop themes and was supported by the student-teachers' responses to their questionnaires. An example is presented below to merge the theme from teacher-educators' and student-teachers' questionnaire responses and teacher-educators' interview and student-teachers' focus groups and the data from the questionnaires, for example, a subtheme 'lack of university support' within the challenges to teachers when inquiry-based pedagogy is practiced.

Views	**Teacher-educators' responses**				**Student-teachers' responses**			
No of teachers = 50 **No of students = 580**	Cannot be Overcome	Serious Barrier	A Minor Problem	Easily Solved	Cannot be Overcome	Serious Barrier	A Minor Problem	Easily Solved
	%	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Universities would not support it	12	58	22	8	16	57	26	11

Table 5.6: Teacher-educators and Students' perceptions: challenges of inquiry

Thus, the above table shows that the majority 58% of teacher-educators and 57% of student-teachers were of the view that a lack of university support is a serious barrier; 12% of teacher-educators and 16% of student-teachers perceived it as something which 'cannot be overcome'. Similarly, the following text from the interview and focus group data is an example of one of the themes from the interviews. This piece of data reports one of the existing situations among teacher-educators who, due to a lack of support from university, face challenges when inquiry is practiced with a large number of student-teachers. For example, Teacher 2 said as below:

> **T2:** I think the biggest challenge is the lack of university support in adopting inquiry-based approaches; it seems that the university does not support teacher-educators in using inquiry. The university does not offer such an arrangement to perform inquiry-based activities. That's why teacher-educators do not use inquiry-based pedagogy. They have to teach in big classes with low resources and with large teaching load. University does not provide teacher-educators with facilities and suitable classroom infrastructure in which inquiry-base pedagogy can work. Thus, multiple problems to teachers are still a concern that our teacher-educators are unwilling using inquiry-based methods. I think that the lack of support from the university is a serious problem.
>
> A student 3 from focus group 2 said as below:
>
> **G2-S3:** The University does not help in adopting inquiry-based activities. If the science teacher-educators use inquiry-based approaches, that is their own choice or decision. Inquiry-based approaches are not encouraged by the university.

The above quotes address one of the challenges that teacher-educators and student-teachers face regard to the lack of university support in using inquiry-based pedagogy with. Thus, data collated by triangulating from interviews and questionnaires indicates that the theme 'lack of university support in adopting inquiry-based pedagogy' is one of the challenges faced by teacher-educators and student-teachers when inquiry is practiced. Finally, the following themes emerged from the data to guide the analysis relating to participants' perceptions of inquiry-based pedagogy:

- Perceptions of the fundamental elements of inquiry-based approaches
- Perceptions of inquiry-based learning
- Perceptions of the contribution of teaching a science method in developing inquiry
- Perceptions of inquiry-based approaches in developing science literacy
- Challenges in adopting inquiry-based approaches

In using a mixed methods approach, I listed down the themes applicable to the data being addressed for qualitative as well as quantitative data analysis. Therefore, the main themes emerging from the teacher-educator and student-teacher questionnaires are presented in the analysis and findings and highlight similarities and contradictions. Also, the main points from the teacher-educators' and student-teachers' interviews reflected similarities and contradictions. Thus, teacher-educators' and students-teachers' data from the interviews in the form of summaries of themes along with illustrative quotes are elaborated. Also, sub-themes defined by main themes are used to analyze the data in each section. The structure of this presentation is sequenced as follows: the statement of the principal themes is presented, then the emergent sub-themes in every theme and then a summary of the issues with each theme.

5.14 The Data and Data Analysis

In this study, questionnaires were applied to teacher-educators (N=50) and student-teachers (N=580), so, particularly involving a very large sample of student-teachers, representing a good cross section of the population. Thus, there can be reasonable confidence in measurements being reliable and the outcomes being generalisable. The key difficulty is being sure that the questionnaires used for the teacher-educators and student-teachers are valid. Questionnaires were carefully constructed in line with the findings from the literature about the key features, advantages and disadvantages of inquiry-based approaches and the connection between inquiry and science literacy. It was also considered by some experienced teacher-educators of science subjects and amended appropriately before use. For the analysis of questionnaire data, a Chi square (Contingency test), Kendal Tau_b correlations and factor analysis were performed with the questionnaire data using SPSS. The detail can be outlined as follows.

Firstly, most of the chi-square values are found to be statistically non-significant. Therefore, for simplicity, only significant Chi-square values indicating differences between groups are reported in Chapter 6. Secondly, most of the Kendal Tau_b correlation values indicate poor relationships. For the sake of simplicity, the relationship of significant and considerable values was reported in Chapter 6.

Thirdly, a Principal Components Analysis, using a varimax rotation, was used to explore whether there was any structure of factors which underpinned the response patterns in the Likert type questions. The aim was to obtain a picture of the perceptions of teacher-educators and student-teachers, covering a wide range of issues. Student-teacher questionnaire was carried out with the items for each question, as well as with all the questions together. In every analysis of student-teachers' questionnaires (N=580), no structure at all was found to be present when a factor structure was looked for within each question (i.e. for questions 6, 7, 8, 9, 10, and11). This means that each individual item is asking a different question and, indeed, this was the way the questionnaires were designed and intended. Also, the teacher-educators' questionnaire was even less likely to give a structure as the sample was smaller (N=50) than that of the student-teachers (N=580). Given the consistency of the findings regarding inquiry-based learning, the questionnaires are deemed to be valid but certainty is impossible.

Furthermore, it would have been ideal to conduct extensive interviewing but time prevented this and, in addition, interviewing more females in Pakistan was tough, for

cultural reasons. Another difficulty concerned voice recording and some teacher-educators (mostly females) hesitated after they saw in the consent and plain language forms that their voices would be recorded. I recorded 22 interviews but two female participants asked me to destroy their recording during the interview recording. I, therefore, had to destroy those files and stopped interviewing them but I still had 20 interview recordings that provided the perceptions of the teacher-educators, given in detail. Nonetheless, the discussions with the student-teachers' focus groups and the completed teacher-educators' interviews presented very useful insights which do suggest that the broad conclusions of the study are valid.

5.15 Chapter Summary

In this chapter, I present the rationale of the methodology employed in my research study. This chapter began by outlining the aims and objectives of the study in which I explore teacher-educators' and student-teachers' perceptions of the role and importance of inquiry-based pedagogy in their professional learning experiences in ITE in a Pakistani University. This was followed by a description of the research design which was, after careful consideration, designed to be a mixed methodology in order to better understand the phenomenon. The rationale behind using mixed methods was that it allowed the researcher to carry out a robust analysis by taking advantage of the strengths of each of the methods involved in the study. After developing the research aims and research design, research questions were developed followed by defining the research setting, research culture, participants and instrumentation. This further led to ethical considerations followed by a pilot study. The findings of the pilot study suggested some of the necessary and timely changes in the layout, appearance, wording, clarity and instructions of the questionnaires which could be made, and which were incorporated during the main data collection procedure. After collecting the main data, SPSS 19 was used to conduct an analysis of the questionnaire data. For the qualitative part of the study, NVivo was used to analyse the emergent themes. The next chapter presents a detailed analysis of the data collected and the findings which were drawn from it.

Chapter 6

Findings from Questionnaires

6.1 Introduction

This chapter reports the findings from my analysis of the questionnaires and interviews generated by this study. The opening section of the chapter presents the background characteristics of the teacher-educators and student-teachers, from the information given in the questionnaires. This is followed by an account of the main themes emerging from the questionnaires, in which the similarities and contradictions between the two data sets are highlighted.

6.2 Teacher-educators' Characteristics

50 teacher-educators completed the questionnaire and for clarity, the data on each item is presented in percentages using SPSS version 19. In the teacher-educator dataset (N= 50), the percentages were counted from the responses received. Table 6.1 shows the percentages of each group in questions Qs.1, 2, 3, 4, 5, and 6 based on the teacher-educators' questionnaires.

N=50	Factors	%
(a)	**Gender**	
	Male	30
	Female	70
(b)	**Age Group**	
	24-30	36
	30-40	32
	40-50	20
	above 50	12
(c)	**Academic Qualification**	
	M.Sc.	38
	Master in Education	20
	Current student of PhD	20
	PhD Science	22
(d)	**Years of experience**	
	Less than a year	20
	1-5	50
	6-10	14
	More than 10	16
(e)	**Courses Taught**	
	Science	56
	Both (Science and teaching Method course)	44

Table 6.1: Background Information of Teacher-educators

(a) Table 6.1 shows that 70% of respondents were female teacher-educators. Teacher education courses are accepted among females as the teaching profession is one of the most popular and socially acceptable professions for women in Pakistan.

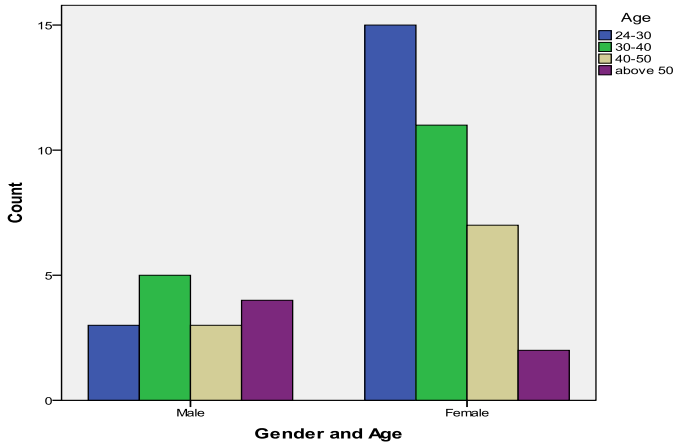
(b) 36% of respondents were between 24-30 years of age, 32% were between 30-40 years of age, 20% were aged between 40-50 years and 12% were more than 50 years old. The University of X is a young university, established in 2002. This university is in the process of recruiting new staff; therefore, the majority of the respondents were young lecturers and therefore have fewer years of experience than the older ones at the university.

(c) The analysis of academic qualifications of the teacher-educators shows that 38% have a Master's degree in Science; 22% have a PhD degree in different disciplines in Science, 20% have a Masters degree in Educational Studies; and 20% are currently studying for a PhD in Educational Studies. As the recruitment of new teacher-educators is an ongoing process at the University of X, the majority of the teacher-educators are young and hold an MSc degree or are currently studying for a PhD.

(d) 20% of the teacher-educators have less than a year's experience; 50% have between 1 and 5 years' experience (the above two categories are also in the young age group), 14% have experience of between 6 and 10 years; and 16 % have more than 10 years' teaching experiences (the above two categories are in the senior age group). A cross tabulation between teacher-educators' years of experience and their age group indicates that 36% (the majority of teacher-educators) having 1-5 years' experience are young and lie in the junior age-group. Also, a correlation ($r= 0.43$, $p=<0.01$) indicates a strong relationship between their ages and years of experience. It can be noted that younger teacher-educators are more likely to have fewer years of experience, and that older teacher-educators tend to have more (i.e. more than 5 years) years of experience.

(e) The data also provided details about the courses being taught by the teacher-educators: 58% of teacher-educators taught science courses (these have been identified as ST) and 42% taught both science courses and teaching methods of science courses (these have been identified as BT). The majority of teacher-educators were in the ST category and this difference in the number of teacher-educators is indicative of a common characteristic, as only those teacher-educators with MSc in Science or in Education teach science method courses.

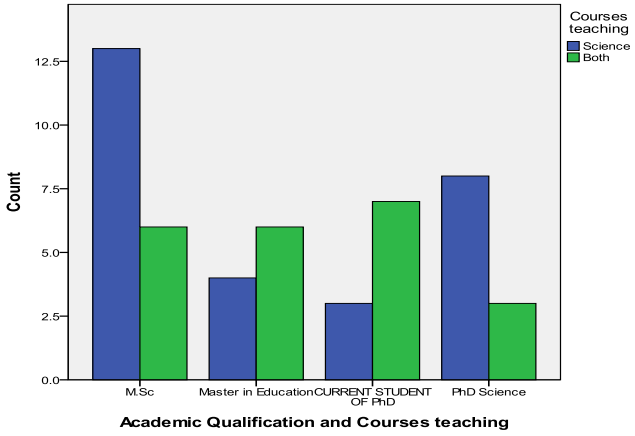
Cross tabulations show that the majority of women participating in this study were in the age group of between 24-30 years old.



Bar Chart 6.1: Gender and Age

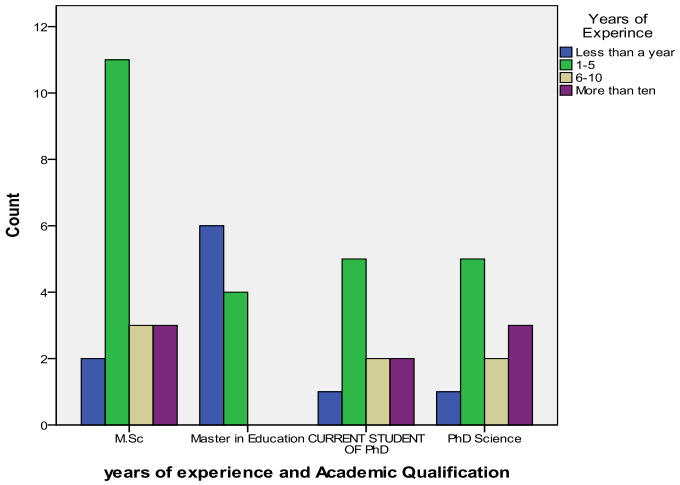
It can also be observed that the majority of female respondents have an MSc qualification whereas the males have more PhDs than females, though no male teacher-educators had Masters in education. A cross tabulation between gender and years of experience indicates that the majority of both male and female were to be found in the young age group. However, females were relatively higher in the young group with 1-5 years of experience, rather than males. Also, a cross tabulation between gender and courses-taught indicates that the majority of females have been teaching BT which is not the case with the male teacher-educators.

A cross tabulation between academic qualifications and the courses they taught indicates that teacher-educators with an M.Sc. qualification have been teaching science courses and teaching method courses more than any other group, as shown in the graph below:



Bar Chart 6.2: Academic Qualification and Courses Teaching

Cross tabulation between teacher-educators' years of experience and academic qualifications and between age and academic qualifications indicated that the young teacher-educators group is higher than the older group at each academic level. The majority of young teacher-educators had either M.Sc. or are currently PhD student-teachers, or already had a PhD. The majority of older teacher-educators (aged above 50 with more than ten years of experience) have a PhD in science, as shown in the graph below:



Bar Chart 6.3: Years of Experiences and Academic Qualification

Thus, the cross tabulations show that the majority of teacher-educators are junior (new and young), have an MSc and are teaching ST courses at the University of X. With regard to the responses to question 7 in the teacher-educators' questionnaire, Table 5.2 shows data on the training the teacher-educators had received.

Training Received	Responses %
Professional development training	48
Presentation skills	40
Hands-on (inquiry-based) science activities	52
Skills for assessing student-teacher	44
Inquiry-based pedagogy	32
Computer skills (e.g. spread sheets)	56
No training offered	64

Table 6.2: Training received by Teacher-educators

7 options were offered to the teachers. It appears from the table that 52% of teacher-educators had received training for hands-on (inquiry based) science activities. The majority of the teacher-educators, i.e. 64%, responded that no training had been offered to them. Thus, the majority of teacher-educators have had no training during their professional time at the University of X.

6.3 Student-teachers' Characteristics

580 student-teachers completed the questionnaires and Qs. 1, 2, 3, 4, and 5 explored their characteristics.

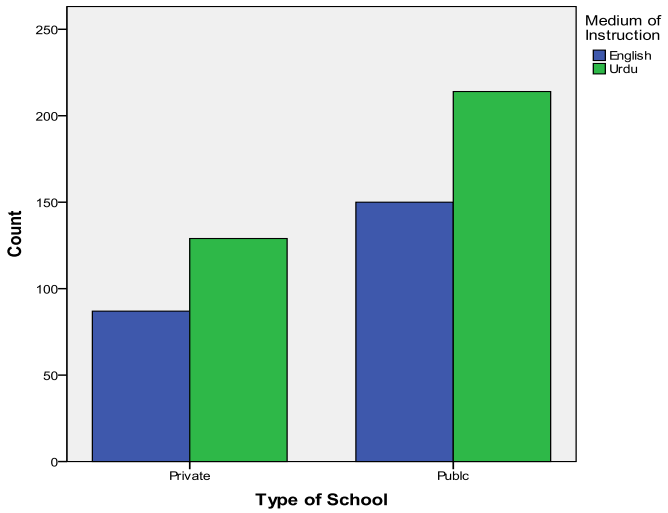
N=580	Factors	%
(a)	**Gender**	
	Male	26
	Female	74
(b)	**School type**	
	Private	29
	Public	71
(c)	**Language of Instruction**	
	English	41
	Urdu	59
(d)	**Years of study**	
	1st year	16
	2nd Year	40
	3rd Year	44
(e)	**Courses studied**	
	Science	25
	Science and Teaching method courses	75

Table 6.3: Background Information on Student-teacher

(a) Table 6.3 shows that 74% of the respondents were female, so the gender distribution is similar to that of the teacher-educators, reinforcing the point that the teaching profession is more popular than any other profession among females, whilst the number of men seeking to enter the teaching profession, as represented by the number in BSc, B.Ed. programmes at the University of X, is lower than that for females.

(b) 71% student-teachers have studied in public sector schools, and 29% have studied in private schools. This is because the University of X is a public sector university and offers teacher-education courses at a lower fee than other private universities. Student-teachers who have studied at public sector schools cannot generally afford an expensive education at private sector universities. Thus, the huge majority of student-teacher enrolled at the University of X went there after finishing their education at public sector schools.

(c) 59% have studied at the schools where the language of instruction is Urdu and 41% of the student-teachers have studied in English-medium schools. It indicated that the majority studied in the Urdu medium with only a minority in English medium schools. From (b) and (c), a cross tabulation between type of school and medium of instruction indicate that the majority of student-teachers from the public sector schools have studied in Urdu.

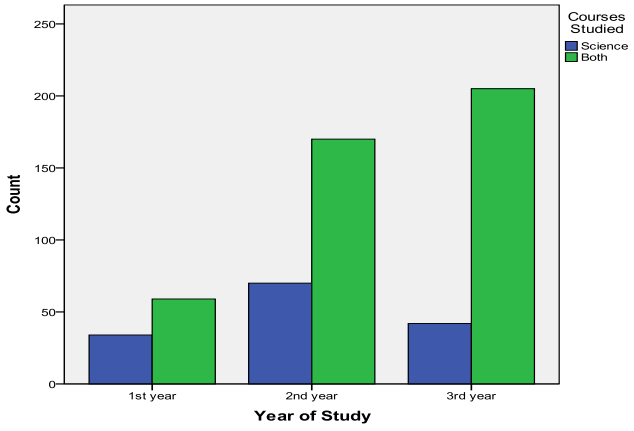


Bar Chart 6.4: Type of School and Language of School

(d) Moreover, data on the year of study indicated that 16% were in their first year, 40% were in the second year and 44% were in the third year in ITE. Thus, the majority of student-teachers who participated in this study were in their 3rd year of a BSc, BEd degree (i.e. B.Sc. and BSc) at the University of X.

(e) The majority of student-teachers have studied BS; this is because most student-teachers participated in the study were in 2nd and 3rd year of their study so they had completed most of the course. Student-teachers in the 1st year of their study were offered only science courses.

Cross tabulations between gender and other demographic variables explored more about their characteristics within groups. Female student-teachers who participated in this study are of a higher number within each category than males. Particularly, the majority of 2nd and 3rd year student-teachers had studied BT as opposed to student-teachers in the 1st year, as shown in the graph below:



Bar Chart 6.5: Year of Study and Type of Course

Thus, teacher-educators' and student-teachers' questionnaires indicated that female teacher-educators and student-teachers are in the majority; therefore, they represent a high proportion in each category of the demographic variables.

6.4 Findings from the Overall Teacher-educators' and Student-teachers' Questionnaires

Analysis of Questions 8-15 in the teacher-educators' questionnaire and Questions 6-12 in the student-teachers' questionnaire provides the following details for all teacher-educators, with total counts for each item in every question.

In each table, SA = Strongly Agree, A = Agree, D = Disagree and SD = Strongly Disagree.

N = Number of responses received

% = the percentage of responses received.

In the responses to Q8 in the teacher-educators' questionnaires, the teacher-educators reported their views on being teacher-educators of science.

No	Views	SA	A	D	SD
	Number of teacher-educators = 50	**%**	**%**	**%**	**%**
a	I enjoy teaching science	69	22	3	6
b	I would like to expand my subject knowledge of science to be effective in my teaching	63	29	6	2
c	My aim is to make student-teachers question what they learn	46	52	0	2
d	I want my student-teachers to be able to recall information accurately	58	40	2	0
e	I like to vary my teaching style according to the student-teacher's needs	58	38	4	0

Table 6.4: Teacher-educators' views about Teaching Science

Looking at all the views in the table, teacher-educators tend to hold very positive views in all five items. They are clearly motivated and committed to give the best for their student-teachers. However, the emphasis on recalling information as a goal is somewhat limited. Although it is somewhat inconsistent with their commitment to have students' question what they learn.

In Question 6 from the student-teachers' questionnaire, student-teachers reported their views on how they learn science.

No	Views	SA	A	D	SD
	Number of Student-teachers = 580	**%**	**%**	**%**	**%**
a	I enjoy learning science as a subject	46	47	5	2
b	I enjoy solving open-ended science problems	25	58	15	2
c	I am curious to explore science more	37	33	25	5
d	I only enjoy science when I am doing experiments	19	34	34	13
e	I only like memorising subject knowledge in science courses	19	41	35	5
f	I find open-ended science problems very difficult	16	43	40	1
g	I feel science is very important in all aspects of life	68	24	6	2
h	Learning science through inquiry-based activities appeals to me	22	60	12	6
i	I do not think I should learn as well if I was taught using an inquiry-based approach	18	40	34	8

Table 6.5: Views about Learning Sciences

Table 6.5 shows that the majority of student-teachers tend to hold positive views about their learning of science. Student-teachers are involved less in doing experiments, they are given fewer opportunities to explore science and their emphasis on recalling, and therefore, they found things difficult when they were required to engage in problem solving. Moreover, a comparison can be noted between the teacher-educators and student-teachers' views. Looking at Tables 6.4 and 6.5 reveals that the majority of teacher-educators and student-teachers are consistent in their views on the various aspects of teaching and learning science. However, teacher-educators seem more positive regarding to making their student-teachers recall information while student-teachers seems more positive towards open-ended problem solving.

Question 9 (Table 6.6 below) on the teacher-educators' questionnaire reported the degree to which they rated their own teaching of science and what inquiry-based activities they have been doing in class.

No	Views	SA	A	D	SD
	Number of teacher-educators = 50	**%**	**%**	**%**	**%**
a	I usually initiate the science topic by inquiring about student-teachers' previous knowledge	50	50	0	0
b	When teaching science, I usually welcome student-teachers' scientifically orientated questions	46	28	2	4
c	I like to do hands-on science activities to engage student-teachers interests in science	36	50	14	0
d	I find it difficult to involve student-teachers in scientific investigations	14	34	44	8
e	I like to generate the active involvement of student-teachers in science investigation	35	25	36	4
f	I like to raise student-teacher curiosity by giving them time to explore science	46	44	6	4

Table 6.6: The Teacher-educators' ratings of their own Teaching of Science

Looking at Table 6.6, teacher-educators tend to hold positive views. All teacher-educators initiate their lesson by asking questions and use questions to warm up their student-teachers about their previous knowledge. It can be noted that the questions about the previous knowledge are the source of interaction between student-teachers and teacher-educators as the latter reported that they usually welcome student-teachers' questions. Also, teacher-educators in their teacher-led teaching practices use science experiments relatively rarely; therefore, they were not well prepared in involving student-teachers in science investigations.

Responses to Q7 in the student-teacher questionnaire investigated student-teachers' views of the teaching practices of their teachers.

No	Views	SA	A	D	SD
	Number of Student-teachers = 580	**%**	**%**	**%**	**%**
a	Acts as a facilitator in the science classroom	38	48	11	3
b	Presents the science content as material to be memorised	23	56	16	5
c	Encourages me whether I solve science problem correctly or not	38	44	14	4
d	Welcomes my scientifically oriented questions	35	50	10	5
e	Motivates me to seek the answers to open-ended science problems	40	42	14	4
f	Involves me in too much written work in science	25	38	32	5
g	Involves me through hands-on science activities in scientific investigations	26	48	20	6
h	Sets test and examinations that allow me to show all I can recall	34	48	12	6
i	Teaches the science mainly through lecturing	41	39	13	7

Table 6.7: The Ways Teacher-educators work in ITE

Table 6.7 shows the student-teachers' views about their teachers' work in ITE. The majority of their views were generally positive. Student-teachers appreciate their teacher-educator's role in encouraging and keeping them involved in classroom although their teacher-educators dominate in their teaching in ITE in Pakistan. It appears from the responses on (d) and (e) that science questions are the most commonly used activity with student-teachers in classroom.

For their responses to Q10 on teacher-educators' and Q8 on student-teachers' questionnaires, student-teachers were offered eight aims and asked to select three out of the eight aims of ITE and rank them in order of importance.

No.	Aims	Teacher-educators	Student-teachers
	Number of teacher-educators = 50, Number of student-teachers = 580	*%*	*%*
1	To enable student-teachers to understand the key ideas of science	58	40
2	To allow student-teachers to see how scientific discoveries have made an impact on society	24	40
3	To enable students to understand how scientific discoveries take place	28	26
4	To enable student-teachers to know all the important facts of science	32	39
5	To train and develop the science teacher for the future	64	50
6	To enable student-teachers to understand the place of experimentation	32	30
7	To enable students to see the contribution sciences have made in the world	16	33
8	To train and develop the scientists for the future	46	47

Table 6.8: Aims of ITE

Eight aims were offered to teachers and student-teachers. In many areas, the priorities of the two groups were fairly similar. The importance of understanding key ideas is not so great for student-teachers while their desire to see the social impact and contribution of the sciences in society is greater. This is consistent with the general findings elsewhere (Reid and Skryabina, 2002). It pinpoints an important gap in science education provision. Table 6.8 shows that the majority of teacher-educators and student-teachers were concurrent in their ranking of the aims of ITE: 'to train and develop student-teachers as science teachers for the future'.

In their responses to Q11 on the teacher-educators' questionnaire, teacher-educators reported their views on inquiry-based pedagogy and the practicalities of teaching.

No	Views	SA	A	D	SD
	Number of teacher-educators = 50	**%**	**%**	**%**	**%**
a	I believe that an inquiry-based pedagogy in science to teaching does not result in much learning	20	20	46	14
b	I like the idea of being a facilitator of learning by allowing the student-teachers to learn in groups	24	66	10	0
c	I feel that an inquiry-based pedagogy in science is a more effective style of teaching science rather than lecturing	22	62	16	0
d	I think inquiry-based pedagogy in science will benefit student-teachers who are only seeking the right answers	26	56	18	0
e	I think that an inquiry-based pedagogy in science should be used in initial teacher education	48	50	2	0
f	Teachers should be taught how to use inquiry approaches in science	44	54	2	0
g	I think that inquiry-based pedagogy in science will help produce better science literacy	38	58	4	0
h	I think that an inquiry-based pedagogy will help develop procedural understanding	36	52	12	0
i	Skills in handling open-ended problems are critical for my student-teachers	26	44	20	
j	I think that an inquiry-based pedagogy in science will encourage critical thinking	42	54	4	0

Table 6.9: Views on Inquiry-based Pedagogy in Science in ITE

Table 6.9 depicts teacher-educators' views on inquiry-based pedagogy and the practicalities of teaching in ITE. The majority held the view that inquiry-based pedagogy helps student-teachers in learning science, like to be a facilitator of learning process and appreciate student-teachers' activities in groups. It can be noted that teacher-educators only use questions or group discussions, so they only appreciate these activities and exhibit their role as a facilitator in these activities. The majority of the teacher-educators' responses indicated that open-ended problems are important as well as hard for their student-teachers, whereas 30% of the teacher-educators disagreed. This indicates that a small portion of the teacher-educators like to involve student-teachers in open ended investigation in science. Thus, a high rated response from teacher-educators appreciated that inquiry helps in developing their students' thinking in science.

Likewise, in Question 9 from the student-teacher questionnaires, the student-teachers views were sought on inquiry-based pedagogy and their own learning in science, and are presented in the table below:

No	Views	SA	A	D	SD
	Number of Student-teachers = 580	**%**	**%**	**%**	**%**
a	Enables me to learn how to identify and ask appropriate questions	39	54	6	1
b	Enables me to only seek the right solutions to science problems	23	55	21	1
c	Allows me to explore science concepts on my own	34	47	17	2
d	Enhances my curiosity to involve me in open-ended science investigations	31	50	15	4
e	Enables me to use appropriate equipment/material to analyse and interpret data	32	48	16	4
f	Enables me to take ownership of my learning during scientific investigations	26	54	17	3
g	Encourages a thought-out solution when I do practical work in science investigation	38	47	12	3
h	Develops my critical thinking to evaluate the evidence in scientific investigations	42	45	10	3

Table 6.10: Inquiry-based Pedagogy helps in Learning

Looking at Table 6.10 above, each statement presents a different question to student-teachers. The student-teachers' responses indicate that the majority of student-teachers held positive views. However, it is notable that the use of inquiry entails more than just seeking the answers to questions. The majority of student-teachers learn to use an appropriate apparatus in science experiments and are likely to develop the skills to analyse and interpret data.

With regard to responses to Q12 in the teachers' questionnaire and Q12 in the student-teachers' questionnaire, Table 5.11 shows a comparison of teachers' and student-teachers' views on inquiry-based pedagogy and student-teachers' learning outcomes in ITE:

No	Views	SA	A	D	SD	SA	A	D	SD
	Number of teacher-educators = 50 **Number of Student-teachers = 580**	%	%	%	%	%	%	%	%
		Teacher-educators Responses				**Student-teachers Responses**			
a	I should like to develop a more inquiry-based style of teaching	32	56	12	0	47	45	6	2
b	I should like to see the library and the internet used more in science teaching	50	40	8	2	44	42	12	2
c	My student-teacher are not mature enough to learn using an inquiry-based approach	6	42	46	6	-	-	-	-
d	Examinations mostly test the ability to recall information	30	62	6	2	35	50	12	3
e	Inquiry-based learning will need much more time	38	46	14	2	35	47	15	2
f	National Examinations must change to assess skills of understanding and of thinking	32	56	10	2	34	48	14	4
g	I should like to develop experimental work which illustrates how science operates	32	56	10	2	38	45	14	3
h	It is not possible to test student-teachers for their abilities in inquiry-based skills	16	36	38	10	18	43	32	7
i	I could not have access to enough resources to teach using an inquiry-based method	16	38	36	10	23	47	25	5
j	Inquiry-based approaches will work well only with the most able student-teachers	12	54	30	4	29	36	25	10

Table 6.11: Teacher-educators' and Student-teachers' Views of Inquiry and Learning

The majority of the teachers and student-teachers' perceptions tend to held positive views. Almost all of the teacher-educators' and student-teachers' responses indicated that they both appreciated inquiry-based pedagogies compared to a pure lecture method. Also, Table 6.3 shows the majority of student-teachers in the University of X had studied in public schools where dominant and teacher-led methods were practiced.

The surprising observation is how similar are the views of the two groups. In fact, in only one item (j) is there a statistical difference (χ^2 = 8.8 (df=2), $p<0.05$). It is clear that the student-teachers are more hesitant than the teacher-educators. Overall, the two groups are showing a desire for a much more open-ended type of education. They recognise the course and time implications of this. However, of greatest importance, they recognise that, unless national examinations are altered so that they reward skills beyond, and then there are limitations in what can be achieved.

Now, turning to the responses to Q11 in the teacher-educators' and Q9 in the student-teachers' questionnaires; Table 6.12 shows a comparison of teacher-educators' and student-teachers' responses to the elements of the possible outcomes in learning using inquiry-based pedagogy.

	Views	Teacher-educators' responses				Student-teacher-educators responses			
No	**teacher-educators = 50 Student-teachers = 580**	Essential	Very important	Of some importance	Not important	Essential	Very important	Of some importance	Not important
		%	**%**	**%**	**%**	**%**	**%**	**%**	**%**
a	Science subject knowledge	54	40	6	0	48	44	7	4
b	Abilities to carry out experiments properly	36	58	6	0	34	54	11	2
c	Procedural knowledge of science (how science works)	54	36	10	0	34	48	17	2
d	Scientific literacy	62	32	4	2	36	41	17	6
e	Understanding of the key ideas of science	46	50	4	0	40	48	10	3
f	Skills in passing examinations in the sciences successfully	48	48	2	2	34	46	18	2
g	Positive attitudes towards science	26	52	18	4	39	50	9	2
h	Ability to think critically and challenge ideas	52	44	4	0	36	48	12	4

Table 6.12: The key Outcomes in Develop Inquiry-based Pedagogy

Eight possible outcomes using inquiry-based pedagogy were offered to the teacher-educators and the student-teachers. Indeed, looking at all eight outcomes of the ITE program, on average, nearly four fifths of the teacher-educators and student-teachers said that they saw them as being essential or at least very important. Thus, responses to (a) and (e) indicates that an important outcome of the ITE programme relates to science subject knowledge and understanding of the key ideas of science.

Responding to Q10 in their questionnaire, student-teachers reported their views of the role of inquiry-based pedagogy in developing science literacy.

No	Views	SA	A	D	SD
	N = 580	**%**	**%**	**%**	**%**
a	Enables me to see science as a subject that educates me as a science literate person	41	47	10	2
b	Enables me to understand the use of science and its applications in my daily life	32	53	13	3
c	Enhances my understanding of the procedure of science investigation	30	49	16	5
d	Provides me with opportunities to gain insights into science concepts	29	52	15	4
e	Enables me draw evidence-based conclusions about science-related issues	30	55	11	4
f	Enables me to use reference science journals, the internet, and the library to research science information	41	46	10	3
g	Improves my understanding of ideas associated with the interpretation of data in science experiments	38	54	7	1

Table 6.13: The Role of Inquiry-based Pedagogy in Developing Scientific Literacy

Table 6.13 shows that student-teachers' opinions were universally positive with the views offered to them. Thus, the students-teachers' responses indicates that 'inquiry develops their reading skills to search science information and they use other resources more than

text books'. 92% of student-teachers agreed that 'inquiry improves my understanding of ideas associated with the interpretation of data in science experiments'. Thus, the student-teachers' responses indicate that they consider the value of inquiry in developing science literacy, understanding procedures and interpreting data in experiments.

From Q13 in the teacher-educators' and Q11 in the student-teachers' questionnaires, the teacher-educators' views were sought on the key barriers of the inquiry-based approach in science.

	Views	**Teacher-educators' responses**				**Student-teachers responses**			
No	**Teacher-educators = 50 Student-teachers = 580**	Cannot be Overcome	Serious Barrier	A Minor Problem	Easily Solved	Cannot be Overcome	Serious Barrier	A Minor Problem	Easily Solved
	Total = 50	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
a	There is insufficient time	8	62	24	6	25	50	18	7
b	Will not provide good examination results	12	34	36	18	10	49	28	13
c	Leaves the curriculum unstructured	8	44	36	12	18	40	33	9
d	Makes classroom management very difficult	6	32	26	36	18	36	27	22
e	There is not enough equipment to teach this way	12	58	20	10	22	47	22	7
f	Universities would not support it	8	44	26	8	16	47	26	11
g	The method is not consistent with the way other subjects are taught	16	34	28	22	16	40	32	12
h	The learners will be left confused	14	24	36	26	17	38	30	15
i	I have not been taught using an inquiry-based approach very much	6	28	38	28	17	38	28	17

Table 6.14: The key Barriers in Seeking to Develop an Inquiry-based Approach

Table 6.14 presents a comparison of teacher-educators' and student-teachers' responses. Nine possible barriers were offered to teacher-educators and student-teachers. These barriers were categorised into four possible responses, i.e. 'cannot be overcome', 'serious barriers' or 'minor problem' and 'easily solved'. Indeed, looking at all nine potential barriers, on average, nearly two thirds of the teacher-educators and student-teachers regarded them as serious barriers or as a minor problem.

The most serious perceived barriers were related to time demands and the necessary equipment to support inquiry-based pedagogy. It also appears from table 6.14 that yjeu consider that inquiry-based approaches lead to poor examination results and regard this as a serious barrier. Student-teachers are exposed to the lecture methods used, and so a test is seen as a tool of assessment. If inquiry-based pedagogy is used for the assessment, it

might not generate good results. Another area of concern for teacher-educators and student-teachers is that 44% of teacher-educators and 40% of student-teachers think inquiry generates unstructured curricula, and that this is a serious barrier. At the moment, teacher-educators have been teaching student-teachers lots of text or substantial information that does not include inquiry-based activities and is not designed for inquiry methods. If inquiry methods are used then this present curriculum could be unstructured and student-teachers might be confused by the new method.

(f) 44% of the teacher-educators and 47% of the student-teachers responded that lacking the University's support is a serious barrier. At the same time, 26% of teacher-educators and student-teachers reported that the lack of the university support is only a minor problem. Also, a correlation ($r = 0.42$; $p = < 0.05$) which exists between lack of equipment and university support reveals a statistically significant relationship. Perhaps, the lack of university support is reflected in equipment deficiencies.

Also, (d) and (g) are correlated ($r = 0.49$, $p = < 0.01$) and this correlation perhaps suggests that if the inquiry method is not consistent across all subjects, then this will make classroom management difficult. This is because student-teachers were not taught using inquiry-based method across all courses so they were not prepared for inquiry in all areas of curriculum. As a result, teacher-educators think they are likely to face management and discipline issues in classroom.

However, consistency of methods across subject areas is important and a lack of consistency will generate confusion. Also, lack of the prior exposure to inquiry-based approaches is a serious barrier in adopting inquiry-based approaches.

6.4.1 Additional Data Analysis using Chi-square

This section illustrates sub-group comparisons; these are mainly built around chi-square data, sets of tables plus comments. The chi-square test is one of the most widely used non-parametric tests (Reid, 2006). The Chi-Square ($\chi 2$), as a contingency test, was used to compare the opinions of the groups where there is no control group. The chi-square test is a "goodness of fit" test is used to compare a set of frequencies with those generated by a control group or, occasionally, and tells us how well a set of observations fits the outcome predicted by the hypothesis being tested.

In using chi-square, he number of categories may vary widely. The sue of the concept of degrees of freedom allows for this. The number of degrees of freedom is the number of

values in the final calculation of statistics that are free to vary (e.g. Reid, 2006; Brace et al., 2000). In this case, this related to the number of categories of frequencies. It is important to state the number of degrees of freedom for any calculated chi-square value. More detail on the use of chi-square is in appendix M.

There are some limitations of chi-square test. For example, the chi-square test does not give us much information about the strength of the relationship or its substantive significance in the population (Reid, 2006). Secondly, the chi-square test is sensitive to sample size. The size of the calculated chi-square is very strongly related to the size of the sample, independent of the strength of the relationship between the variables. The sensitivity of chi-square to sample size may make a weak relationship statistically significant if the sample is large enough. Thirdly, the chi-square test is sensitive to small frequencies in one or more of the cells in the table. Frankfort-Nachmias and Leon-Guerrero (2011:350) pointed out that: "*most researchers limit the use of chi-square to tables that either (1) have no* frequency *values below 5 in value or (2) have no more than 20 percent of the* frequency *values below 5 in value*":

For example, in this study, the frequencies of responses to items were compared by gender using chi-square as a contingency test. There can be no control group in such gender comparisons. What chi-square indicates is whether men and women differ, in statistical, terms. This is express, for example: $\chi^2 = 7.56$, df= 3, p= < 0.05.

Similar tests were carried out for other items in the teacher-educator and student-teacher questionnaires. In this section, I present only those chi-square results which show statistically significant chi-square values to differentiate the opinions within groups for the sake of simplicity and clarity. Each statement shows the question number in the same way that these were numbered in the questionnaires (Note: the questionnaires themselves are attached in Appendix A and B)

6.4.1.1 Gender Comparisons by Chi-square in Teacher-educator Data

The following table shows only those chi-square values within groups of males and females.

No	Views	Group	SD	D	A	SA	χ^2	df	p
Q11(d)	I think inquiry-based pedagogy in science will benefit student-teachers who are only seeking the right answers	**Male**	0	3	11	1	10.6	2	p<.01
		Female	0	12	9	14			
Q11(e)	I think that an inquiry-based pedagogy in science should be used in initial teacher education	**Male**	6	5	4	0	7.8	2	p<.05
		Female	3	23	9	0			

Table 6.15: The frequencies of distribution by Gender

The differences between males and females are dubious in that the category numbers are so low. Overall, there is slight trend that females are less positive.

No	Views		Easily solved	A minor Problem	Serious Barrier	Cannot be Overcome	χ^2	df	p
Q14(i)	I have not been taught using an inquiry-based approach very much	**Male**	8	3	4	0	7.1	2	p<.05
		Female	6	16	10	3			

Table 6.16: The frequency of distribution by Gender

Table 6.16 shows that females were more likely than males to agree with 'I have not been taught using an inquiry-based approach very much'. All other chi-square values for males and females in relation to the remaining part of the questionnaire showed that the differences between both of the groups were non-significant. Additionally, chi-squares by gender were found in the student-teachers' groups to be as follows:

6.4.1.2 Comparisons on Gender in Student-teachers Data

No	Views	Group	SD	D	A	SA	χ^2	df	p
Q12(j)	Inquiry-based approaches will work well only with the most able student-teachers	**Male**	11	30	48	62	14.2	3	p<.01
		Female	44	115	161	108			
Q12(i)	I could never have access to enough resources to teach using an inquiry-based method	**Male**	7	26	64	53	17.6	3	p<.01
		Female	21	119	206	83			
Q12(h)	It is not possible to assess student-teachers for their abilities in inquiry-based skills	**Male**	9	26	77	39	22.9	3	p<.01
		Female	28	159	175	67			
Q10(c)	Enhances my understanding of the procedure of scientific investigation	**Male**	5	24	64	57	8.8	3	p<.05
		Female	10	47	242	130			
Q9(b)	Enables me to only seek the right solutions to science problems	**Male**	2	26	74	49	10.9	3	p<.05
		Female	8	93	244	83			
Q9(a)	Enables me to learn how to identify and ask appropriate questions	**Male**	2	11	64	73	11.0	3	p<.05
		Female	4	24	248	151			
Q7(d)	Welcomes my scientifically oriented questions	**Male**	9	15	61	66	8.4	3	p<.05
		Female	17	47	225	139			

Table 6.17: The frequency of distribution on Gender

Table 6.17 shows that females and males generally responded with positive views. Looking at all the items in the table above, it was found that; overall, females were more likely to agree than males with the views offered to them. Table 6.15, Table 6.16 and 6.17 above shows that female group (in both teachers and students) are more likely to agree with the views than males.

6.4.1.3 Comparisons by Age groups of teacher-educators

No	Views	Group	Not important	Of some importance	Very Important	Essential	χ^2	df	p
Q12(d)	Science literacy	**Younger**	0	2	11	22	n.s	3	p<.05
		Older	1	0	5	9			

Table 6.18: The frequency of distribution by age groups

Table 6.18 shows that both groups, i.e. younger and older, responded with the positive views. It is appeared from their responses that overall, the junior group was more likely to take the view that inquiry is important or essential in developing science literacy.

6.4.1.4 Comparisons of the courses taught by teacher-educators

No	Views	Group	SD	D	A	SA	χ^2	df	p
Q11(k)	I think that an inquiry-based pedagogy in science will encourage critical thinking	**ST**	1	8	17	2	13.3	3	p<.001
		BT	1	2	7	11			

Table 6.19: the frequency of distribution by courses taught

No	Views	Group	Of some importance	Important	Very Important	Essential	χ^2	df	p
Q12(b)	Abilities to carry out experiments properly	**ST**	2	0	12	14	6.1	2	p<.05
		BT	1	0	17	4			
Q12(e)	Understanding of the key ideas of science	**ST**	1	0	8	19	6.6	2	p<.05
		BT	1	0	14	7			
		BT	0	0	16	6			

Table 6.20: The frequency of distribution by courses taught

Tables 6.19 and 6.20 show that BT were generally more likely to take the view that inquiry-based pedagogy is very important in building 'abilities to carry out experiments properly'; 'understanding of the key ideas of science' and 'the ability to think critically and challenge ideas'. However, the majority of teacher-educators belong to ST essentially think that inquiry is essential in achieving these outcomes offered to them.

6.4.1.5 Comparisons by Courses Studied by Student-teachers

It appears from Tables 6.21 and 6.22 (see Appendix M) that, overall, the BT and ST groups in students hold positive views regarding inquiry-based approaches in science. Thus, BT was more likely to hold the views in each item.

6.4.1.6 Comparison by Years of Study of Student-teachers

Table 6.22 (see Appendix M) shows that, overall, student-teachers in each year of study are positive towards inquiry-based pedagogy. It is noted that student-teachers in their 3rd year are more likely to be positive about inquiry-based pedagogy. This is because 3rd year student-teachers have studied most of the science course and science teaching method course and tend to have more positive view about inquiry-based pedagogy.

Table 6.23 (see Appendix M) shows that 3rd year student-teachers were more likely to hold the view that insufficient time could be serious barrier or that it cannot be overcome

in implementing inquiry than that of the 1st and 2nd year student-teachers. Second-year student-teachers are however of the view that insufficient time is a serious barrier.

6.4.2 Relationship between Inquiry and Other Measures Within the teacher-educators' Questionnaire (see Appendix N)

Correlation shows the degree and type of relationship between any two quantities. Kendall Tau_b is used to find the correlation between two variables in this study. Kendal Tau_b is defined that it is a correlation coefficient is necessary in order to deal with ordinal data samples with tied ranks. Kendall's tau-b coefficient is more effective in determining whether two non-parametric data samples with ties are correlated. The correlations were found between the teachers and between the student-teachers' responses to the questionnaire items using Kendall's Tau-b (see appendix O). Correlation coefficients were obtained for each comparison and none exceeded a numerical value of 0.1. This indicates that student-teachers' perceptions relating to their learning are not related in any substantial way either to their inquiry-based pedagogy or their understanding and applying of inquiry-based pedagogy. Obviously, the questions were designed not to make any excessive demands around inquiry-based pedagogy and the evident lack of correlations may simply reflect the structure of the questionnaire.

Of greater interest in this study is the lack of correlation or low correlation between the outcomes for inquiry and the student-teachers' perceptions relating to their learning and other measures. By contrast, when the teachers' responses to the questionnaire items were correlated with those of their student-teachers', some larger correlations were obtained, although, most of the survey items showed no significant correlations. The following items gave correlations greater than 0.1, the questions being shown to be polarised to give a positive correlation. Here, I present only those correlation results which show statistically significant values for the sake of simplicity and clarity.

It can be noted from Table 6.24 (See Appendix N) that the correlation values that those teachers who positively perceive an inquiry approach in science also perceive other measures in learning science through inquiry. However, most of the correlations' values are not substantially strong so it can be noted that it is difficult to draw any clear-cut conclusions from these results.

6.4.3 Relationship of Inquiry and Other Measures (student-teachers' questionnaire)

Table 6.25 (See Appendix N) shows that the correlation values within questions from the student-teacher's questionnaire. It appears by looking at the overall correlation values which indicate a weak or a moderate relationship between what the student-teachers reported as their attitudes to inquiry and the other measures of inquiry-based learning. Most of the correlation values were not significant; so only significant correlation values are presented for the sake of clarity and simplicity.

6.4.3 Factor Analysis of Questionnaires Data

Principal Components Analysis, using a varimax rotation, was used in this study to explore whether or not there was any structure of factors which underpinned the response patterns in the Likert type questions. This was carried out with the items for each question as well as with all the questions together in the student-teacher questionnaire (N = 580). In each of the analyses, no structure at all was found to be present. This means that each individual item is asking a different question and, indeed, this was the way the questionnaires were designed. The aim was to obtain a picture of the perceptions of the teacher-educators and student-teachers with regard to the role and importance of inquiry-based pedagogy in ITE covering a wide range of issues. Moreover, the teacher-educator questionnaire (N=50) is even less likely to reveal a structure, as the sample is smaller than the student-teacher questionnaire.

The next chapter (Chapter 7) contains a report of the main points from the interviews and focus groups with some of the teacher-educators and student-teachers who completed questionnaires and, again, similarities and contradictions are explored, both between the teacher-educators, and student-teachers, responses in the interviews and also between the questionnaire responses and the interviews.

Chapter 7

Finding from Interviews

7.1 Introduction

This Chapter is an extension of the research findings, as Chapter 6 has focused on reporting the findings from the teacher-educators' and student-teachers' questionnaires. It presents the findings for the teacher-educators' semi-structured interviews and student-teachers' focus groups as a second instrument of data collection (See interviews and focus groups in Appendix C and D). The semi-structured interviews and focus groups were designed to explore the participants' in-depth perceptions of inquiry-based approaches, their perceptions of inquiry-based learning in the practicalities of teaching, and of the challenges involved in adopting inquiry. The characteristics of 20 teacher-educators from the interviews are described in Tables 5.3 and 5.4. Eight student-teachers participated in the focus groups (4 student-teachers per each group); their details are given in Chapter 5. The following were the main themes which emerged from the questionnaire and interview data:

1. Perceptions of the fundamental elements of inquiry-based approaches
2. Perceptions of inquiry-based in developing learning
3. Perceptions of the contribution of the science method course in developing inquiry
4. Perceptions of inquiry in developing science literacy
5. Challenges in adopting inquiry-based approaches

7.2 Perceptions of the Role and Importance of Inquiry-based pedagogy

The main goal of this study has been to capture science teacher-educators' and student-teachers' perceptions regarding their understanding of inquiry and inquiry-based science pedagogy through interviews and questionnaires. With regard to their understanding of inquiry and inquiry-based pedagogy, the interview data supported the questionnaire data and also provided a richer insight to the questionnaire data. Although teacher-educators' exposure to inquiry and inquiry-based pedagogical strategies differed, they shared common ideas, as demonstrated by their perceptions of inquiry-based pedagogical approaches, the practicalities of teaching using inquiry, their perceptions of inquiry in relation to science literacy and the factors contributing to the understanding of inquiry-based pedagogy.

A strong pattern has emerged from the teacher-educators' and student-teachers' responses in that almost all of them show positive perceptions with regard to inquiry and inquiry-based pedagogy towards the teaching of science; however there are some clusters of ideas. The emerging themes within teacher-educators' expressed understanding about inquiry and inquiry-based pedagogy were used to guide the analysis of the data which now follows. A detail of key themes emerged from interview and focus group responses and sub-themes underneath the main theme are presented below:

Theme 1: Perceptions of the Fundamental Elements of Inquiry-based Approaches

i. Questioning as a Fundamental Element of Inquiry
ii. Inquiry as a Constructive approach
iii. Reflection and Thinking Skills
iv. Collaboration
v. Teacher-educators Role as a Facilitator

Theme 2: Perceptions of Inquiry-based learning in Developing Learning

i. Inquiry-based pedagogy develops learning

Theme 3: Perceptions Contribution of Science Method course in Developing Inquiry

i. Inquiry-based pedagogy engage students in learning

7.2.1 Perceptions of the Fundamental Elements of Inquiry-based Approaches

In the context of inquiry, teacher-educators and student-teachers reported their perceptions regarding their understanding of inquiry and inquiry-based pedagogy in relation to various inquiry-based activities in science teaching. From the questionnaires, the majority of teacher-educators and student-teachers reported that teaching of the science mainly is done through lecture method. From the question 7 in student-teachers' and question 9 from teacher-educators' questionnaires, findings were consistent mostly with the views of teacher-educators and student-teachers from interviews.

Many of teacher-educators' and student-teachers' responses from questionnaires showed concurrence in their perceptions about inquiry and inquiry-based approaches in science. Looking at interview data, indeed, there were many associated cluster/group of perceptions/ideas. According to the content analysis, the qualitative data was grouped to

make one sense from the emerging themes (see Section 5.13). Thus, the table below shows the categories of the perceptions on the issues and their strength in the qualitative data:

No	Categories of Responses	No of Responses Evident in
1	Questions about Previous knowledge in science	18
2	Examples of scientific experimentation within curriculum	14
3	Group Discussion in classroom	12
4	Demonstrations	12
5	Science problem solving/assignments	6
6	Science investigations through Field work	6
7	Guided Science-oriented questions	4
8	Numerical problem solving	4
9	Presentation of the solution of science problems to peers	4
10	Hands-on science activities	3
11	Open-ended/full science investigations	2
12	No inquiry/ Lecture only	2

Table 7.1: Teacher-educators' Responses on their Teaching Activities

Table 7.1 shows that the above responses are about the types of inquiry and inquiry-based activities that the teacher-educators used in their science teaching. Thus teacher-educators responded to overall 12 different activities. The above 12 categories indicate teacher-educators' understanding of the essential features of classroom inquiry in science courses. When teacher-educators were asked how the teaching strategies used and taught in the science compared with their previous exposure/experience of inquiry, most of the teacher-educators indicated that they had little exposure of inquiry-based instruction or used it less as reported below:

> I had a little idea about inquiry-based learning. (T2).
>
> I had done inquiry till this class, sometimes. (T3).
>
> I really had not even thought about what inquiry is? (T15)
>
> I really didn't know much about it. (T18)

Also, the majority of teacher-educators responded that inquiry-based pedagogy in science is a process that could involve student-teachers exploring science concepts, enabling them to understand logically:

> Inquiry-based pedagogy consists of methods that involve student-teachers understanding step by step science through science activities. (T10)

Also, student-teachers' perceptions in focus groups regarding their understanding of the importance of inquiry and inquiry-based pedagogies in learning science were examined, to see how they understood the benefits of teaching and learning science through inquiry-based pedagogy. It was found that student-teachers' reflections on the focus groups

indicate that they understood how inquiry-based instructions involve student-teachers' learning.

The majority of student-teachers reported similar views as teacher-educators. For example, they reflected that inquiry starts with probing science questions that require tools to find information, and can raise more questions that lead to further investigations.

> Inquiry-based methods involve student-teachers learning science through hands-on activities and seeking solutions of questions. (G1-S1)

Furthermore, 12 out of 20 teacher-educators reported that they also use some activities as well as questions. For example, student-teachers work in groups; and having student-teachers involved in those inquiry-based activities that are more student-centred than teacher-centred. They facilitated their student-teachers by involving them in field work and science investigations as illustrated by the following examples:

> The certain benefit of inquiry for student-teachers is that student-teachers partake in field work, they give presentations by utilising multimedia, and they make investigations and explore the properties of material. I think that student-teachers enjoy field work activities and experience a new way of learning. (T4)

Furthermore, 14 out of 20 teacher-educators responded that skills to handle experiments and analyse data is hard to handle by student-teachers as reported:

> I cannot perform science experiments. I feel that it is hard for student-teachers to handle experiments and analyse data themselves (T3).

Furthermore, the majority of teacher-educators responded that they assign problems to student-teachers to solve the problem and find the solution together. Teacher-educators' views indicate that this allows student-teachers to develop a deep understanding as reported:

> When I involve my student-teachers in data analysis such as graphing or interpreting the results, I observe that if they get stuck, they think about the problem, and sort it out. When they reflect on their constructed solution, they are confident in presentation of the solution. Student-teachers learn more, show a deep level of understanding, and develop solutions through inquiry-based methods. (T10)

Moreover, most teacher-educators' responses indicated that they understand that student-teachers must be exposed to activities that engage them to answer scientifically-oriented questions and participate in other science-exploring activities. A few teacher-educators also agreed that learning was something that cannot be imposed on student-teachers; they must take responsibility for their own learning. They proposed that student-teachers answer scientifically-oriented questions or science problems by observing, communicating results

and justifying their explanations independently. This indicates their understanding of abilities and concepts of inquiry as reported by the response below:

> Inquiry-based pedagogy in my classroom includes exploring science concepts using science materials. For example, in an experiment on magnetism, student-teachers were given materials and asked to perform directed experiments, record their observations, and report their findings. So, guided inquiry-based activities like this provided student-teachers a step by step direction on what to do. Though I do hands-on experiences least and science questions most. (T10)

Moreover, the majority of teacher-educators reported that they had little prior exposure to inquiry-based science teaching strategies. Nonetheless, there were a few teacher-educators who had some knowledge of the purpose of inquiry and inquiry-based pedagogies; for example, science-oriented questions. Thus, teacher-educators have reported that they made connections to their previous exposure to inquiry-based instruction through science content only after using inquiry-based pedagogy; though they used it less.

Also, teacher-educators said that structured and guided scientific questions were initially used to develop concepts. They responded that most activities started out with structured or guided partial inquiries and then led to unguided, open and full inquiries for example open-ended scientific investigation as reported:

> I could provide student-teachers with only structured inquiries motivate them to seek for science problems and design the procedure to test their question and the resulting explanations. For example, student-teachers were asked to record the number of times the pendulum swung, how they count it, to repeat their experiment and record the number of swings it made in 20 seconds. Additionally, student-teachers could identify the variables that might affect the swing rate and record their results for changes in each variable; keeping every other variable constant. Student-teachers could be able to do open inquiries by progressing in understanding of inquiry-based pedagogy. (T5)

Thus, the above response indicates that teacher-educators still provide question and guided procedure. However, student-teachers could generate an explanation supported by the evidence they collect. Also, teachers' responses indicated that student-teachers were able to do open inquiries when they understand the process of inquiry-based pedagogy.

Moreover, some of the teacher-educators' responses indicate that they often question, though they could not plan an entire curriculum using inquiry-based approaches as reported:

> I cannot teach the entire curriculum using inquiry. I could only engage student-teachers in questions and demonstrations. (T18)

Teacher-educators' 13 and 20 responses were negative about the use of inquiry and inquiry-based pedagogy with the current curriculum. They reported that they rarely use inquiry as said:

> I prefer transferring knowledge to student-teachers in my lessons. I explain to them well, and it seems that the lecture method is the most suitable choice. (T15)

Also, students-teachers reported that lecture method is the most convenient approach:

> Lecture seems only workable method in science class. (G2-S3)

Likewise, student-teachers reported lecture as teaching method made student-teachers passive, and want student-teachers listening to lectures. Student-teachers reported that they do not get involved in inquiry-based activities as reported:

> We do not have much use of inquiry in our classes. Student-teachers also try to avoid when inquiry-based activities are used. They want to be explained to them. (G2-S1)

Also, the majority of teacher-educators responded that they do not use solely lectures; rather they use completely inquiry or inquiry-based activities during their lessons as reported:

> I do not lecture solely nor could entire teaching be possible using inquiry-based teaching method. (T16)

Also, the majority of teacher-educators' reported that they had rarely been exposed to inquiry-based instructions in their science courses because of the other problems they have to face when inquiry is practised as reported:

> I would personally prefer using inquiry methods but I used less inquiry-based strategies particularly open-ended science investigations. (T19)

Likewise, student-teachers reported their apprehensions that they were less involved using inquiry according to their learning experiences as reported:

> We are only exposed to questions; some components of inquiry such as open-ended investigations are less used because of shortage of time and resources. (G2-S4)

Thus, teacher-educators' and student-teachers' responses indicated that they were exposed to questions but rarely implement inquiry-based strategies, for example, science investigation in their science class. An important sub-theme emerged (responses reported by teacher-educators and student-teachers) that questioning as a fundamental element of inquiry.

7.2.1.1 Questioning as a Fundament Element of Inquiry

The majority of teachers and student-teachers were of the view that question is the very important component of inquiry-based pedagogy. From the questionnaire data, 82% of teacher-educators agreed that inquiry-based pedagogy in science will benefit student-teachers who were only seeking the right answers. Similarly, 78% of student-teachers agreed that inquiry enables them to only seek the right answers to science problems. Likewise, the majority of teacher-educators from interviews responded that the key elements of inquiry-based teaching are frequent use of science questions about the previous knowledge of student-teachers.

> I usually ask student-teachers questions regarding their previous knowledge. (T1)

They expanded that they often used questions to stimulate student-teachers' thinking and inquiries as articulated:

> I question student-teachers in my daily lesson to find the solution which makes them think conceptually in order to figure it out. (T3)

Thus, the responses of teacher-educators indicate that the most important thing to do is to ask science questions about the previous knowledge of student-teachers in class as the main inquiry-based activity. Likewise, most student-teachers in focus groups responded that inquiry-based approaches involve student-teachers into questions as reported:

> Inquiry involves student-teachers mainly in questions. We could be involved in a range of inquiry-based activities thought not in actual. (G1-S2)

The majority of teacher-educators reported that they start their lessons by asking questions from the previous lessons, in order to ensure that student-teachers have a grasp of the topic they studied in previous class as reported:

> Inquiry is question-oriented and attempts to find the answers. Student-teachers learn to find the correct answer that's why I use questions a lot. (T16)

Student-teachers' responses from focus groups indicate that inquiry is not to find one specific answer for each phenomenon, but to involve student-teachers in reflecting back on solutions such as: what the data indicates in light of what is already known. They reported that inquiry could lead to develop new knowledge as articulated:

> I feel that inquiry-based activities bring an ease in understanding science concepts, not only exploring answers of science questions, also think solution. (G1-S4)

Thus, teachers' and student-teachers' perceptions indicate that questions were often used to seek the right answers and also make connections between inquiry-based activities they

carry out, and their views on inquiry-based approaches.

7.2.1.2 Inquiry and Scientific Investigation

The majority of teacher-educators reported their positive views towards inquiry that impact positively on student-teachers' involvement in scientific investigation as reported:

> Inquiry-base pedagogy is the same process as the scientific investigation. Student-teachers seek out the science problem and test it to find the solutions, share the solution. Using inquiry-base activities, student-teachers learn systematically. If they get stuck in any step, they learn their own and they explore science process. (T2)

Thus, above responses indicated that teacher-educators appreciated their role using inquiry in engaging student-teachers in science investigations. It also indicates that inquiry develops an approach in student-teachers to investigate science deeply.

Moreover, the majority of teacher-educators reported their positive attitude towards importance of inquiry-based pedagogy in teaching science. They responded that scientific inquiry was a vital part of science and inquiry is an important form of science:

> Inquiry-based pedagogy is highly related with the nature of science. Inquiry method really helps in developing scientific attitude. (T16)

In addition, student-teachers reflected that it is important how to discover it or examine or test the problem to interpret solution so their belief is that scientific investigation relies on the process of inquiry-based pedagogy as reported below by the response:

> It is important how to discover it or examine or test the problem to interpret the solution; scientific investigation relies on the process of inquiry-based pedagogy. Inquiry in science works as how science works. So, inquiry helps in understanding the process of scientific investigation. (G1-S3)

The majority of teacher-educators reported that inquiry-based pedagogy does have a positive impact on understanding scientific investigation as reported:

> Inquiry in science means that student-teachers do not simply perform experiments with the known answers, but they actually think what it means. I believe that inquiry-based activities gradually influence student-teachers' attitude in science. (T16)

Similarly, the majority of student-teachers in focus groups discussed similar views about inquiry-based pedagogy improving understanding of science investigation. Most student-teachers reported positively about the impact of inquiry-based pedagogy to scientific investigations. Student-teachers reflected that they have been realised positively that

inquiry-based strategies help them understand their experiments in science as reported:

> Using inquiry, student-teachers' understanding of science investigation and science concepts is clearer than in sole lectures. (G1-S1)

Likewise, student-teachers reported that they were initially frustrated with the lack of structure to inquiry-based experiments but inquiry-based strategies were helpful to make them learn meaningfully as indicated by their responses below:

> Inquiry-based methods initially a difficult experience but gradually develops investigative skills with a continuous practice. (G2-S1)

Thus, the majority of teacher-educators and student-teachers were positive regarding the finding from the interview data that inquiry-based teaching emphasizes the importance of evidence in decision making. The responses from the questionnaire confirmed the similar finding that student-teachers agreed that inquiry enables them draw evidence-based conclusion about science related issues.

7.2.1.3 Inquiry-based Pedagogy and Procedural Understanding

The majority of teacher-educators reported their positive attitude towards inquiry-based instructional strategies in developing science procedural understanding in student-teachers as reported:

> Inquiry-based pedagogies enhance the procedural understanding. This help student-teachers' learning deeply about how science phenomenon happens. (T15)

However, student-teachers mostly perform an experiment in the given curriculum and do not have the opportunity to plan experiments. Gradually, they started developing an understanding of the relationship between procedural knowledge and inquiry-based pedagogy in science. Thus, the majority of student-teachers reflected that they can learn a science procedure systematically with help of inquiry-based activities as reported:

> I think inquiry enhance procedural knowledge of science step by step procedure; more in doing practically as a real understanding of science. (G1-S3)

Additionally, the majority of teacher-educators reported that student-teachers learn best by doing. They can go through the experiment in detail as reported:

> Procedural knowledge during scientific investigation is similar to inquiry-based pedagogy itself. It is a systematic process to discover science facts. (T5)

Also, student-teachers indicated similar response to teachers as articulated:

> I think that procedural understanding, inquiry and science literacy are interrelated with each other. (G1-S2)

Thus, the above teachers' and student-teachers' responses indicated that procedural understanding is how student-teachers understand working in science.

In sum, teacher-educators' and student-teachers' perceptions on the exposure of inquiry and inquiry-based approaches are presented in a diagram below. Four colours were used in the diagram to differentiate between various inquiry-based approaches/pedagogies. The purple boxes indicate inquiry-based activities those are frequently used by all of the teacher-educators. The pink boxes indicate inquiry-based activities which are used less or by few teachers. The majority of teacher-educators used questions about previous knowledge, and demonstrations in their teaching sessions; and these boxes were presented at the bottom. As the triangle goes up; it indicates strategies those were used less by teacher-educators, for example, open-ended science investigations.

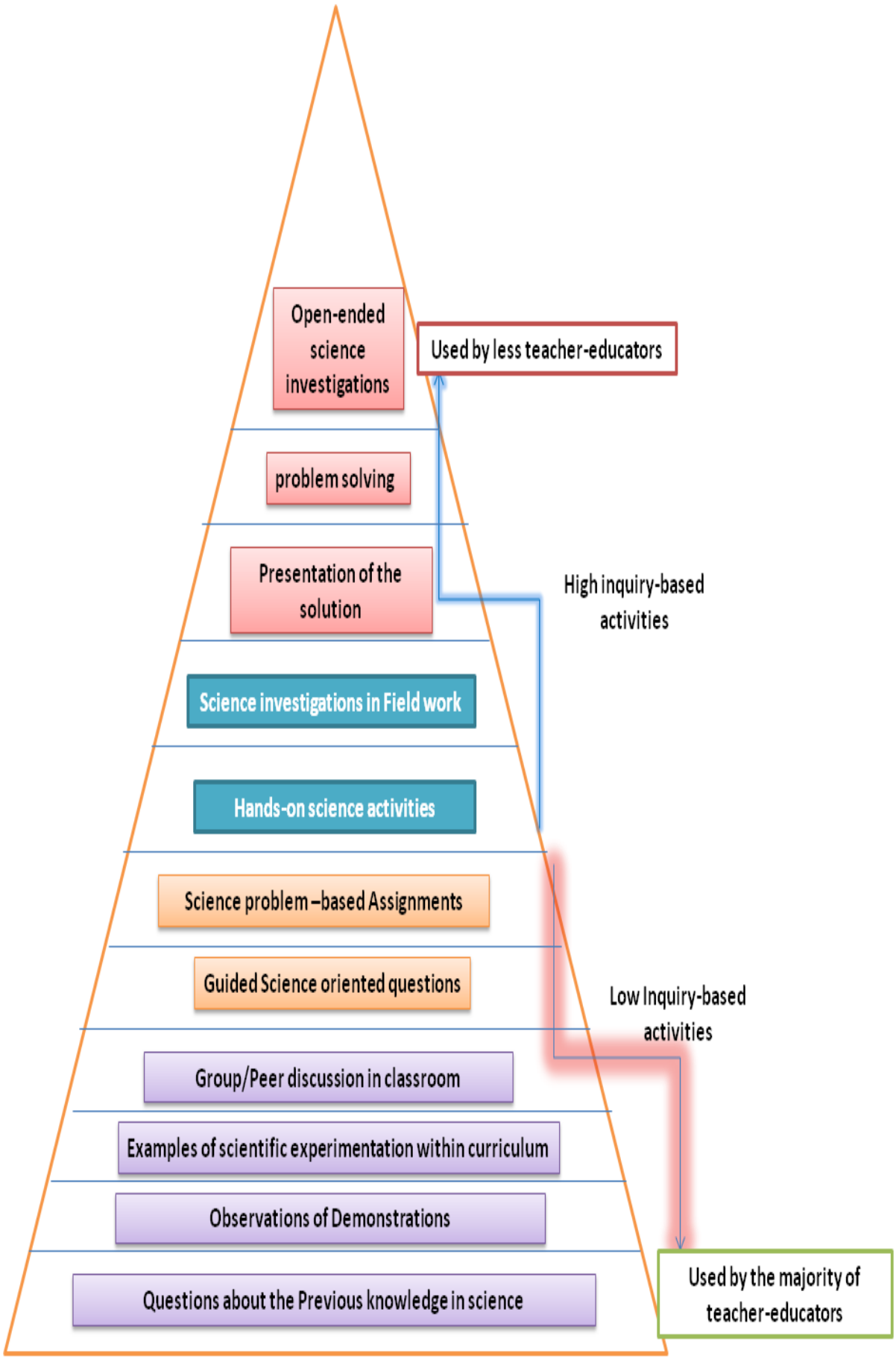


Figure 7.1: Perceptions about Inquiry and Inquiry-based Pedagogy

7.2.1.4 Inquiry as a Constructivist Approach to Learning

The teachers and student-teachers showed their perceptions that they initially struggled using inquiry-based approach to learning science whereby they construct their own understanding through active involvement in the learning process. Also, a reason for using inquiry-based activities where student-teachers are responsible for their own learning keeps student-teachers involved in exploring science as reported:

> Student-teachers were taught inquiry through guided, and hands on activities; however open inquiries have used a little when with little or no guidance. Best part of student-teachers' learning is that they left on their own to construct their learning. (T6)

Another student-teacher was of the view as reported:

> I think inquiry-based leaning enables us to learn meaningfully (G2-S1).

Specifically, the teachers indicated that student-teachers were taught inquiry through guided, hands-on activities. However, open inquiries have not been used or used very little when there was little or no guidance given by teacher-educators, and student-teachers, when left on their own to construct their learning, struggled with the execution of the activity. The response below by a teacher indicates that he picked up on the student-teachers' struggle/frustration of learning science:

> Student-teachers initially were confused in doing inquiries; they seem struggled with the execution of inquiry-based activities. (T11)

The majority of teacher-educators' reflections indicated that they understood the importance of inquiry-based instruction in their student-teachers' learning. Specifically, they think that inquiry-based pedagogy makes student-teachers responsible for their own learning and develop their attitude towards science as reported:

> I think all inquiry-based activities for example, hands-on and experiment, small group discussion involve in the learning process instead of teaching from text. They become responsible for their learning, construct their own ideas and meaning of science concept. (T10)

Likewise, T12 pointed out about independent work but saw this more in terms of a way of doing things rather than constructing meaning:

> I think all inquiry-based activities develop a sense of independent work. They construct their own way or procedure to do it. (T12)

Moreover, student-teachers felt that the inquiry approach allowed them freedom to break up ideas so that they could be grasped better:

> Using inquiry, we learn better when we break up the complex concept into small one, get into it, construct the meaning and understand it meaningfully. (G1-S4)

Thus, inquiry-based pedagogy the respondents think that it is much better in bringing about their understanding of science concepts than having them memorize concepts as this form of instruction helps student-teachers build on what they already know and thus sustain their knowledge.

7.2.1.5 Reflection and Critical Thinking

From the questionnaire data, the majority (95%) of the teacher-educators were positive regarding the view that inquiry-based teaching encourages critical thinking. Likewise, student-teachers were also positive that inquiry encourages a thought-out solution when they do practical work in science investigation. 87% agreed that inquiry develops critical thinking to evaluate the evidence in scientific investigations.

Also, ST (teachers of the sciences) and BT (teachers of science education) differ in their view on "*I think that an inquiry-based pedagogy in science will encourage critical thinking*" ($\chi 2$ = 13.3, df= 3, p = < 0.001), with BT more likely than ST to agree that an inquiry-based pedagogy in science will encourage critical thinking. Also, an overwhelming majority of the teacher-educators from the interview data responded that inquiry develops scientific thinking to review the science process and to analyse science experiment data critically as reported:

> Using inquiry-based activities, student-teachers reflect on what they understand in science experiments; also they think how and why things are happening in science. (T19)

In addition, it was also supported by one other teacher-educator that the use of inquiry is a rich experience in developing critical thinking in student-teachers as reported:

> Inquiry-based pedagogy provides rich experiences to student-teachers' thinking. (T12)

Thus, teacher-educators responses from questionnaire and interview data indicated that the role of inquiry is vital in developing analytic and cognitive abilities in science as well as critical thinking in student-teachers.

Likewise, most student-teachers reported that they developed into reflective thinkers and were able to learn deeply through inquiry teaching strategies. This ability to understand and reflect their work itself is learning that will help student-teachers develop their own pedagogy in science as reported:

> Inquiry is useful in developing thinking in science processes. I believe that inquiry brings a way to go into a depth in investigating. (G1-S4)

Moreover, student-teachers' reflected that even student-teachers who considered themselves doing structured inquiry appreciated the importance of unstructured approach to learning science as reported:

> Inquiry-based sessions helped enhancing open-ended and unguided activities encouraging seeking knowledge; It has been a bit uneasy initially because we are not reasonably involved in open-ended, though we develop an understanding from structured inquiries and this helped to be reflective and think critically. (G2-S3)

Another important reason cited by the student-teacher-teachers for their intent to use inquiry-based pedagogy was that inquiry-based pedagogy promoted their professional learning experiences through inspiring 'higher order thinking' as reported:

> Inquiry develops thinking critically in science processes; indeed we learn to think critically, and rationally. This enables us to solve problems. (G1-S4)

Thus, teachers' and student-teacher-teachers' responses showed that not only did they develop an understanding of the use of inquiry to answer questions and solve science problem; but also applied their learning about science concepts to think and understand then explain real life experiences. Their reflections indicated that this transition in thought was facilitated through the positive outcome in their inquiry-based activities.

On the contrary, some teacher-educators were of the view that student-teachers were given little guidance or no guidance in their science activities as it was, there were fewer opportunities for student-teachers to develop their thinking abilities as response below:

> Unfortunately, we do not have much practical work to do in our lectures/sessions. Rather have to restrict our student-teachers to a limited use of unguided inquiries. That's why student-teachers got a little chance to develop critical thinking. (T18)

Likewise, student-teachers were of the same view to teacher as G2-S4 reported:

> Most lecture session do not let us do our own constructed activities so we got no or less chances to be reflective or develop a critical thinking. (G2-S4)

Thus, both teachers and student-teachers reported their apprehension regarding a restricted environment in the teaching session where they have little or no opportunity to develop thinking skills.

7.2.1.6 Inquiry and Collaborations

The teachers and student-teachers' responses were found on the student-teacher collaboration and learning. The majority agreed that inquiry-based methods facilitate students' learning in groups. Likewise, from interview data, the majority of teacher-educators presented similar views about the role of the inquiry based method in developing social skills in student-teachers and enhances communication and collaboration among student-teachers as reported below:

> I think inquiry-based activities enhance communication among student-teachers in group activities; this develops social skills as well as moral values in student-teachers. (T4)

Teacher-educators responded that inquiry helps student-teachers in developing confidence in doing inquiries was by having them work in groups and provide feedback to each other. Thus, one of the ways in which teacher-educators developed student-teachers' confidence was through social interaction as said here:

> I think student-teachers learn best in groups when they discuss in group. The group discussion is the best idea with them. Low confident student-teachers get a chance to develop their confidence, share and reflecting their ideas. (T10)

Moreover, student-teachers indicated that their intention to use inquiry-based pedagogy was coming from their understanding of the importance of inquiry-based instruction to inculcate student-teacher and teacher interaction within groups. Moreover, another benefit cited by the majority of student-teachers of the use of inquiry-based science instruction and learning was the social interaction promoted through this form of learning as illustrated:

> I think inquiry is a method that involves me in learning more than any other method. I think inquiry brings a lot of interest in learning science especially when I interact with others and participate in cooperative learning. (G2-S2)

Moreover, female and male teachers differ in their view on "I like the idea of being a facilitator of learning by allowing the student-teachers to learn in groups". From questionnaire data, a Chi-square ($\chi 2 = 7.8$, $p < 0.05$) indicated that female teachers are more likely to agree than males on the above mentioned view. Likewise, student-teachers responses lead to the fact that they appreciated their female teachers like sharing and interacting with teachers so they find it an opportunity to collaborate with them in inquiry-based settings as reported:

> I feel motivated when teacher involves me using inquiry-based methods. Mostly female teachers are very cooperative, encouraging and interacting. (G2-S1)

Thus, teachers' and student-teachers' responses indicated that the understanding of the

importance of social interaction for learning is a hallmark of inquiry-based approaches in science. Furthermore, student-teachers were confident when teacher-educators worked with them collaboratively and helped them in developing inquiry-based skills. Thus, an agreement is appeared among teacher-educators and student-teachers that one of the ways in which student-teachers' learning is promoted is with social interaction.

7.2.1.7 The Role of Teacher-educators in Adopting Inquiry-based Pedagogy

The teacher-educators' responses from the questionnaire indicated that 90% agreed that they liked the idea of being a facilitator of learning by allowing the student-teachers to learn in groups. In addition, interview data indicated that the majority of teacher-educators reported that they appreciated that inquiry-based strategies help them to develop as a friendly and interactive educators with student-teachers; also their role as facilitator of learning develops a confidence and a sense of ease in their student-teachers as reported:

> Using inquiry-based activities, I facilitate student-teachers' learning in class. My student-teachers feel easy in communicating with me; that developed their confidence. (T3)

Teacher-educators mentioned that their role as a facilitator enables them in meeting student-teachers' level of understanding that they have been undertaking in their sessions. Teacher-educators reported that they learned to pick a democratic style of teaching rather than an autocratic style of teaching using inquiry-based strategies as reported:

> Using inquiry, I work with them with a democratic style; I understand student-teachers' needs better using inquiry-based methods. (T4)

The majority of teacher-educators responded that they need to vary their role in their teaching according to classroom environment, for example, if they teach a lengthy topic in a big class then they prefer lecturing as reported:

> I vary my role during my teaching; as a facilitator or a lecturer. I cannot teach throughout using inquiry; some topics in zoology need explanation. (T8)

The majority of teacher-educators reported that their role in an inquiry-based classroom is quite different from that of a teacher in a conventional classroom. It is an important issue to note that teachers are misunderstood in doing inquiry-based activities because they are assumed not doing a worthwhile job. Their apprehensions were particularly in an environment where most of the other lecturers are not consistent in using inquiry as said:

> My role in an inquiry-based classroom is unconventional and also inconsistent with other teacher-educators, it is sometimes misunderstood. Administrators,

> parents, or even student-teachers may not recognize the hard work that goes into planning and implementing inquiry-based methods. In fact, it may seem to others that teachers are not doing anything and student-teachers talk to each other. (T12)

The perceptions here are very realistic and identify the trepidation and uncertainty felt by teachers. Inquiry-based learning may well be misunderstood by others.

Nonetheless, the majority of student-teachers reflected their personal dissatisfaction in the way the teacher treated them. The majority of the student-teachers reported that they were disappointed and their self-esteem was lessened when they were discouraged by teachers as reported:

> Teachers get annoyed by questions; do not respond them nicely and discourage asking them. (G2-S2)

Moreover, student-teachers reported that teachers appreciate only those who present their work initiatively to teacher as reported:

> Sometimes, teachers get annoyed with student-teachers' questions; sometimes only gifted and first-row sitters participate. Therefore, teachers appreciate only those student-teachers. All student-teachers rather not only a few student-teachers should be encouraged so that everyone develops confidence. (G1-S4)

Thus, student-teachers comments to teachers' teaching style were the least positive. Student-teachers reported that inquiry-based teaching styles involve them actively though teachers were conventional in their teaching style and did not pay much attention to student-teachers' needs as reported:

> I think that teachers usually do not have interactive relationship with student-teachers. Teachers also not understand student-teachers' need of learning. (G1-S1)

Moreover, student-teachers responded that they feel that a change should be brought in to develop a relationship between student-teachers and teachers. They felt that teachers' role should be more interactive with student-teachers as reported:

> I believe that teachers and student-teachers should not have a distance in their relationship and develop an effective communication. (G1-S3)

Thus, the above responses indicated that teacher-educators and student-teachers should have a good relationship so that student-teachers feel able to be understandable enough to tell their problems to teacher as reported:

> Teacher should involve student-teachers in learning science. For example, we are taught by teachers that has PhD. Sometimes we cannot understand how they are attempting to convey to us. I think inquiry-based methods are effective to make teacher as a facilitator that understand student-teachers' needs. (G1-S1)

Although, a few teachers were of the view that they present themselves as strict teachers or exhibit reserved behaviour to maintain discipline in class as reported:

> I always like discipline and attentive student-teachers in class. Inquiry makes teacher friendly and interactive but think discipline is necessary to manage so I am a bit strict teacher. (T3)

Thus, there is an inconsistency in what teacher-educators claim and what student-teachers say. Student-teachers are more likely to report what happen in the classroom. The figure below depicts the teacher-educators' and student-teachers' perceptions on the role of teacher using inquiry. It appears from the teacher-educators and student-teachers' responses that the teachers' various roles using in inquiry-based sessions in facilitating learning, managing class and reacting to the challenges when inquiry is practised. These three roles can be illustrated in figure 7.2.

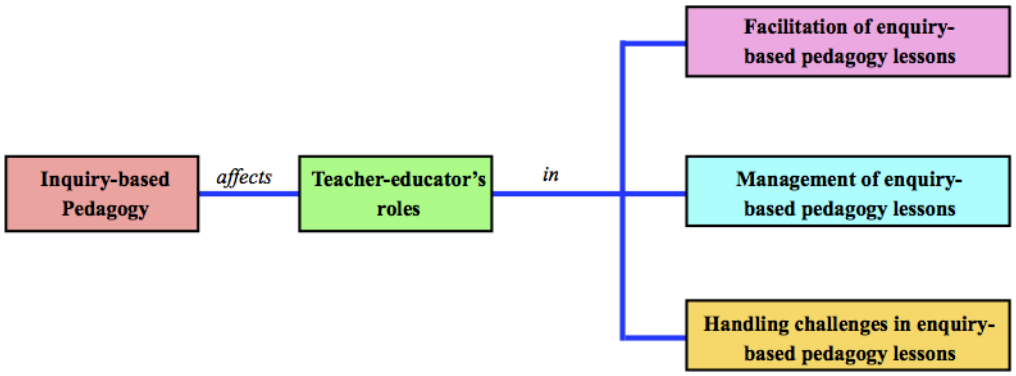


Figure 7.2: Teacher-educators' Role using Inquiry

In sum, the teacher-educators' role as a facilitator with student-teachers makes them engaged and encouraged (e.g. Brookfield, 1995). Teacher-educators responded that the inquiry-based teaching style develops such attributes in them that help student-teachers in their learning. Also, student-teachers' responses indicated that science teachers did a good job of drilling into their heads that inquiry-based instruction was a good way to teach science. Though, student-teachers responded that they had fewer opportunities using inquiry-based activities by their teachers, therefore, they did not feel prepared on their experiences; that make them realise the importance of inquiry-based pedagogy in learning science.

7.2.2 Perceptions on Inquiry-based pedagogy in developing Learning

Teachers and student-teachers used inquiry-based pedagogies in their academic session but they appreciated the value of inquiry in learning. What does this mean? Some cluster of

ideas from the emerging themes of teacher-educators' and student-teachers' views of inquiry-based pedagogy were used to guide the analysis of data.

Interview data provided an insight to questionnaire data and showed that almost all teacher-educators and student-teachers held positive attitudes to inquiry and inquiry-based pedagogy regarding student-teachers' learning in science. Interview data indicated that all teachers agreed that inquiry is helpful in improving learning and develops learning in science. For example, the majority of teacher-educators responded that student-teachers' learning is the result of their active involvement in the process where they themselves learn and understand the concept. Therefore, teacher-educators believe that inquiry-based lessons include all those activities that make student-teachers active learners and thus inquiry is helpful in improving learning as reported below:

> I think student-teachers learn when they are given an insight to look at things themselves. They learn best when they get something to examine, observe it and think. I believe that inquiry-based pedagogy include the entire element that make student-teachers observer, thinker and examiner of science phenomena. Thus, inquiry-based pedagogies help in learning science. (T4)

Correspondingly, student-teachers' responses on the focus groups were examined for their reflections on how they learn science. The majority of student-teachers in focus groups discussed similar views to teacher-educators about inquiry-based methods help in developing learning as reported:

> I learn best when the concept is clear to me, I explore through various sources until I find the solution. When I get stuck at a question I struggle to seek answer. I understand concept in inquiry-based sessions and learn it with an interest. (G1-S4)

Although some teacher-educators responded that student-teachers were initially frustrated with learning science through inquiry, and did not feel prepared to handle independently science projects assigned to them though they were able to pass through the challenge. While reflecting on their experiences, they realized the importance of inquiry-based pedagogy for learning and teaching science. Teacher-educators' reflections indicated that this transition in thought was facilitated through the positive outcome in their inquiry-based activities, from peer discussions necessitated by lack of teacher-educators' interaction and through their reflection on the benefits of inquiry-based learning as reported below:

> I think student-teachers initially realised inquiry as a challenging method but they started understanding inquiry-based strategies gradually. I feel that student-teachers enjoy when they interacted with teachers in inquiry-based sessions though interactions happen little. Inquiry-based strategies engage student-teachers

> in learning science, they have fun, share with others and develop confidence and their interest to learn science increased. (T11)

Likewise, most student-teachers reported that inquiry-based activities help student-teachers in improving their learning as reported:

> I think when we deeply understand the concepts using inquiry-based activities. I learn best science through observation and practical experiments in science that makes me active. We learn science most effectively by doing using inquiry-based activities quite. (G2-S2)

Moreover, most teacher-educators' responded that they understood that instructional strategies using inquiry would be more readily accepted by their student-teachers as these strategies would allow student-teachers to take ownership in their learning and develop their interest in science. Therefore, the majority of teacher-educators indicated their intent to use inquiry-based teaching strategies to teach science rather than teaching from the text as the latter strategy leads to student-teachers being bored and uninterested while the former strategy results in student-teachers' involvement and interest.

Furthermore, the majority of teacher-educators were of the view that inquiry-based teaching involves student-teachers in learning science by raising their curiosity. Inquiry, therefore, helps student-teachers achieve understanding in science though they use inquiry-based instructional strategies very little. They appreciate all benefits when inquiry is practiced in science courses as T4 further responded:

> Inquiry-based methods raise curiosities that help student-teachers learn deeper. (T4)

It is notable from teacher-educators' responses that inquiry includes those activities through which student-teachers are actively involved in learning. Also, teacher-educators reflected that inquiry-based pedagogy is one of those methods that make themselves the best learner. In addition, some teachers believe that inquiry makes learning attractive using colours and visuals. Moreover, some teacher-educators were of the opinion that almost all student-teachers learn using visuals. When they watch things being demonstrated to them, they understand profoundly as reported:

> I think student-teachers learn best when they see things visually. Visual-aids are best source of learning. Also they learn deeply when they reflect, share their ideas in solving a problem. Inquiry-methods use hands-on activities with help of visual aids that support student-teachers' learning in science. (T9)

> Some teacher-educators mentioned that colours and visuals are things that attract pupils, and are fun when learning. Student-teachers learn best using visual-aid so inquiry involves these methods as reported:

> I use audio and visual aids in my class in my daily lessons. I think science student-teachers learn authentically using visuals. They remember colours and they take interests in learning. I demonstrate diagrams using projectors. I also ask student-teacher to draw diagrams so they are involved through these activities. (T13)

Thus, the above responses indicate teacher-educators' understanding of the importance of getting student-teachers interested in science through inquiry-based pedagogy. Teacher-educators' reflections about the importance of learning science through inquiry into a natural environment where their minds can freely observe, explore and develop explanations for natural phenomena (e.g. the woods) as articulated below:

> When student-teachers watch how science happens and take part in scientific investigation then they understand deeply. They explore freely in the field through inquiry-based pedagogy. (T13)

A similar view arose from the focus groups that most student-teachers reported that inquiry-based learning involves student-teachers in learning process in class. Student-teachers felt that inquiry was beneficial because it makes them investigate and experiment as reported:

> I think I learn best when I explore science myself. Inquiry-based methods are ways to explore science through investigating and experimenting. So it is always interesting when I do experiments especially field work such as zoo trips. (G1-S2)

Moreover, the majority of teacher-educators strongly appreciated the role of inquiry in student-teachers' learning as reported:

> As our teacher education program aimed at training student-teachers as future science educators, I believe when student-teachers learn using inquiry-based pedagogy then they themselves got idea how to teach science effectively. (T9)

Thus, the above response indicated that the inquiry-based approach to teaching is an active and creative way. Additionally, the majority of teacher-educators reported that inquiry is the method of teaching that helps student-teachers develop their abilities and improve their skills so that student-teachers could exhibit positive attitudes toward science as said:

> My student-teachers will get the opportunity to show what they have {prior knowledge} and most likely able to take ownership of their own learning experiences. (T10)

Thus, most teacher-educators and student-teachers were strongly positive that inquiry-based activities were important in exposing student-teachers' learning in the sense that weaknesses in understanding were more apparent. Specifically, student-teachers were engaged by scientifically-oriented questions, learned to give priority to evidence which they used to develop explanation of the science phenomenon they were observing, and

were required to report their findings in terms of what they had learned.

Similarly, student-teachers credited the preparation of inquiry-based lesson plans they were required to prepare with inculcating a comfort and desire in them learning science through inquiry. They reported that inquiry-based lesson brought them the realization of how much science can be interesting in using inquiry-based pedagogy. However, they were used to rote the information as said:

> In inquiry-based sessions, I realize that how much more interesting and fun in science can be if inquiry-based instructional strategies are used rather than lecturing and memorising of text for examination. (G2-S3)

Likewise, another student reported:

> Using inquiry, we learn with an encouragement that we are facilitated and get a chance to explore rather than pushes toward rote learning. (G2-S1)

Thus, the majority of teacher-educators and student-teachers concurrently had positive attitudes towards inquiry-based pedagogy in that it helps improving learning in science. Likewise, student-teachers started understanding the benefits of using inquiry-based pedagogy in their learning of science as articulated:

> I believe that inquiry is very beneficial in science. So we do not learn not only what text means rather, we enhance our understanding. (G1-S4)

In sum, teachers and student-teachers' responses showed a great consistency on their understanding about the process of inquiry, the abilities necessary to do inquiry, the fundamental concepts about inquiry.

7.2.3 Perceptions on the Contribution of Science Method Course in developing Inquiry-based Pedagogy

Teachers and student-teachers in my sample showed interest in learning from the Science Teaching method course. The majority of teacher-educators and student-teachers reported that teaching of science courses or science teaching methods courses (at University of X) have an important role in developing their understanding of inquiry-based pedagogy. The majority of teacher-educators reported that their teaching experiences were strong enough to develop them into effective teachers of science but they learned more about inquiry when they taught teaching science method course. This is illustrated by their responses below on teachers' views on the contribution of science methods course in teaching

science and they have been learning a range of approaches as reported:

> Teaching science method courses helped me to know a range of teaching approaches. *(*T2)

Regarding the influence of science methods course, it is helping teacher-educators on how to teach science through inquiry. Thus, science methods course contributed well to inquiry-based pedagogy.

> I have taught teaching methods of science courses. Our student-teachers enjoy this course and they learn a range of teaching skills how they perceive the teaching methods they could use it in their future teaching using inquiry-based methods. (T17)

Moreover, teacher-educators' reflections indicated that they were exposed to different instructional strategies through science teaching method course that helped them understand inquiry such as: the use of inquiry-based activities to develop student-teacher abilities to conduct inquiries, use of questions to trigger student-teachers' questions and further investigations as reported:

> I think when I taught teaching method course, I learned about the process of inquiry method of teaching how inquiry-based teaching works out. I learned a range of activities that I could use with student-teachers; science questions about prior knowledge, guided and unguided science problems, etc. (T12)

Although, the majority of science teacher-educators' responses indicated that even though inquiry-based instruction had been used in some of their previous science courses, they had realized that inquiry was an important instructional tool for teaching science as reported:

> I use inquiry-based methods very less though I believe that making such inquiries to student-teachers is important because student-teachers get a deeper understanding of science concepts. (T2)

Most student-teachers in the two focus groups presented similar views on the contribution of science method course in developing their understanding of inquiry-based pedagogy. The student-teachers reported that science teaching methods course/s they studied at university influenced their views about their understanding of inquiry-based pedagogy. The majority of student-teachers reported that the contribution of science methods course provided good exposure in understanding the process of inquiry-based pedagogy as reported:

> I think this teaching method course has been helpful to let us know about a range of teaching methods of science generally and how to teach science effectively by

> involving student-teachers, collaborations and developing their thinking to explore science. (G1-S4)

Thus, teacher-educators started developing connections to the use of inquiry to teaching and learning science their teaching experiences. Also, the majority of teacher-educators reported that preparation of inquiry-based lesson plans when they taught teaching method courses helped them to develop their own pedagogy; also they learned how to teach science using inquiry-based approaches reported below:

> Inquiry-based lesson plans in teaching method course helped me developing pedagogical knowledge as well as enhanced my knowledge on a range of teaching approaches. (T2)

Also, their personal concept of pedagogy developed as they were exposed to the teaching strategies exhibited in the science methods course. Also, not only did student-teachers receive good exposure to inquiry-based science pedagogy from the science methods course, this exposure helped them start formulating their own pedagogical strategies for teaching science.

> I develop my concepts what an effective teaching method should be taught when I was exposed to the teaching strategies exhibited in the science methods course. I understand how learning happens in student-teachers through activities. This course helped me formulating my own pedagogical strategies. (G2-S2)

It can be noted that there was concurrence among the teacher-educators and student-teachers that teaching science methods course importantly developed an understanding to teach science using inquiry-based strategies. Also, student-teachers' reflections indicated that they were exposed to different instructional strategies that helped them understand inquiry through science teaching method course such as: the use of inquiry-based activities to develop their abilities to conduct inquiries and the use of science-oriented questions to activate further investigations. Thus, data from interview and focus groups supported that an extensive exposure was received to inquiry-based pedagogy through the science methods course; however, teachers and student-teachers have had a little exposure to inquiry in their science courses.

7.2.3.1 Student-teachers' Engagement in Learning Science

The majority of teachers reported that student-teachers' involvement is high in inquiry-based method. Thus, they thought that inquiry develops a deep interest in science, for example, one responded:

> Inquiry-based strategies engage student-teachers in learning science, they have fun, share with others and develop their interest to learn science increased. (T11)

As well to teacher educators, the majority of the student-teachers reported their intention to use inquiry, as being anxious about using inquiry-based instruction initially i.e. student-teachers understood the importance of inquiry for bringing about sustained interest in learning science, for keeping student-teachers interested in science and for making science fun.

> Using inquiry, we were initially anxious in responding inquiry-based activities though we developed interest with passage of time. (G1-S3)

Also, student-teachers realised that making science fun and interesting through inquiry-based instructions as reported:

> Inquiry-based methods make us having fun that makes science interesting. This is really exciting and engages them in understanding science problems. (G1-S4)

Thus, it can be noted from the above comments that these student-teachers were acknowledging that science as a subject is boring, but articulating their understanding that inquiry-based pedagogy as a method of teaching that make science learning fun and interesting to them. Also, the majority of student-teachers' responses indicated that as they started developing understanding of inquiry, they had fun; their involvement helped them overcome their apprehension about using inquiry as another reported:

> I really enjoy my experiences when I am involved in fieldwork. (G2-S3)

Moreover, most student-teachers reported that inquiry-based pedagogy in science helps learning sciences in initial Science Teacher Education. One of the reasons student-teachers gave for using inquiry-based instruction to teach science in their own classroom was that they had had a little experience with inquiry-based instruction though it made them realize its importance for making science fun and enjoyable for their student-teachers as reported:

> It is commonly believed that science student-teachers are mostly book-worms so they do not participate in co-curricular activities; also they are not confident and not interactive. I think that inquiry involves learner so they participate in talks and share their ideas. So we have fun in learning in inquiry methods. (G1-S1)

Thus, teacher-educators' and student-teachers' responses indicated that student-teachers do not only understand the fundamental concepts of what constitutes inquiry; their growing interest in learning science also drew connections to the use of inquiry in other fields. Specifically, they understood that inquiry-based pedagogy helps develop and sustain student-teachers' interest in science, develops attitudes towards science and develops confidence in student-teachers to do science.

7.2.4 Perceptions of Inquiry in Developing Science Literacy

From questionnaires and interview data, teacher-educators' and studies responses indicated that they have been exposed to open ended inquiry-based pedagogies little though they appreciated value of inquiry in developing science literacy among teachers and as well as student-teachers. Teacher-educators' responses to different categories from interviews were noted as follows:

	Categories	Responses Evident in
1	Understanding science in real life is important	20
2	Inquiry-based pedagogy develop science literacy	20
3	Exploring science enhance deep learning of science	15
4	Inquiry deepens their knowledge more than text book	10

Table 7.2: Categories on teacher-educators' views on science literacy

The table indicated that all (100%) teacher-educators were of the opinion that science is very important in real life. They also reported that there is a connection between Inquiry-based pedagogical strategies and student-teachers' vision to understand science phenomena in their real life situations as reported below:

> Science literacy is the understanding of the application as well as the contribution of science in society. Inquiry helps in developing student-teachers' thinking and attitudes to science. So inquiry pays an important role in promoting science literacy. (T19)

In addition, the majority of student-teachers in the focus groups expressed similar views that inquiry helps in developing science literacy. Most student-teachers presented their understanding of science literacy and they understand science literacy and science application in real life situations as reported below:

> Inquiry-based activities help us in understanding the science processes and products and tell us how important science plays a role in our daily life as well as useful for society. (G1-S4)

Thus, the above response indicates that student-teachers investigate science through experiments and understand scientific application in their daily life. Teacher-educators appreciated a link between inquiry-based strategies and science literacy among student-teachers. The majority of teachers believe that exploring science enhances deep learning of science as reported:

> The importance of inquiry in developing science literacy is very obvious. More inquiry-based activities develop science literacy and motivate students to explore science because student-teachers develop deep learning and understand the usefulness of science in their daily lives. (T10)

Another teacher-educator' response is as follows:

> I believe that inquiry-based pedagogy and science literacy are integral in supporting each other. (T3)

Likewise, the majority of teacher-educators and student-teachers reported their positive attitude towards inquiry-based instructional activities regarding a connection between inquiry and science literacy. They reflected their views that inquiry-based strategies used in class motivate them to think about science application in their life and in their personal use. While they think that inquiry-based pedagogy may enhance science literacy, there is little evidence that this is so.

Likewise, T10 maintained that inquiry-based pedagogies include many activities that motivate student-teachers to read rather memorise text from books as reported:

> Inquiry-based methods play a worthy role to be science literate. When I set student-teachers problem in biology, I encourage them to read books, articles to look at the recent research using internet; also readings develop thinking and overcome superstitions; develop a scientific attitude. (T10)

Thus, all of the teacher-educators understood how student-teachers deepen their understanding of science phenomena using inquiry-based activities. Moreover, the majority of teacher-educators stated that inquiry-based instructional strategies develop literacy practices that have not been developing in student-teachers using text-based curriculum. It can be noted a concern that their apprehensions of text books do not develop scientific attitude in student-teachers as reported:

> I think inquiry-based pedagogy develops literacy more than only receiving subject knowledge from books. (T17)

Likewise to the comments from teacher-educator, student-teachers' appreciation of how inquiry-based pedagogy can make learning science more interesting for the student-teachers than learning from the text:

> Inquiry-based instructional strategies include all the components develop our understating of science and applicability of science through our observation in daily life experiments. We seek solution of problem that we cannot by knowing only books. Using inquiry, we construct ideas to explore solution of science problem. Thus, inquiry develops a literacy of science so I feel inquiry and science literacy are strongly connected to each other. (G1-S3)

Hence, teachers and student-teachers responses pinpointed that inquiry is a method that enables them to think scientifically in a way that could not be a product of memorising books and subject knowledge. In addition, the majority of teacher-educators perceived that inquiry-based activities help them in building concepts and clarifies the science terminologies so student-teachers learn the science concepts meaningfully. T4 narrated a story of science illiteracy through an example, he said:

> I recall a story with my family members…my younger brother is a graduate in computing. One day, he was talking to me in Urdu and was telling me that a rose was eaten by Deemak [Dermite]. In fact, he wanted to say Deemak in Urdu but did not have the required linguistic knowledge close the word…so he did not have true understanding of the process and terminology. Science literacy should have developed using inquiry-based activities. Student-teachers are supposed to have a deep understanding of science phenomena and terminology. (T4)

Also, some teacher-educators identified constraints in developing science literacy regarding the curriculum as reported:

> Using inquiry-based activities, student-teachers explore science phenomena so know how they use in daily life. Unfortunately, teachers and student-teachers do not read widely. They only rote the curriculum offered to them. (T16)

Thus, teacher-educators' responses indicated that inquiry-based pedagogy helps in developing awareness of science in student-teachers' real-life experiences. They emphasised that student-teachers should be encouraged to be science literate people and not only the seekers of knowledge.

7.2.4.1 Inquiry Develops the Public Understanding

Data indicated that the majority of female teacher-educators highlighted that female student-teachers' awareness was an important factor that has been prominently developed using inquiries. Teacher-educators reported their apprehensions that student-teachers think superficially because of their myths about those things happen scientifically but they are not unaware of scientific phenomena. Teacher-educators appreciated the role of inquiry-based pedagogy that helped them to develop an authentic understanding of science and make them avoid thinking superficially as reported:

> Our student-teachers are only prepared to recall information and sometimes have unrealistic ideas regarding science. I have experienced many occasions where girls misunderstood appliances of science. They neither think scientifically nor have scientific attitude. For example, when exams are near, a couple of girls became faint due to stress. I had to call their parents so that they could take their daughters back home. They had unrealistic thoughts (like being afraid of spells) and refused to bring their daughters back to the hostel. (T12)

Thus, above response indicate that scientific literacy was the real understanding of the phenomena of daily life. Also, student-teachers could avoid thinking of their life matters superficially and develop scientific thinking as well as scientific attitudes towards the application of science. Teacher-educators said that student-teachers should be encouraged

to read extensively and to watch informative programmes and channels. Teacher-educators feel that particularly female student-teachers' thinking should be developed positively and scientifically, and then they could bring up the future generation in a better educated way.

In addition, the majority of female teacher-educators reported that inquiry develops scientific attitude and thinking in educating female student-teachers. Besides this, females were more likely confined to household affairs than men in Pakistani culture so they essentially should have true knowledge of science and its application in real life situations.

> Female are in majority in our class. Our females should be trained with a scientific understanding as they are supposed to perform a big role. I believe inquiry helps in promoting a better science educated female cohort in ITE. (T10)

Thus, the above responses indicated the teacher-educators' understandings of inquiry in science was not only restricted to experimentation but also connected to developing them a scientific literate person. Most of the student-teachers' reflections in the focus groups pointed out that inquiry-based pedagogies help them develop scientific literacy.

7.3 Perceptions of Challenges to Inquiry-Based Pedagogy

Teachers and student-teachers reported that they encountered several challenges when inquiry is practiced. They also reported some difficulties when they intended to do inquiry but these difficulties hinder them planning and preparing inquiry-based methods. These categories further assertion:

Theme 1: Challenges of resources

- Lack of facilities in class and laboratories
- Insufficient time

Theme 2: Challenges with the university system

- Lack of university support
- Teaching Load
- Curriculum does not support inquiry
- Assessment and inquiry-based approaches
- Lack of teachers' autonomy

Theme 3: Challenges with professional development

- Teacher lack of preparation using Inquiry-based pedagogy
- Student-teachers lack of Motivation and Willingness

Theme 1: Challenges of resources

7.3.1.1 Lack of Facilities in Classroom and Laboratories

The majority of teacher-educators reported that lack of resources hinders the practice of inquiry-based activities. They also reported that they use less inquiry-based activities because of the lack of resources. The teachers agreed with one reason that there was lack of resources and they cannot involve student-teachers in a wider array of activities as articulated:

> I think that no teaching and learning could happen without resources. Firstly, we need trained staff in using inquiry-based pedagogy in science and secondly laboratory equipment. (T8)

Another said:

> Due to the lack of resources, I only do inquiry-based activities such as questions, and group discussions where I do not need material in classroom. (T15)

The majority of teacher-educators' responses indicated that they always depend on the availability of resources in lab or in their science class when they intend to use inquiry-based instructional strategies. They had problems due to lack of laboratory equipment since they have been teaching in university. Another teacher reported:

> The problem of shortage of electricity is faced by all over the country makes teacher-educators relaxed in their teaching. Because we need resources and audio-visual aids those depend on electric power that should be available. (T14)

Similarly, student-teachers responded that lack of resources was a major problem that is why they were taught a little how to develop inquiry-based strategies for learning and teaching science through inquiry:

> Firstly, we do not have laboratories equipped sufficiently to do inquiry- based in each session. Secondly, if we have resources those are not properly used. Thirdly, it seems teachers are not trained in using recourses even if they have. (G1-S2)

Teachers and student-teachers were concurrent on their views on lack of resources. They also agreed that the available resources are not sufficient in using inquiry-based learning. Nonetheless, some teacher-educators reported that effective inquiry-based strategies could be planned without being dependent on resources:

> The resources are important but not desperately important in our science class. You cannot pamper student-teachers with equipment for a scientific class without inculcating a clear understanding of the scientific procedure. (T5)

Most teacher-educators reported their apprehension that they are disappointed by insufficient resources particularly when they intend to use inquiry-based instructional strategies. Therefore, they adopted the ways they could involve student-teachers in inquiry-based activities but with a little use of resources as reported below:

> I think the sufficient resources provide a better environment to learn science investigation. (T1)

Thus, teacher-educators responses indicated that student-teachers' learning always do not depend only on the availability of resource but through other activities. So that student-teachers could be engaged in learning science through science problems. Some teacher-educators responded that importance of resources is not vital and they could teach using inquiry-based activities as reported:

> Science could be taught better with inquiry-based activities rather than providing too many resources. We have not sufficient funds for advanced laboratories. (T2)

7.3.1.2 Insufficient Time and Inquiry-based Pedagogy

Similar to the questionnaire data, interview data provided a richer insight to teachers' and student-teachers' views that the majority of teacher-educators and student-teachers reported the shortage of time as a serious barrier; also a big challenge when inquiry-based methods are practised as reported:

> I think the biggest problem for me is a lack of time. As having short of time, I felt nervous to manage a lesson when student-teachers were not prepared to use inquiry in class. But gradually student-teachers started responding to how inquiry-base teaching works out. We better need to spend plenty of time with our student-teachers. (T2)

Another teacher-educator reported:

> I always feel that I don't have enough time to complete curriculum. Student-teachers sit in internal and external exams so courses must be completed on time. (T15)

Student-teachers likewise reflected their worries about the increased time it would take to develop inquiry-based lessons as articulated below:

> I believe that teachers require more time to prepare their sessions and it seems impossible with too lengthy curriculum. (G1-S3)

The majority of student-teachers from focus groups were of the same view. They reflected their apprehensions about whether teachers would have enough teaching time to teach science through inquiry in the current set-up in ITE.

> Our teachers are pushed to lectures than inquiry-based activities because time is too short with lengthy curriculum. (G2-S2)

Consequently, teachers' over-loaded work makes them busier and time seems too short. Thus, teacher-educators' and student-teachers' views are concurrent that they struggle hard to manage their lesson in time. Time is a problem because teachers convey the entire lesson to student-teachers in the given time and not make student-teachers' independent learner and do not assign student-teachers task to read them.

> Theme 2: Challenges with the University System
>
> 7.3.2.1 Lack of University Support in adopting Inquiry

Lack of university support is another serious challenge reported by the majority of teacher-educators. They presented their apprehension about the lack of university support that hinders if they intend to use inquiry-based methods as reported:

> The biggest hurdle is lack of support from university. (T7)

The majority of teacher-educators reported that lack of support from university seems a big

hurdle in their teaching, as reported by the response below:

> The university did not set an environment to support teachers to decide on how they plan to teach. It seems that student-teachers' learning is not their priority. (T19)

Furthermore, the majority of teacher-educators reflected their unhappiness about the lack of university support currently, which has been a big hindrance to inquiry-based pedagogy. They mentioned that it seems that inquiry-based pedagogy has been problematic in the current circumstances as reported below:

> Overall infrastructure in our education system is in chaos. Also, there is no focus on teaching method, or how student-teachers learn. (T3)

Similarly, some student-teachers expressed anxiety about using inquiry form of instructional strategies in their teaching practice during their school placements because they feared lack of support from the university to implement inquiry-based instruction. It might be hard for the student-teachers to implement inquiry-based instructional strategies in their classrooms given the current set-up of the university as there seems no university support as reported:

> University does not help in adopting inquiry-based activities. If the science teachers use inquiry-based approaches that is their own choice or decision. Inquiry-based approaches are not encouraged by university. (G2-S3)

Thus, teachers and student-teachers agreed that lack of university support in implementing inquiry has resulted into lack of teachers' readiness and motivation to use inquiry.

7.3.2.2 Teaching Load

Additional to questionnaire data on the details of the barriers in implementing inquiry, a high teaching load is also reported as another constraint by teachers. Some teacher-educators reported that they are highly involved in administrative responsibilities at the university rather than solely in teaching. These responsibilities are part of job without any incentives. Overloaded with work make them less motivated to prepare inquiry-based activities as said:

> I am over burdened and have no time to prepare inquiry-based lessons. I am an exam controller and also a member of many committees; this makes me unfocussed what to do. Therefore, I do not prepare for inquiry-based methods. (T19)

Student-teachers pinpointed another point that reported that junior teachers seem working harder than senior teachers even though young teachers have excessive teaching load as reported:

> Young teachers seem to work hard and teach more effectively than older. Young seems used inquiry-based teaching, though elderly teachers lecture. (G1-S1)

Thus, teachers and student-teachers responses indicated that teaching load also hindered their efficiency in using inquiry-based pedagogies and junior teachers seem more proactive in using inquiry-based pedagogy.

7.3.2.3 Curriculum Development to Support Inquiry

Teacher-educators' and student-teachers' reflection provided a deeper insight on questionnaire data that the current curriculum does not support inquiry-based methods to be used. One of the key take-away messages is that teacher-educators' intentions was to rely less heavily on text but more heavily on student-centred learning. The majority of teacher-educators were of the opinion that current science courses are very textual and lengthy. Indeed, science is presented as a knowledge-based subject to them as articulated:

> The science curriculum is text-based and too lengthy. It offers inquiry based activities very little. For example, curriculum of Chemistry does not present Chemistry to be taught using inquiry. (T18)

The majority of teacher-educators reported that curriculum do not support using inquiry-based instructional activities. This is one of the reasons makes teacher-educators avoid inquiry-based pedagogy as reported:

> Curriculum does not support inquiry-based pedagogy. (T19)

Thus, teacher-educators' responses indicated that inquiry-based pedagogy was a better approach in bringing about student-teachers' understanding of science concepts than memorize concepts as this form of instruction helps student-teachers build on what they already know and thus sustains their knowledge as said:

> When I engage student-teachers in inquiry-based activities then I feel a support from inquiry to get rid of text. Student-teachers learn, understand the main ideas of science. (T2)

Thus, the key reasons given by the teacher-educators for using inquiry-based pedagogy were that it would help them get away from dependency on the text and student-teachers understand the key ideas of science deeply using inquiry. Also, the majority of teacher-educators emphasised the revision of science curricula in order to make connection with inquiry-based instructional strategies. Also, their apprehended whether the curriculum is inquiry-based that science curriculum used might be unstructured and not such effective as said:

> Currently, most of science curriculum involves lengthy and substantial knowledge. I am afraid that inquiry-based curriculum could be employed hardly. May be the learner might not benefit as much as it would be expected. (T18)

Also reported by T3:

> Too length curriculum made "confused" teachers and student-teachers with loads of substantial texts. Firstly, I think inquiry-based teaching needs to be revised. Secondly, I think teacher-educators should be trained to use inquiry. (T3)

Also, the majority of teacher-educators stated that curriculum being inquiry-based might be demanding. So teacher-educator should be trained to use inquiry-based strategies as reported:

> If the curriculum be changed then our educators should be trained to use inquiry otherwise inquiry-based curriculum will still not so benefit. (T4)

Likewise, the majority of student-teachers reported the same voice of apprehension about curriculum. The majority of student-teachers reported that they were used to memorise text rather than involved in inquiry-based curricula.

> Student-teachers appreciate that teachers-prepared notes help them to pass exams. Therefore, using inquiry, student-teachers do not benefit. (G1-S3)

Thus, teacher-educators responded having a little experience to do inquiry-based activities because curriculum do not support in using inquiry. Furthermore, the majority of teacher-educators reported a connection between lengthy text-based curriculum and shortage of time, which is the reason using lecture method not inquiry-based method:

> Curriculum is too lengthy for too short time and has ample information. So we have no an alternative but to lecture. (T18)

Thus, most teacher-educators' responses indicated that curriculum is an unhappy aspect because of lack of time and incentives if they do struggle to plan inquiry-based lessons. Most educators feel that is an easier job to do lectures rather than using inquiry-based lesson.

Thus, teacher-educators and student-teachers reported problems regarding structure of the curriculum. Firstly, lengthy curriculum does not motivate teacher-educators to use inquiry-based strategies. Secondly, science curriculum is not specifically designed for inquiry-based pedagogy. Thirdly, there is no autonomy of teacher-educator to arrange inquiry-based session. Fourth, teacher-educators wanted to do inquiry-base lessons then they had other constraints with time management, and lack of resources so the problem is still there (e.g. Mohammed, 2008). Teacher-educators were not awarded with any incentives rather they may be accused as fail to complete the course on time.

7.3.2.4 Examination and Inquiry-based Assessment

The majority of teacher-educators' and student-teachers' responses from interviews show similarities in perceptions about inquiry-based assessment. Similar to questionnaire data, all teacher-educators indicated their apprehension about the examination that assesses how student-teachers are good in recalling. Teachers think that learning is not assessed through exams as reported below:

> Our entire assessment is summative using exam and student-teachers are not assessed for their learning. (T3)

Though inquiry-based assessment is not used, teacher-educator's responded that inquiry based assess could be a chance in their student-teachers' deep learning than rote learning.

> Inquiry-based assessment is a way to assess student-teachers' learning and inquiry-based skills. I therefore suggest that inquiry should be encouraged. (T14)

Likewise, the majority of student-teachers reported their apprehensions about assessment that they are not assessed entirely or sufficiently to achieve learning outcome using inquiry. One of the key reasons given by the student-teachers to avoid inquiry-based pedagogy was that exam and curriculum would not help them get away from dependency on memorising text as reported:

> Curriculum offers a lot of information to recall and memorise. Examinations test memory and do not assess learning. (G2-S1)

Thus, teachers and students do not come across any connection between inquiry-based pedagogy and current assessment methods used in ITE. Even the majority of student-teachers feel easy in memorising information and sitting in examinations. Therefore, alternation in examination into inquiry-based assessment could bring teachers and students more in using inquiry-based leaning. Most teacher-educators feel that teacher would not be willing to assess using inquiry-based assessment as said:

> It seems teachers want to get rid of hard work in asessment. If they are to assess using inquiry, I am afraid that teachers will leave this task up to student-teachers. (T20)

Similarly, G1-S4 highlighted their apprehensions:

> Additionally, our assessment method tightly binds us with examinations and we have very little chance in getting involved using inquiry-based assessment. (G1-S4)

Also, some student-teachers stated that the role of teacher should be independent and autonomous in handling how inquiry works out with curriculum.

> Curriculum should include inquiry-based and problem-based activities. Some specific chapters should be restructured to include inquiry-based activities. (T15)

In sum, teacher-educators' and student-teachers' responses indicated that though, teacher-educators apreciate the role of inquiry in assessing student-teachers' learning, they do not find themselevs automonus in inqiury-based assessment and also are not willing using inquiry-based assesmment.

7.3.2.5 Teacher' Lack of Autonomy in Adopting Inquiry-based Pedagogy

The majority of teacher-educators' responses indicated that they have no freedom and autonomy in choosing the method teaching in classroom in their practices in ITE. Furthermore, the choice of adopting an approach to teach is influenced by university culture and custom how other teachers teach and curriculum and method of assessment as reported:

> The teacher's task in this university is to lecture student-teachers. I am not independent enough to chose inquiry-based method myself. The biggest hurdles are curriculum and assessment; these are set by the top authority of university not the working lecturers. (T2)

Likewise, T6 reported:

> I am neither autonomous in choosing my teaching nor I cannot develop questions to assess to student-teachers' performance. The exam pattern is set. I am instructed to do so. In such a situation, I do not feel motivation to adopt inquiry-based approaches. (T6)

Similarly, G1-S4 highlighted their apprehensions on teacher lack of autonomy:

> We can notice that our teachers are teaching as their seniors have been taught as they have a stereotype in their teaching. They do adopt any innovation in their teaching style. It seems they are not autonomous to choose method of teaching and method of assessment according to their choice. (G1-S4)

Also, some student-teachers reported that the teachers do not seem independent and self-directed in handling how inquiry works out with curriculum and examination. Another student-teacher shed light as:

> I think curriculum and examination that hinder teachers' independence to make the choice of adopting inquiry-based approaches. Teacher are to teach what are they instructed (G2-S3)

Moreover teachers were of the view that the majority of student-teachers feel easy in memorising information. Therefore, the teachers have to choose method of teaching according to student-teachers' needs and style they feel comfortable as reported:

> Another reason that teacher are not enough autonomous that student-teachers are in habit of rote learning. Lecture is well received. They feel that teacher are not going to assess them using inquiry-based assessment. That is the reason, I would not prefer teaching inquiry-base approaches in presence of all these constraints. (T15)

In conclusion, both teacher and student-teachers agreed that teacher lack in autonomy in deciding inquiry-approaches to teach if they do not achieve desire learning outcomes. Rather teachers have to face a number of problems that does not support inquiry in the current situation, such as curriculum, examination and the habits of student-teachers' rote learning.

7.3.3: Theme 3: Perceptions on lack of Teachers' Professional Development and Preparation in Adopting Inquiry-based Pedagogy

Responses to Q7 on teacher questionnaires indicated that only 16% teachers reported that they received training on inquiry-based pedagogy and 64% teachers responded that have had no training offered to them. In addition to questionnaire data, the interviews data provide a richer picture of the key issues on lack f professional development on inquiry-base approaches. Thus, teachers reflected their apprehensions being untrained how to conduct an inquiry-based lesson as reported:

> Training and refreshing courses are mandatory in implementing inquiry-based methods. It is very important to have trained teachers and specialist lab instructors in inquiry-based sessions. (T15)

Similarly, student-teacher reported those teachers are sufficiently trained to handle inquiry-based lessons because they lack training as reported:

> Our teachers are not skilled in using inquiry-based methods; they do not seem equipped with the knowledge how to conduct inquiry-based methods. So, they should be trained enough in using inquiry-based methods. (G1-S2)

Interview data indicated that the majority of teacher-educators' responses indicated that teacher-educators' lack of willingness makes them avoid using inquiry-based pedagogy and hinders in developing inquiry. Also, teacher-educators realised lack of training is the reason for their unwillingness/ eagerness in using inquiry-based pedagogy as reported:

> Teachers are neither prepared nor trained to use inquiry. It is still a concern that our teacher-educators seem not willing to use it. (T10)

In addition, T2 reported:

> I think the lack of training is also a cause of lack of motivation for teachers who actually want to use inquiry-based strategies. (T2)

Thus, the above responses indicate that teacher-educators' apprehension to use inquiry has to do with their lack of professional development to teach inquiry [they were not prepared] or their fear that they cannot manage inquiry-based lessons. Furthermore, teacher-educators reflected that use of inquiry depends upon teacher-educators' willingness and motivation as reported:

> It is up to teacher how they use inquiry-based pedagogy. (T15)

Similarly, student-teachers pointed out that they understood inquiry-based pedagogy requires them to explore on their own and learn from their experiences, though they voiced frustration with the lack of understanding the process of inquiry as said:

> Unfortunately, student-teachers are unaware the process of inquiry. We are not guided by our teachers so we feel nervous how to participate when inquiry is used. (G2-S3)

Moreover, the majority of teacher-educators feel that could reduce their apprehensions if they have proper knowledge about the process of inquiry-based pedagogy as reported:

> Teachers should understand inquiry-based process and how inquiry improves student-teachers' learning with effective trainings. (T10)

Student-teachers also reported similar apprehensions. They lack initiative how to participate in inquiry-based activities. They realised that there are other issues that might arise because student-teachers do not understand the process of inquiry. This apprehension was voiced by the student-teachers in their 1st year of their studies as reported:

> Teachers should clarify what approach she is using in class so that student-teachers get ready for that. Especially, student-teachers at their first year are not confident in using inquiry-based strategies. Student-teachers should be enough prepared to understand the process of inquiry to attain learning outcome. (G1-S1)

Moreover, the majority of student-teachers reported that teachers' willingness seems little in using inquiry-based activities.

> Teachers do seem willing to use lecture only not inquiry-based activities. They want their student-teachers to listen them. (G1-S4)

Similarly, Student-teachers mentioned that their background from school also a major reason that they are not prepared using inquiry as reported:

> I think we were not prepared using inquiry-based teaching from our school education. Though, inquiry-based teaching seems impracticable currently. (G1-S4)

For these student-teachers, the anxiety was caused by the realization that teaching science through inquiry might raise questions from student-teachers which they might not be able to answer. Although the teacher-educators claimed they encouraged the use of questions with their students, in practice they tended to discourage too many questions because of this anxiety. Moreover, the student-teachers were insecure by the practices of their teacher in teaching science. Though inquiry-based methods present several challenges to student-teachers, student-teachers realised that is most important method to meet standard of science education. Teacher-educators also responded that student-teachers are not prepared enough to use inquiry-based instructional strategies as reported:

> Most student-teachers do not participate in activities. They seem afraid of initiating in participation in inquiry-based activities. (T15)

Another teacher reported that a range of activities could be used to reduce the apprehensions about inquiry based activities, for example: student-teachers could be given an assignment to explore a scientific problem according to their interest.

In addition, the majority of teacher-educators reported that the student-teachers' background in science and prerequisite qualification was not sufficient enough to support inquiry-based instructional strategies, as outlined by the response:

> I think our student-teachers are good enough to work hard but they are lacking initiative skills to participate in inquiry-based pedagogy and are not prepared to use inquiry. Firstly, they do not understand the procedure of inquiry-based strategies; secondly they have not enough confidence to take part in inquiry-base activities. (T14)

Teacher-educators 3, 7 and 19 were of the similar views. Also, data found that the lack of student-teachers' pre-requisite knowledge in science was the most frustrating aspect of teaching science using inquiry-based instructional approach. Thus, the feeling of uncertainty about teacher-educators' own ability to teach science is not unusual, given the fact that teacher-educators were moving away from the protected environment of their science course where they would have to implement inquiry-based strategies themselves. Though, some teacher-educators reported that they cannot use inquiry-based pedagogy much until student-teachers understand the process of inquiry and feel comfortable using inquiry as reported:

> When I use inquiry properly then my student-teachers do not immediately accept this method or become confused soon because student-teachers are not used to do it. (T3)

Also, teacher-educators stated that student-teachers had not been equipped with sufficient inquiry-based experiences in their primary and high school education. Also, they reported that student-teachers get frustrated with inquiry-based experiences initially because they were not prepared for inquiry-based activities as reported:

> Most student-teachers come from public schools where their social and thinking skills are not developed. They do not seem prepared for inquiry-based activities; but they gradually start developing their interests in taking part in inquiry. (T10)

Also, student-teachers are of the same view as teachers that inquiry is hard to apply as reported:

> We got used to lecture methods and also big classes minimise student-teachers' questions. (G2-S3)

Teacher-educators' responses indicated several difficulties related to the use of inquiry-based pedagogy, supposed to be used in current infrastructure (e.g. Ali, 2008; Mammon, 2010; PRIMAS, 2010).

It can be noted from teachers' and students' perceptions that their understanding of inquiry-based pedagogies depends on their readiness to use inquiry. Most teachers use inquiry if they want to use inquiry despite all the constraints from those discouraging using inquiry. From the questionnaires and interview data, the diagram below depicts the teacher-educators' and student-teachers' perceptions on their preparation to use inquiry and their involvement using inquiry-based pedagogy. This diagram shows that teacher-educators with positive perception of inquiry are likely to better prepare/involve inquiry-based lessons than those of the teacher-educators with less positive perceptions.

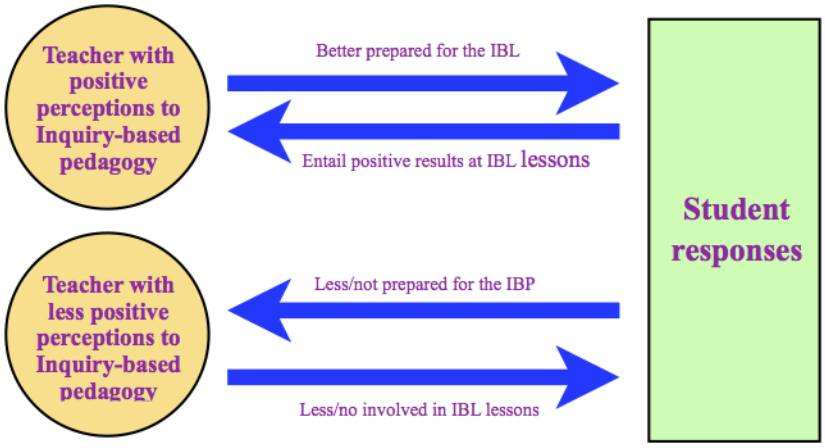


Figure 7.3: Student-teachers Responses to Teachers using IBL

In conclusion, the majority of teacher-educators are of the view that their preparation of inquiry-based activities is important to develop their understanding of the process of inquiry-based pedagogy. However, both teachers and student-teachers agreed that their academic background and their own schooling did not prepare them for inquiry-based methods. Most teacher-educators have been studied in conventional teaching method by their teacher, for example, lecture method only. Therefore, they are likely to teach the similar way they were taught (e.g. Mohammed, 2006; Abbas, 2010). Therefore, teacher-educators and student-teachers found it hard to make transitions between inquiry-based strategies and their own traditional teaching style.

7.4 Findings Summary

The questionnaires and interviews used in this study attempted to measure teachers' and student-teachers responses' to five main themes, i.e.:

1. Perceptions of the fundamental elements of inquiry-based approaches
2. Perceptions of inquiry-based in developing learning
3. Perceptions of the contribution of the science method course in developing inquiry
4. Perceptions of inquiry in developing science literacy
5. Challenges in adopting inquiry-based approaches

Additionally, interview data has been linked to further illustrative insights into the questionnaire data. A comparison of the responses of the teachers and student-teachers seems to show a high level of consistency in their responses. So, teacher-educators and student-teachers strongly agree in their responses from questionnaires and also agree in their responses from their interviews.

It appears from the data that the majority of teacher-educators and student-teachers who reported positive attitudes in teaching science also agreed with the positive views of using inquiry-based pedagogy in ITE. The aim of inquiry-based pedagogy in ITE is to develop science teachers at the University of X. This is because the university most importantly prepares student-teachers as prospective teachers. Therefore, most student-teachers join the teacher education programme in order to become future teachers. For that reason, ITE programmes are highly popular among student-teachers in preference to other science education programmes at the University of X. It also becomes apparent that teacher-educators and student-teachers alike understood the two key dimensions of inquiry-based pedagogy: an understanding of the fundamental elements required to conduct inquiry, and

the key concepts of inquiry-based pedagogy in science. Teacher-educators and student-teachers reported their understanding of the fundamental elements of inquiry as they often used science questions, group discussions, and teacher-led or guided science investigations in their science classroom.

It should, however, be noted that the student-teachers have been exposed only to structured science questions or questions about their previous knowledge and guided/teacher-led inquiries. Therefore, the majority of teacher-educators and student-teachers expressed that the main outcome of inquiry is science subject knowledge and understanding of the key ideas of science. Inquiry-based learning enables student-teachers to take ownership of their learning during scientific investigations and in turn, student-teachers value inquiry in developing their understanding of science concepts.

The majority of teacher-educators and student-teachers perceived inquiry as being beneficial in improving their learning of science. Student-teachers tend to enjoy science as a subject and they also indicated that enjoyed solving open-ended science problems. Inquiry-based teaching strategies used in science courses moved them from a dependency on teaching from the text towards using inquiry-based approaches in science.

Inquiry-based pedagogy in science was appreciated in encouraging critical thinking. This is because text/content knowledge does not necessarily let student-teachers develop their thinking skills rather promoting their rote memorisation. Also, the majority of the teacher-educators and student-teachers who reported that they believed that inquiry-based pedagogies develop scientific literacy in student-teachers and the teachers would like to see the library and the internet involved in science teaching. Also, inquiry-based pedagogy is perceived as being essential in developing procedural understanding in scientific investigation.

Teacher-educators and student-teachers reported that learning science through inquiry, which can be frustrating at first with a lack of experience using inquiry, builds as student-teachers gradually develop an interest in inquiry-based activities which later gives them an appreciation of the value of inquiry-based strategies. Also, most teacher-educators were of the view that inquiry-based approaches in science were helpful in keeping student-teachers involved, interested, confident, and responsible in learning science.

Nonetheless, teacher-educators and student-teachers intended to use inquiry-based instruction to teach science, lengthy curriculum constraints, time constraints and a perceived lack of support from the University were reported as the serious barriers.

Teachers are concerned about lacking autonomy in developing the curriculum as well as assessment strategies using inquiry-based pedagogies. Standardised examinations mostly test the ability to recall information and the responses said that it was impossible for examinations to test student-teachers for their abilities in inquiry-based skills. Lack of training and the unpreparedness of teachers in using inquiry may make them avoid inquiry as well as raising a discouraging response in student-teachers' attitudes to inquiries.

Hence, Chapter 6 has presented the teacher-educators' and student-teachers' perceptions, as captured through questionnaires. Chapter 7 has provided deeper insights into these findings and has extended (or some of them were confirmed) through the interviews. So, the findings from the quantitative data related to those seen from the qualitative data. However, this mixed method approach has yielded dividends when comparing teachers' and student-teachers' responses. For example, the majority of the teachers reported that the changing role of the teacher to a facilitator had allowed them to facilitate learning rather than to simply be subject matter experts. Nonetheless, student-teachers reported a concern that teachers used inquiry-based activities very rarely; rather, they directed their class or adopted an orthodox attitude to teaching. Although student-teachers appreciated their performance of teachers, particularly, young teachers and female teacher, they point out that that they have to face a discouraging response by teachers. Also, teachers involve them in too much written work for preparing examinations that resulted into rote learning in ITE in Pakistan.

However, the findings from interview data indicated some gaps or differences between teachers' and student-teachers' perceptions. For example, the majority of teachers reported that the changing role of the teacher towards that of a facilitator allowed them to facilitate learning rather than be subject matter experts. Nonetheless, the student-teachers reported that teachers mostly behave in a strict and orthodox manner in their science teaching. So, the gaps were highlighted by the student-teachers when they comment on the practices of teachers in class. Additionally, teachers perceive that classroom management could be a problem using inquiry methods; nevertheless, student-teachers reported that classroom management issues could be easily solved when they are engaged in inquiry-based approaches. In addition, teacher-educators want discipline during their teaching and they think that classroom management could be a problem when using inquiry methods. Nonetheless, most teachers responded that inquiry better engage students than that of traditional teaching.

7.5 Chapter 6 and 7 Summary

Chapter 6 and 7, through its analysis of the questionnaires and interviews, has revealed findings and themes as presented above. The analysis has identified the perceptions of teachers and student-teachers about the role and importance of inquiry-based pedagogy, the relationship between inquiry and science literacy and the challenges in implementing inquiry. It is found that the majority of teachers and student-teachers held positive views of inquiry-based pedagogy and of the key features of inquiry that help in developing learning of student-teachers. The findings related to views about inquiry-based pedagogy, and the existing knowledge of the teacher-educators and student-teachers, will be discussed in Chapter 8 in relation to the research questions and the literature review in Chapters 2, 3 and 4. There will also be more clarification in Chapter 8 on some of the key issues, and discussion of the findings from the questionnaires and interviews data.

Chapter 8

Discussion

8.1 Introduction

This chapter discusses the findings obtained from the study, which has focused on teacher-educators' and student-teachers' perceptions of inquiry-based pedagogy in ITE at the University of X. The results of the study, reported in the previous chapter, exposed several important points for discussion and explanation. To help guide the discussion, this chapter returns to the research questions that the study seeks to answer. It will first provide a brief summary of the results that pertain to the particular research questions, which will then be followed by an interpretation and clarification of these results, with reference to the literature review and relevant theory in the subject area.

8.2 Research question 1: How do teacher-educators perceive the role and importance of inquiry-based pedagogy in science in ITE?

As reviewed in the literature review in Chapters 2, 3 and 4 and through the data analysis and findings in Chapter 6 and 7, the teachers' and student-teachers' perceptions of inquiry and inquiry-based pedagogy have been elicited. The following is a list of themes, merged from the teacher-educators' and student-teachers' perceptions and there are also sub-themes underneath these main themes to answer RQ1 below:

Theme 1.1: Perceptions of the Fundamental Elements of Inquiry

- Questioning as a fundamental element of inquiry
- Learning in a Constructivist Environment
- Collaborations and Learning in Groups
- Inquiry-based learning and Thinking Skills
- Inquiry develops Procedural Understanding

Theme 1.2: Perceptions of Inquiry-based pedagogy in ITE in Science

- The role of teachers using Inquiry
- Learning using Inquiry-based Pedagogy

Theme 1.3: Perceptions of the Contribution of the Science Method Course in developing inquiry

- Inquiry-based Pedagogies' engagement in learning

8.2.1 Theme1.1: Perceptions of the Fundamental Elements of Inquiry

As seen in Chapter 6 and 7, the teacher-educators reported their perceptions regarding understanding the two key dimensions for inquiry-based pedagogy: their understanding of the fundamental elements to conduct inquiry, and of the main concepts about inquiry-based pedagogy in science.

8.2.1.1 Questioning as a Fundamental Element of Inquiry

As reported in Chapter 6 and 7, the most-used component of inquiry to teaching science is the use of questions on the previous knowledge and science questions by teachers, to show student-teachers how to initiate the process of inquiry. Also, class discussions and assignments were focused on the use of science questions for initiating thinking from teacher-educators. In the science classroom in ITE, teacher-educators are expected to create opportunities that promote inquiry by asking science questions that stimulate student-teachers' interest in following through with an investigation. Consistent with this vision, one of the key competencies associated with an understanding of inquiry are the questioning strategies for engaging student-teachers in scientific inquiries.

From interviews and questionnaires, teacher-educators' and student-teachers' responses indicated their understanding of science by conducting science questions, science investigations that explain scientific phenomenon and presenting the results to raise questions that could trigger more investigations into the currently held concepts. Teachers' and student-teachers' perceptions of questioning as an important and fundamental element of inquiry are consistent with the National Science Education Standards for inquiry-based pedagogy in science (National Research Council, 2000; Lee, 2004; Kuhn, 2010).

Teacher-educators and student-teachers reported their positive understanding that learners must be exposed to activities that engage them to answer science questions. The student-teachers were taught only using a little inquiry, so they expressed that they did not fully understand the process of inquiry. This finding has not been examined before this study in ITE in Pakistan. For example, student-teachers' involvement in science questions and field work to investigate science were all geared towards developing their understanding of inquiry and its value to learning science, but they have had little chance to do open inquiry-based activities in science. Though student-teachers were less exposed to inquiry-based pedagogy in ITE, they appreciated the value of inquiry-based approaches and demonstrated an understanding of the fundamental components of inquiry, consistent with those set out

in previous studies (e.g. Anderson, 2002; Newman et al., 2004: Abell et al., 2001).

Thus, inquiry is mainly used in the form of questions; answering science questions, questions about previous knowledge, developing explanations, and communicating explanations to student-teachers and to their peers. Generally, every teacher asks questions and has used questions for three main reasons: firstly, questions are asked about the previous knowledge, as a tool. Secondly, questions are asked as the main activity to involve student-teachers in class. This is very common in a Pakistani class; most teachers use questions to seek out previous knowledge rather than invoking and exploring science investigations. Thirdly, most teachers mainly use a lecture method, so they may use questions in between their sessions. Teachers use questions as a warm up tool in class to trigger student-teachers' active involvement (Abell et al., 2001; Kane, 2004; Newman et al., 2004).

Furthermore, the findings from this study indicate that teachers' and student-teachers' exposure through scientific oriented questions to inquiry has helped them to understand inquiry-based science teaching strategies. Thus, the teacher-educators' responses indicated that student-teachers learn inquiry-based pedagogy through the use of questions, such as:

(1) Questions about student-teachers previous knowledge;
(2) Questioning strategies to initiate critical thinking;
(3) Learning how to facilitate student-teachers' inquiries in class;
(4) Understanding their role as facilitator when teaching science through inquiry;
(5) Understanding the importance of inquiry-based pedagogy to learning in science.

The understanding of inquiry through engagement in science questions is consistent with the NSES explanation that "inquiry also refers to the activities of the student-teachers in which they develop knowledge and understanding of scientific ideas" (NRC, 2000: 23). Thus, embedded in the responses from the student-teachers in the focus groups and in their responses to the questionnaire is their understanding about what an inquiry-based pedagogy constitutes, reflecting the nature of inquiry-based pedagogy, consistent with Anderson (2002) and NRC (2000).

Thus, most teachers and student-teachers agreed that questions are a main activity to be used in class, though student-teachers reflected their concern that teachers ask questions only to seek the right answer. Teachers do perhaps only use questions to find the answer or merely an activity to engage student-teachers in classroom. However most student-teachers responded that they seek only the right answer is not the core principle of inquiry-based

learning. Thus participants pointed out that their understanding about inquiry is that the question is the fundamental component of inquiry-based pedagogy. Although questions do not generate inquiry as well as these questions used in class do not trigger them to wish to deeply explore the scientific phenomenon. It seems that the teachers and students named some of the elopements of inquiry for example; everybody used questions in the classroom are they mentioned about it. It indicates their limited understanding about the process of inquiry because question regarding students' previous knowledge relate a little to inquiry-base learning.

8.2.1.2 Learning in a 'Constructivist Environment'

As reported in Chapter 6 and 7, this study has found that teachers and student-teachers reported inquiry as an approach whereby student-teachers develop their understanding of science by constructing their own understanding of science.

The majority of the student-teachers and teachers in this study welcomed the constructivist approach or a shift to inquiry-based pedagogy for teaching science. This is because inquiry-based pedagogy has allowed them to get away from the traditional textbook dependency which is often the main source of science information and make a transition to a more hands-on approach where student-teachers are central to the knowledge construction and learning process. They also reported that inquiry-based learning can help student-teachers to retain knowledge better than if they are simply taught using a textbook. This perception of student-teachers and teachers is consistent with reports in the literature that inquiry-based teaching strategies for the development of personal meaning in science can lead student-teachers towards higher achievements in science (Duran et al., 2004; Newman et al., 2004; Bybee, 2000; but see the review of Krischner *et al.*, 2006 who have shown that this is not a valid generalisation).

Much of this is based on a misunderstanding of the nature of constructivism. This word is often equated with any learning that s not didactic in nature and this seems to be how the teacher-educators see the word. In fact, constructivism related to what goes on in the mind of learners as they, naturally, seek to make sense of what is provided for them in any learning situation. Thus, constructivism is a description of what goes on in the head of the learner and cannot be used to describe an external learning situation. Indeed, Krischner *et al.* (2006) has demonstrated that constructivism does not hold the answer in seeking more meaningful learning.

The teacher-educators also reported their apprehensions about the use of inquiry; almost everyone reported that the teachers initially felt frustration in adopting inquiry but that they gradually started feeling comfortable in their teaching after inquiry is practiced. Though teachers developed an appreciation for the value of active learning experiences using inquiry-based approaches, they still expressed a need to be more skilled in using inquiry.

Moreover, the majority of student-teachers initially experienced frustration with inquiry because inquiry-based approaches in science are new and challenging methods to them. Indeed, student-teachers are likely to become frustrated without direction. Most student-teachers and teachers initially indicated experiencing frustration with the inquiry-based. The student-teachers had been receiving direction from the teachers and were therefore often feeling lost and frustrated without this direction. However, the majority of student-teachers reported that after this initial frustration, they developed a new appreciation for the value of the inquiry form of science instruction in their student-teacher learning and valued the active learning experiences and opportunities afforded to them by their instructors. The majority of student-teachers complimented the hands-off approach taken by their teachers and indicated that this approach had helped them to buy into the premise that learning science is something student-teachers can do, not something that is explained or given to them by their teachers. This cognitive development of the student-teachers is consistent with the development theory of Piaget (1975) according to which "learning begins when individuals experience disequilibrium" and which aims to bring their understanding back into equilibrium. Thus, student-teachers realised that there had been a change their thinking and perceptions through interaction with their environment.

The finding that teachers and student-teachers moved from an initial feeling of frustration in a learning environment to a feeling of acceptance and appreciation adds strength to the pedagogical practices in ITE in Pakistani universities. Teacher-educators moved through an initial feeling of hesitation in developing inquiry which is consistent with Friedrichsen (2001). Another prior study has found that student-teachers participating in a redesigned inquiry-based chemistry course to help them develop pedagogical content knowledge initially reported their concerns as they adjusted from a traditional course to an inquiry-based course, but at the conclusion of the course reported that they felt better prepared to teach chemistry (e.g. Mohammed & Jones, 2008). Hence, Teacher-educators and student-teachers reported that learning science through inquiry, which can be initially frustrating at first due to a lack of preparation using inquiry, gradually improved as they developed an interest in inquiry-based approaches. Also, their continuous practices with inquiry-based

methods later gave them an appreciation of the value of inquiry-based approaches, with their teaching practices seeking to make learning fun.

Another finding of this study is the student-teachers understand that when they persist through their initial feelings of frustration in doing open inquiries, they can develop better insights into the scientific concepts and retention of learning compared with going through a traditional lecture based class. This insight into the value of inquiry-based learning was the key motivator in their intent to use inquiry-based pedagogy for teaching science in their own classroom. Specifically, based on their own experiences, they felt that they would be able to use inquiry-based pedagogy to develop student-teachers' interest in science.

Thus, the results of this study suggest that the initial frustration and struggle with inquiry-based pedagogical experiences for teachers and student-teachers can be very effective means of learning about science processes and methods and is consistent with research findings that student-teachers who deal with the issues they are struggling with while doing inquiry show more learning (Haefner & Zembal-Saul, 2004). However, despite their frustrations as learners, they held a positive view of inquiry-based courses as a model for future teaching, consistent with prior studies (Volkmann et al., 2004; Newman et al., 2004). Thus, the teachers' and student-teachers' reporting of the benefits of using inquiry-based teaching strategies to learn science and indicate the development of the teacher-educators in the area of inquiry-based teaching strategies (e.g. Brooks & Brooks, 1993).

8.2.1.3 Collaborations and Inquiry-based Pedagogy

A finding of this study indicates that inquiry develops learning in a social setting and encourages student-teachers to learn in groups. The majority of teachers and student-teachers responded that they do inquiries in groups and promote group learning in student-teachers. The majority of teachers reported that they found that student-teachers learn best in groups and with the most pleasure. Thus, small group discussions were one of the most highly used activities in ITE in Pakistani classes (Khan, 2012; Ahmed, 2011). Also, most student-teachers responded that they enjoy their learning in groups and enjoy interactions with peers and teachers. Hence, this study contributes the insight that student-teachers got this opportunity to collaborate and share their ideas with peers as well as with their teachers; this has also helped in building their confidence to participate.

Moreover, both teachers and student-teachers held consistent views on the importance of social interactions as a characteristic of inquiry-based approaches in science. Furthermore,

student-teachers and teacher-educators worked with each other collaboratively and helped them in developing inquiry-based skills. This also helps to develop student-teachers' confidence in adopting inquiry-based skills where the teacher usually behaves in an orthodox way and stick with stern classroom discipline. There is a consensus among teacher-educators and student-teachers that one of the ways in which student-teachers' learning is promoted with social interaction. In the present situation regarding teaching in ITE in Pakistan, where equipped lab and facilities are not available to use for inquiry-based approaches in science, collaboration in the forums of group discussion and group project is found to be very helpful (Halai, 2010). Thus, collaborations using inquiry-based approaches develop an atmosphere of confidence and ease for student-teachers; as well as helping them in developing learning and knowledge.

8.2.1.4 Inquiry-based Learning and Critical Thinking

From the questionnaire and interview responses, the majority of teachers and student-teachers were positive regarding the view that inquiry-based teaching encourages critical thinking. Moreover, the student-teachers' responses in focus groups were also positive that inquiry encourages a thought-out solution when they did practical work in a science investigation. Thus, teachers and student-teachers were of opinion that inquiry develops critical thinking with respect to evaluating the evidence in scientific investigations. Although this is interesting, there is evidence from other studies that it is true.

Also from the interview data, the majority of teacher-educators and student-teachers responded that inquiry develops thinking in order to be able to review the science process and to analyse science experiment data critically. Also, Kyle (1980) suggests that the teacher, who fosters critical thinking, fosters reflections in student-teachers by asking questions and stimulating thinking. Thus, the use of inquiry is a rich experience in developing critical thinking in teachers and student-teachers.

Thus, teachers' and student-teachers' responses showed that, not only did they develop an understanding of the use of inquiry to answer scientifically oriented questions and solve science problems, but also applied their learning about science concepts to think and then understand and explain real-life experiences. This transition in thought was facilitated through the positive outcomes of their inquiry-based activities, through their reflecting on the benefits of inquiry-based learning. Thus, teachers and student-teachers were of opinion that inquiry develops critical thinking that leads to the learning outcome. Effective teachers

cultivate critical thinking using inquiry at every stage of learning, including the initial period. This is consistent with prior studies (Brookfield, 1995; Hooks, 1994).

Though teacher-educators and student-teachers, particularly in science courses in ITE in the Pakistani context, were given little or no guidance in their science activities, they appreciated the importance of an unstructured approach to learning science. The student-teachers and teachers reflected a shared concern that the comfort zone of working in a structured environment did not develop their self-reliance and thinking towards being able to adopt inquiry-based approaches. Thus, there were fewer opportunities for student-teachers in developing their thinking abilities.

8.2.1.5 Inquiry develops Procedural Understanding

As seen in Chapter 6 and 7, the majority of teachers and student-teachers appreciated the role of inquiry in developing an understanding of the process of science investigations and attitudes to scientific method. Moreover, both sets of participants of this study responded that inquiry-based pedagogy works similarly to an open-ended science investigation; they understand that inquiry is a similar process to a scientific investigation (Abd-El-Khalick et al., 2002).

Moreover, **t**he majority of teacher-educators and student-teachers reported their positive attitudes towards the importance of inquiry-based pedagogy in developing a procedural understanding. Both groups indicated that scientific inquiry was a vital part of science and scientific investigations and that inquiry is an important form of science (Lederman, 2003). Also, the findings indicated that teachers and student-teachers responded positively that inquiry-based strategies help them understand science experiments and investigations in the field. However, it has to be recognised that the sciences do not always operate by any set of standard procedures (Ziman, 2000).

Most student-teachers felt that it is important how to explore or test a problem to interpret solutions, so their belief is that scientific investigation relies on the process of inquiry-based pedagogy. This is because student-teachers mostly perform experiments within the given curriculum and do not have the opportunity to plan out their experiments as they please. Indeed, they have been confined to teacher-led activities and structured experiments in laboratories. Thus, most student-teachers were also of the view that inquiry-related teaching produces such outcomes as understanding of science processes, the conceptual understanding of science investigation, and attitudes toward science consistent

with (Haury, 1993).

However, as has been discussed above, student-teachers reported that they were initially frustrated with the lack of structure in inquiry-based experiments, but inquiry-based strategies to science investigation were helpful for them to learn meaningfully. They held diverse views of their teachers and their responses indicated that in general their teachers did not appropriately involve them in science investigations. Because student-teachers were not facilitated to undertake science investigations, they therefore did start developing an understanding of the relationship between procedural knowledge and inquiry-based pedagogy in science. In sum, teachers and student-teachers had positive perceptions of inquiry-based activities in developing a systematic understanding of science procedure.

8.2.1.6 The Role of Teacher in Adopting Inquiry

This study found that teachers appreciated their role as a facilitator of learning, though teachers organised their lessons with previous knowledge questions and opportunities for student-teachers' inquiries. This research found that the majority of teachers believed that teachers are facilitators in student-teachers' learning, though a few teachers believed that teachers would work better being a knowledge transmitter and a discipline keeper. Also most student-teachers' responses indicate that teachers were putting their greatest efforts into maintaining discipline, although they tried their best to make the lesson inquiry-based. As a result, teachers often hold control over their class during the lesson so that student-teachers lost their interest in learning.

In addition, the teachers also often expressed the view that they should provide suitable instruction and guidance for student-teachers before asking student-teachers to engage in any inquiry and that they had reservations about accepting the principle *"inquiry is about seeking the right answer"* as applied to student-teachers. Consequently, they prepare model answers (i.e. the given answers or teacher-made notes). Thus, this study found that the role of teacher to interact with student-teachers takes the form of questions in ITE in Pakistan. Although, the teacher-educators used the terminologies of group work, discussion, open questions, so on, they did not discuss the substance of all the mentioned terms. It can be noted that they did not know or think about how these approaches would contribute to students' learning.

Moreover, it could be said here that the teachers had got the shell by showing the names of strategies and methods but not had the understanding on them. Also, it could be said that the teachers' perceive or learn about new ideas without thinking about their implementation relating them to the classroom resources and teaching realities where the actual teaching takes place, it is put as a layer of 'new practice' on their traditional practice. In addition, it could be taken to mean that new expectations of change could be seen as a difference from the teachers' previous experiences. Therefore, this is not unexpected that they remember some terminologies without an in-depth understanding.

From the questionnaires and interviews responses, most teachers and student-teachers indicated that the teacher's role is limited to the use of questions. The teachers generally asked questions instead of giving answers; also, teachers welcomed student-teachers' questions and encouraged them to raise questions. Student-teachers disagreed with the views of teachers on the point of whether teachers challenged student-teachers' questions and encouraged the student-teachers to rethink the whole process of inquiry. The facilitator role for teacher-educators is consistent with the science classroom as envisioned by the NSES, where an effective teacher-educator role is more than a facilitator in creating opportunities and promoting inquiry (NRC, 2000).

One of the major reasons for some teachers to resist the principle of *"teacher as facilitator of learning"* lies in the conventional practice and culture of the University of X. As discussed in the literature review in Chapters 2, 3 and 4, the teachers in ITE in Pakistan tend to reproduce traditionally authoritarian and didactic patterns of instruction at the University of X. In addition, teachers were inclined to adopt a traditional teacher-centred approach in teaching. Some teachers may worry that once they have to stand aside and allow student-teachers to take ownership of their learning, the traditional pattern of teachers dominating the lessons may disappear. This may create discipline problems and the classroom may get out of control. In fact, those teachers who tended to resist the 'facilitator role' did encounter the difficulties they worried about.

Overall, then, this study found that teachers felt comfortable in their new role as facilitators of science learning. This finding is consistent with reports in the prior literature which suggest that teachers initially struggled with the implementation of inquiry teaching methods and gradually became familiar with the idea of inquiry, since it allowed them to begin thinking of working with student-teachers to generate ideas and the questions specific to student-teachers' experiences (Hayes, 2002).

The transition of practice in teaching in ITE is a complex phenomenon (e.g. Fullan, 1999, Mohammed, 2004). Given that the teacher-educators can be noted having difficulties rationalising their role in two ways. One role is based on their tacit perception of being a teacher, completing the textbook and preparing their students for an examination, particularly, in ITE in Pakistan. The second role is to enable students to participate actively in their learning according to the teachers' understanding to a new pedagogy. Limited time and support did not allow and encourage them to reflect on the implications and gain insights; rather, it created a 'tension of living between two opposites', as a result, this expands a gap between theory and practice instead of improvement pedagogy in ITE. Therefore, change in teachers' behaviour at the university was evident but, in the absence of support, the teachers were unable to work accordingly in their own context.

In ITE in Pakistan, the role confusion of the teachers might have set off their perceptions that inquiry-based learning should be limited to a certain extent so that they would not change their current teaching practice. Also, reflections during the process of learning in teaching in ITE progresses, realities of the social world's changes and various new images of teachers emerge. Diversification of teachers' as well as student-teachers' roles present teachers as innovators, leaders, social reformers, and catalysts for educational change, etc. (Ali, 2007; Ahmed, 2012, Khan and Saeed, 2009), and this perhaps encourages teachers in any society to combine their role as educators and active agents for social and educational change.

Little attention has been given to this subject area before this study into ITE in Pakistan; most teachers usually stuck with their authoritarian approaches and were therefore less friendly with student-teachers so this sometimes discouraged the student-teachers. The majority of student-teachers reported a concern that most teachers wanted strict discipline in class in ITE in Pakistani universities. Usually a friendly relationship does not seem to have been developed between teacher and student-teachers. In the University of X, student-teachers were not provided with enough time to do inquiry-based methods, so teachers involved them in small group discussions.

Also, ITE prepared teachers should see themselves as agents of social change who will work with their peers to their personal and academic problems in schooling and the broader society (Zeichner and Flessner, 2009:24). Furthermore, a concern is noted on the difference between the student-teachers' interpretations of their learning and expectations with their teachers. Most of the students were generally pleased with the teachers' role as a facilitator of learning. Nonetheless, students appreciated the authoritarian teachers who

took the responsibility of explaining/delivering them all the knowledge rather than those who try to engage them in problem-solving activities or try to make them think.

The teachers work according to the university expectation, which uncovers the problems of teachers' adaptations of behaviour with respect to authority or culture. It could be seen as an unintentional imposition on the teachers who have had opposite experiences of working that might resist the change in understanding a new pedagogy but appeared in the changing their behaviours. Although the change in thinking can be noted through the teachers' expression of interest towards student-centred learning approaches the practice did not change towards promoting student-centred teaching.

8.2.2 Theme 1.2: Perceptions of Inquiry-based Learning

As found in Chapter 6 and 7, the teacher-educators' reflections indicated that they also understood the value of teaching science through inquiry. An important finding of this study indicates that teachers and student-teachers appreciate the value of inquiry in their teaching of science and show positive views of inquiry-based pedagogy. They understood inquiry-based methods and defined them in their own way even though teachers use a little in their own teaching. Their understanding of the value of the inquiry-based pedagogy was indicated by the connections made to the use of inquiry-based approaches to investigate what inquiry-based learning is about. Teacher-educators' and student-teachers' understanding of inquiry and inquiry-based pedagogy in science is consistent with the findings in the prior literature indicating that inquiry teaching must not be considered independently of inquiry-based pedagogy and inquiry learning, as they are all interrelated (AAAS, 1994; Abell et al., 2001; Anderson, 2002; Blumenfeld, et al., 1994; Krajcik, et al., 1994; National Science Teacher Association (NSTA), 1998; Newman et al., 2004).

Thus, teacher-educators' understanding of science as inquiry and learning as inquiry are fundamental to their understanding of inquiry-based pedagogy. In short, the results of this study showed that teacher-educators expressed a fundamental understanding about inquiry in ITE, how to teach science through inquiry and the value of inquiry-based science pedagogy to learning science, consistent with the NRC (2000).

This study found that teacher-educators and student-teachers responded that inquiry-based learning can help student-teachers to retain knowledge better than if they were simply taught using a textbook. This finding is consistent with the literature in that inquiry-based teaching strategies' emphasis on inquiry methods for the development of concepts in

science can lead to higher levels of student-teachers' achievement in science (Krajcik, et al., 1994; National Science Teacher Association, 1998; Newman et al., 2004). However, this research also pointed out that, unless student-teachers have the opportunity to receive guidance as they investigate science, they will not develop the necessary abilities to perform inquiry. Also, the teacher-educators in this study used an inquiry related approach spanning from guided inquiry where the teacher-educators give step by step directions to student-teachers on how to conduct an inquiry, while student-teachers struggle through on their own to conduct an investigation triggered by questioning (Volkmann et. al., 2005).

In addition, this study found that the majority of teacher-educators and student-teachers reported their perceptions about inquiry-based learning as carried out by some teachers have not developed practically; hence, there are different judgements made by teachers that it may the case that inquiry-based learning has its value theoretically but not practically. During the interviews, the majority of teachers and student-teachers said that inquiry is one of the best methods used in ITE but 'not the only one best teaching method in ITE' or necessarily the most workable method in ITE in the present circumstances. Such differences were shown by the fact that even though the majority of teachers understood the advantages of inquiry-based learning, they themselves seldom used it in their classrooms. Thus, teachers still showed hesitation in actually adopting an inquiry approach in their lessons consistent with many findings (Anderson, 1998; Kuhn, 2010; Khan, 2012; Abell et al., 2001; Krajcik, et al., 1994; Newman et al., 2004).

Moreover, teachers responded in their interviews that they themselves struggle to adopt inquiry-based approaches but that they had started developing an understanding of inquiry. Also, it depends on individual teachers as to whether they take the effort and time in preparing inquiry-based activities with low resources. If they do, they will spend more time. For example, in a study conducted into teacher-educators' struggles to implement inquiry-based projects, Hayes (2002) explained that teacher-educators struggled to implement inquiry; however, after coming through their struggles, teacher-educators came to define and truly understand the nature of inquiry-based pedagogy.

Teachers and student-teachers alike reflected that student-teachers like to learn using inquiry-based teaching. On the whole, this is supported by the majority of findings from the questionnaires. This is consistent with many prior studies (e.g. Anderson et al., 2004; Abell et al., 2001; Anderson, 2002; Blumenfeld, et al., 1994; Krajcik, et al., 1994; National Science Teacher Association, 1998; Newman et al., 2004). Likewise, in this study, the participants reported that they would benefit considerably from using an inquiry-based

pedagogy. Thus, teachers and student-teachers demonstrated positive perceptions of the inquiry-based pedagogies used in ITE in Pakistani universities. They have also shown a strong agreement that inquiry-based pedagogies help student-teachers to use science in their daily lives, and to develop their skills through understanding the concepts of science. It seems that teachers and student-teachers believe that these factors helped in improving student-teachers' understanding, achievements and performance in the classroom.

Teachers and student-teachers' were of the opinion when they carry on through their initial feelings of frustration of inquiry-based activities, they can develop better insight into the scientific concepts and maintenance of learning than from a traditional lecture in ITE in Pakistani class. This insight into the value of inquiry-based learning is the key motivator in their intent to use inquiry-based approaches for learning science. Thus, the results of this study suggested that frustration and struggle with the inquiry-based pedagogical experiences for student-teachers particularly can be a very effective means of learning about science in class. Thus, the student-teachers who are struggling with inquiry show more learning than those who do not attempt to resolve their frustration.

This study has found that inquiry-based approaches help student-teachers developing deep learners. Moreover, the teachers and student-teachers also reported that inquiry develops learning through social interaction, the sharing of ideas with peers and inspires interest in student-teachers to do science. This later understanding is important because it indicates that not only did the teachers understand the value of inquiry-based teaching for theirs student-teachers doing inquiry, but they also understood that student-teachers could take a direct interest in using inquiry. Particularly in ITE in Pakistani universities, student-teachers could be encouraged to understand science phenomena in their real-life situations.

8.2.3 Theme 1.3: Perceptions of the Contribution of Science Method Courses to the Understanding of inquiry

The majority of teachers and student-teachers in this study reported that they had little or no previous exposure to inquiry-based science through their high school or college science courses, but they had exposure to the inquiry form of instruction and learning in ITE through the science methods course they had taken. The student-teachers and teacher-educators recalled experience of inquiry-based teaching exposure in their basic science courses (e.g. a physics course). They indicated that at the time when they went through their science content course they did not recognize the teaching strategies as inquiry-based, nor did they realize the value of the teaching strategies being used. This finding is

consistent with reports in the literature that teacher-educators do not receive adequate preparation in the theory and practice of inquiry (Hayes, 2002). This is, to a certain extent, the case in ITE in Pakistan because teachers as well as student-teachers have been brought up in the same education system and context.

In this study, teacher-educators indicated that the concept of classroom inquiry and inquiry-based pedagogy was emphasized through the science methods course and that they drew connections to their earlier experiences with inquiry-based pedagogy only after being exposed to classroom inquiry. However, the development of the skills necessary to carry out inquiry was facilitated through participation in inquiry-based activities. The questionnaire and interview data showed that guided inquiries are used more for teaching the science concepts and developing the abilities necessary to carry out inquiry, consistent with NSES (NRC, 2000). However, the majority of student-teachers did not experience inquiry-based pedagogy by teacher-educators and this finding is consistent with Abell (2006). In the present teaching situation in the ITE program at the University of X, the transmission mode of teaching has been developing teachers as 'stereotype' teachers rather than as scientifically literate people. Teachers need to look at how key science ideas contribute to student-teachers' lives. The results of this study show that students-teachers develop an understanding of the components and abilities necessary to conduct inquiry through a science method course, particularly in a Pakistani classroom where the lecture method is often used.

The prior literature points out that construction of an identity as a science teacher can be complicated, due to the multifaceted nature of inquiry science teaching (Colburn, 2000; Hayes, 2002). However, most student-teachers in this study reported that the teaching strategies taught and practiced by the student-teachers on the science methods course were beneficial to them in developing their own teaching strategies. This is consistent with the findings reported in the literature, that engaging student-teachers in scientific inquiry-based courses not only leads to the development of their understanding of science inquiry but that it also helps student-teachers become more accepting of inquiry-based approaches to teaching science that encourage students' questions about scientific phenomena (Haefner & Slekar, 2006).

In addition, the student-teachers reported that an interesting benefit of inquiry-based science teaching and learning strategies is the inculcation of confidence in them and a readiness to use inquiry to teach science; ultimately, they gain a realization that this form of science instruction can be used by them. These results are consistent with Hudson

(2004). Also, this course had been used to examine the development of student-teachers' thinking about science teaching and the nature of science (Newman et al., 2004; Abell et al., 2001).

Moreover, the results of this study indicated that inquiry-based pedagogy in the science methods course gave student-teachers insight into what teaching practices they would and would not adopt. For example, the student-teachers were accepting of an inquiry-based pedagogy for teaching science as it alleviated their apprehension about teaching science, stemming from their insecurity about their knowledge of science content and their fear of not being able to respond to all the student-teachers' questions which might be raised during inquiries. Specifically, with exposure to inquiry-based science pedagogies through the science methods course, their view of teaching science has often changed from the traditional view, where teachers are expected to be subject experts and provide answers to all the student-teachers' questions, to a view which is consistent with the NSES recommendations that teachers support student-teachers' inquiries and intervene in the learning process to encourage, challenge, and focus student-teachers (NRC, 2000).

Little attention had been given to student-teacher and teacher perceptions of the development of the teachers' and student-teachers' own pedagogy in science after completing the science methods course in ITE at the University of X, before this present study. This gap in research is therefore addressed through this research study. The majority of the student-teachers in this study indicated that the teaching strategies they used were consistent with those that were taught in the science methods course and that these similarities helped them to understand inquiry-based pedagogy for teaching science, a finding which is consistent with Kuhn (2004).

Having said that, science method course is potentially influential factors in development of teacher-educators and student-teachers. Overall, the results of this study indicate that student-teachers report being prepared for, and start understanding, an inquiry-based approach to teaching and learning after completing the science methods course. This study has successfully answered RQ1. However, it was not known previously that the majority of the student-teachers and teachers in this study indicated their intent to use inquiry-based strategies to teach science in their classrooms. There is indication in the literature that a science methods course can change student-teachers' perceptions. Therefore, it is possible that these student-teachers might implement inquiry in their classrooms.

8.2.3.1 Inquiry-based Pedagogies' Engagement in Learning

An interesting benefit cited by teacher-educators and student-teachers of inquiry-based pedagogy arising from learning science was that it engages student-teachers in their own learning process and helps in managing the class. Teacher-educators indicated that student-teachers who are engaged in inquiry-based science activities would face fewer classroom behaviour and management challenges. The teacher-educators felt that the inquiry form of instruction afforded opportunities to keep student-teachers engaged that this would perhaps lead to fewer classroom management problems in ITE in Pakistan classroom. Specifically, Hayes (2002) found that with regard to teacher-educators' concerns about implementing inquiry with their student-teachers, teacher-educators appeared to be worried about the possibility of discipline problems, and expressed concerns about maintaining control of their student-teachers during open-ended science activities or explorations required for inquiry-based learning. Also, this adds to our knowledge in the context of Pakistani traditional classroom, where many teachers wish to have comfort and no discipline problems during their teaching when student-teachers are involved in learning using inquiry-based methods.

The findings do indeed indicate that most of the teachers appeared to be worried about the possibility of discipline problems and expressed concern about maintaining control of their student-teachers during the open explorations and group discussions required for inquiry-based learning. Therefore, they risked missing out the components of fun, interest and enjoyment in learning. Others have pointed out that concerns about classroom management are quite common for student-teachers and teachers, consistent with prior studies (Bullough, Knowles & Crow, 1992). They, therefore, might not be specific to teaching by inquiry-based approaches in science.

Also, until this present study, little attention has been devoted to the fact that many teachers and student-teachers enjoy their learning in ITE when they are engaged in activities when they can bring out the solution of a problem. Also, concepts could be clarified when they got stuck solving questions or science problems; they struggled to solve them, and even though they may not have got the correct answer, they learned in the process. Thus, the teachers confine themselves only to questions as classroom activities though can still provide a range of activities or planned experiments in laboratories.

Moreover, student-teachers also pointed out that their concerns about classroom management are quite common and they, therefore, might not only be specific to using

inquiry-based science. One of the benefits cited by student-teachers of inquiry-based approaches to learning science was in the area of classroom behaviour management. The majority of student-teachers are of the view that if they are engaged in inquiry-based science then this would perhaps lead to a friendly atmosphere in the classroom. But, student-teachers also have concerns about the real practices of the classroom, in that the majority are autocratic and do not wish to develop an interactive environment with student-teachers. Many teachers do not welcome student-teachers' participation and do not wish to be challenged by inquiries from student-teachers. Teachers' attitudes to student-teachers in student-centred approaches are also consistent with prior studies (Mohammed, 2006; Khan and Saeed, 2009; Hayes, 2002; Ahmed, 2011; Hussain, 2010).

8.3 Research Question 2: How do Teacher-educators and Student-teachers Perceive the Role and Importance of inquiry in developing Scientific Literacy?

As reported in Chapter 6 and 7, the majority of the teachers and student-teachers were of opinion that inquiry-based pedagogies help in developing scientific literacy. The teachers' and student-teachers' responses from the questionnaires indicate that all respondents (i.e. 100%) were of the opinion that an understanding of applications of science is very important in real-life and inquiry plays a very important part in developing science literacy. They also reported that there is a strong connection between inquiry-based approaches, and teachers' and student-teachers' understanding of science phenomena in their real life situations. Thus, the present findings indicate that inquiry-based pedagogy in ITE is perceived as an essential element in developing science literacy.

The teachers and student-teachers appreciated the connection between inquiry-based approaches and science literacy; also, the aim of science education in ITE is to develop science literacy. This is consistent with previous studies in the subject area (Krajcik et al., 1998). The student-teachers and teachers have perceived that the process works in similar ways. Until the present study, little attention has been given to the fact that females, in particular, are lacking in scientific literacy. This study has found that female teachers and student-teachers emphasised the need to developing science literacy more with females. The majority of female teacher-educators' and female student-teachers' responses highlighted that female student-teachers' awareness of scientific phenomena is an important factor that has been prominently developed using inquiry-based approaches. Most female teachers reported that female student-teachers think superficially because of their mythology and misunderstanding about the application of science in their everyday life. This indicates that they are unaware of scientific phenomena in real life. Teacher-

educators appreciated the role of inquiry-based pedagogy that has helped them to develop an understanding of the processes inherent in science, developing in them an attitude of scientific methodology and ensuring that they no longer think superficially.

It was found that the majority of teacher-educators and student-teachers liked to see the library and the internet involved in science teaching. This initiated the development of an understanding that inquiry allows them to understand scientific methods and strengthens their beliefs about what science is in real life, consistent with past studies (Krajcik et al., 1998). In ITE in Pakistan, as has been mentioned, student-teachers are mainly taught by means of the traditional lecture method that promotes teacher-led teaching using a text-book, and they are confined to rote memorisation, rather than learning through reading widely. Therefore, most student-teachers wish simply to complete the syllabus by rote learning and pass the exam. Also, their insufficient knowledge and lack of understanding of science applications in their real lives lead to confusion and can develop superstitions in them. Inquiry-based methods, even when only through science questions, encourage them to read widely and search for knowledge. Using inquiry, they thoroughly learn scientific concepts and understand the function of science's applications in real life. This outcome not only indicates that student-teachers are convinced of the importance of scientific literacy, but suggests that colleges and universities will want to give due attention to the place of such courses in their curricula.

Likewise, the teachers' and students' responses indicated that they are less likely to read or refer to science journals, consult the internet, or use the library to research science information. Because of this, in the current practices in ITE in Pakistan, students might not learn deeply and might not have a broad vision of, or enough information about, the application of science. A fact raised by the literature is that students' focus is often on reading aiming for the memorizing of the text and key science facts in textbooks, even though it is globally accepted that students should learn and understand (Mohammed, 2006; Ahmed, 2012). Thus, teachers' and students' groups strongly agreed that inquiry-based approaches improve their understanding of ideas associated with the interpretation of data in science experiments. Accordingly, students' learning science, understanding the importance of science as a process, interpreting data, and having correct insights into learning science deeply are all very important factors in the learning of science, consistent with Norris et al. (2003). Thus, inquiry helps in developing science literacy and building a set of skills in students which they will need when reading a science articles, interpreting published tables and figures, and making personal and societal decisions.

As was found in Chapter 6 and 7, teacher-educators and student-teachers appreciated how inquiry-based pedagogy can make learning science more interesting for the student-teachers than learning from the text. Moreover, the majority of teacher-educators stated that inquiry-based instructional strategies develop literacy practices that have not been developing in student-teachers using a text-based curriculum. However, some student-teachers expressed apprehensions about textbooks in that they do not develop scientific attitudes and literacy in them. The courses taught in ITE programmes in Pakistan are structured to explain concepts and factual knowledge, and do not include activities which can bring student-teachers to think, brainstorm and solve problems. Therefore, the curriculum and teaching approaches in the current circumstances do not foster understanding of the application of science.

8.4 Research Question 3: What are the Teachers' and Student-teachers' Perceptions of the Challenges when an Inquiry-based Approach is Practiced?

Throughout the findings presented in Chapter 6 and 7, a number of important points regarding the difficulties and challenges faced by the participants using an inquiry-based approach to teaching and learning were listed and clarified. These challenges and difficulties were revealed through the process of data collection and analysis. The literature has demonstrated that adopting an inquiry-based form of learning does not necessarily lead to better learning when learning is seen as understanding (e.g. Krischner et al., 2006). They showed that the key lay in how inquiry-based learning took place, specifically in terms of cognitive load.

Moreover, during the data collection and analysis, it was found that the participants are influenced by their teaching practices, i.e. university culture and learning in ITE in Pakistan, which is not rooted in deep learning. Also, research ethics are not strengthened by these practices. From questionnaires and interview responses, the teachers and student-teachers revealed a number of challenges and provided deeper insight into adopting inquiry-based pedagogy approaches at the University of X. These challenges are discussed in the following sections.

Theme 3.1: Challenges of Resources

- Lack of physical facilities
- Insufficiency of time

Theme 3.2: Challenges within the University System

- Lack of university support
- Exam-based Assessment
- Curriculum does not support inquiry

Theme 3.3: Lack of Professional Development and Preparation to use Inquiry-based Pedagogy

- Lack of teacher preparation
- Teachers' autonomy using inquiry-based pedagogy

8.4.1 Theme 3.1: Challenges of Resources

8.4.1.1 Lack of Physical Facilities

An important finding of this study is that the majority of teachers and student-teachers argued that they like to use inquiry-based approaches but these elude them because of specific constraints. Consistent with prior studies (Ali, 2005; Mohammed, 2006; Halai, 1998), teachers and student-teachers report that they have been facing challenges in adopting inquiry-based approaches when classes are big, e.g. insufficient resources and no facility to work on inquiry-based activities. Thus, more than 90% were not satisfied with the situation, because inquiry-based teaching approaches are not feasible for them due to the resource constraints.

Teacher-educators reported that they had failed in using inquiry-based instruction to teach science because they lacked resources, were deprived of information technology facilities in classrooms and apparatus in laboratories at the University of X. This study found that inquiry therefore remains unimplemented in most classrooms, consistent with past studies (Weiss et al., 2003; Anderson, 2002).

Moreover, both the teacher-educators and the student-teachers groups reflected back on their experiences of implementing inquiry-based pedagogy, and they voiced concerns about inquiry-based teaching as a mix of several problems together. They expressed a belief that these are caused by the lack of resources. For example, inquiry-based lessons

require resources, equipped laboratories, additional preparation for inquiry-based science investigations, and trained lab staff (Hayes, 2002:151). Therefore, a high budget is required. The University of X, being a new university, lacks the resources for laboratories and classrooms as well as sufficient budgets to arrange well equipped laboratories in the present circumstances.

Another concern expressed by the student-teachers was that they may be provided with apparatus in the laboratory but are not able to use it for their independent projects. Student-teachers also reported that teachers discourage them from engaging in science investigation rather preferring to lecture them so that the apparatus remain useless. Research indicates that the technologies and activities of inquiry-based learning must fit within the practical constraints of the learning environment, such as the restrictions imposed by available resources and fixed schedules. Therefore, lacking the desired technology or not fitting within the existing schedule may doom any intentions to use inquiry-based approaches to failure (Blumenfeld et al., 1991; Weiss et al., 2004).

Another resource problem relates to computers and the information technology (IT) facilities available in classrooms. No evidence has previously found that student-teachers used IT frequently or easily at the University of X. In a few classrooms, there is one computer and these are installed at the teachers' desks. Even teachers are not always trained in using computers and multimedia. IT solutions can become effective tools for inquiry-based approaches, but the lack of IT resources hinders any arrangements for student-teachers to engage in inquiry through IT facilities.

8.4.1.2 Insufficient Time

This study has also found that tight and short teaching and preparation time also increases the pressure on teachers and student-teachers in adopting inquiry-based approaches. Teacher-educators' and student-teachers' apprehensions about teaching inquiry-based science stem from a belief that inquiry-based instructions are more time-consuming, expensive, challenging and requires additional effort and preparation time. This was also found by the prior studies (e.g. Bovill et al., 2010; Mohammed, 2006; Khan, 2012; Hussain, 2010; Nazir, 2006; Ullah, 2010). The teachers showed their concerns about whether the traditional curriculum would provide an adequate amount of time to implement inquiry-based science teaching approaches.

Student-teacher and teacher-educators also voiced their apprehensions about inquiry-based teaching given the current set-up through the science courses in ITE curriculum, which might not afford them adequate class time to prepare inquiry-based lessons. This apprehension is consistent with similar findings in the literature for implementing inquiry (Hayes, 2002; Weiss et al., 2002). Additionally, the majority of teachers reported that they have excessive amounts of work to teach. They have to teach the whole content in curriculum before the exam starts and they cannot therefore pay attention individually to each student-teacher. Therefore, a large teaching and administrative load influence their performance because of time pressure. These findings are consistent with past studies (Anderson, 2002; Volkmann et al., 2005).

Furthermore, teachers teaching science courses (ST) and those teaching science and method courses (BT) agreed in their opinions that inquiry-based approaches also require as much time, space and resources as necessary as well as a feasible environment in the classroom (e.g. Anderson et al., 2005). Teachers, particularly in the University of X, concentrate on completing the text-book during the semester, whether student-teachers understand its content or not. So, inquiry-based methods could not be used all the time to cover the whole curriculum. This is because the curriculum presents an enormous volume of science course contents to student-teachers to learn, and time to teach is limited.

8.4.2 Theme 3.2: Challenges Within the University System

8.4.2.1 Lack of University Support

An outcome of this study is that even though some teacher-educators felt insecure about their pedagogical knowledge and realized that traditional university environments might not allow them to use inquiry-based science activities, they also expressed nervousness that they could manage their time to implement inquiry-based instruction in any case. This is consistent with the finding in the literature that teacher-educators struggle and experience anxiety about using inquiry-based pedagogy for teaching science, even though these struggles may ultimately help them to understand the value of inquiry-based teaching practices (Anderson et al., 2005; Khan, 2012; Weiss et al., 2002).

As one of the discoveries that had not been explored in the existing literatures, it is evident that the administrative structure of the university affected the implementation of inquiry-based learning. Different administrative structures allow different degrees of freedom for teachers' actions. The University of X has a traditional and bureaucratic administration in

place, and decisions are made with a top to bottom approach; therefore, teachers and student-teachers are not involved in any way. Therefore, a focus is on teachers' relationships with the authorities rather than on the quality of teaching and learning for student-teachers (Khan and Saeed, 2009; Ahmed, 2012; Memmon, 2010; Halai, 2008).

University traditions and its culture also affect teachers' motivation to work when their problems are not solved, affecting the way new ideas are implemented, especially if people do not collaborate with each other. This is examined a little in the literature concerned with the influence of university culture in inquiry-based approaches. University culture provides a wide context that reflects the values, views, norms, traditions, and rituals that build up over time as people work together (Fullan, 2000). Most of the teachers' and student-teachers' responses indicated that use of inquiry depends on their own choice or their will as to whether or not they want to use inquiry; otherwise, the university culture and authorities do not seem to encourage teachers and student-teachers in using inquiry-based approaches. Moreover, a concern of the teachers is noted. The teachers feel a fear that inquiry, being an active and dynamic activity, engages student-teachers in interaction and creates noise and bustle. Teachers face the risk that they might lose control and discipline of their student-teachers. This situation might be seen as reflecting inefficiency in their job. Hence, the university culture influences the actions of the teachers as well as student-teachers, especially teachers in their motivations and readiness in adopting inquiry-based approaches.

8.4.2.2 Curriculum does not Support Inquiry

One of the main findings presented here is that an inquiry method does not support the curriculum because the curriculum is not inquiry-based. The science curriculum in ITE consists of a heavy use of factual information and content (Plevyak, 2007; Ross et al., 2010; Ali, 2008). In such circumstances, teachers rarely use inquiry-based approaches in the classroom. Another concern shown by the teachers and student-teachers is that science courses cannot be revised to develop them in an inquiry-based way, because inquiry might generate unstructured curricula and make teachers and student-teachers nervous being unprepared. Teacher-educators need to develop their key skills related to working and thinking using inquiry-based methods and to be less concerned with content coverage. Coverage of the text does not let student-teachers develop their thinking skills and they will also struggle in preparing inquiry-based activities.

Another finding indicates that teachers and student-teachers enjoyed learning science through inquiry instead of teaching from the text. Most student-teachers, from the interview responses, indicate a wish to get rid of text dependency. The inquiry-based teaching strategies used in science courses moved them from a dependency on teaching from the text to using inquiry-based approaches. The teachers also reported a number of obstacles to change that ranged from a lack of expertise in collaborations with other staff to the problems inherent in joint planning in transforming existing curriculum materials that excessively use textbooks (Kraijcik et al., 1998; Ali, 2008; Ali and Reid, 2012; Memon, 2007; Samuel, 2002; Hussein and Reid, 2009). So, the textbook could perhaps be redesigned to include structured and open inquiry-based activities, thus raise inquiry-based pedagogies.

8.4.2.3 Examination-based Assessment and Inquiry

An important finding is that the system of assessment has been suffering from an overload of exams that focus simply on the memorization of facts and learning by rote (e.g. Ali, 2008). This causes fear in student-teachers who feel uncomfortable about what is expected. In the current situation in ITE in Pakistan, exams are a huge part of assessing student-teachers. Also, student-teachers are assessed to a lesser degree on their classroom activities, projects, assignments and inquiry-based approaches, consistent with prior studies (Ahmed, 2012, Mohammed, 2008, Khan and Saeed, 2009). So, teachers do not have an opportunity to evaluate student-teachers' skills and abilities using inquiry-based approaches (Khan, 2012). It seems that ITE programs in Pakistan develop future teachers to be masters of the factual information of science without necessarily understanding of these facts. Thus, the purpose of learning is solely to pass exams; therefore, inquiry-based approaches seem peripheral and will not be helpful in reducing panic in exams.

Summative assessment does not enable the active role of student-teachers that learning through inquiry requires; it is equally important for summative assessment to reflect the range of learning goals of inquiry-based learning and take a role in the improvement of science teacher education. In Pakistan, student-teachers are more likely to memorise subject knowledge and less likely to think reflectively and to learn using inquiry-based strategies. The examinations check student-teachers' recalling abilities. Subsequently, examinations may cause a deterioration of learning outcomes; this is what, happens in ITE in Pakistan. It is essential that the examinations system is changed; otherwise, inquiry-based learning will remain a still-born child (e.g. Gibbs, 1992). Suitable assessment is a

crucial part of inquiry-based learning (Alberta Learning, 2003). In addition, from the findings emerging from the teachers' and student-teachers' questionnaires and interviews, assessment is one of the major challenges in making inquiry-based approaches unworkable. Both teachers and student-teachers do not find any trace of inquiry-based approaches within the current form of examinations.

The findings indicate that the teachers do not do justice to the work in their marking of the answer scripts due to their lack of training. Grading is very objective; only information is tested and the characteristics of a student-teacher's whole personality are ignored. Our examination and assessment system revolves around grades instead of gaining in-depth knowledge and learning in science. It is argued that the examinations not only assess the student-teachers' performance but the teachers' performance as well, but our examination assessment system lacks such measuring techniques (Shirazi, 2004; Khan, 2011). There should be a system of assessing teachers using the same tests as the student-teachers, and providing for training in weak areas of teaching and assessment by introducing a system of incentives and disincentives (UNESCO, 2005). Moreover, student-teachers reported a concern that some student-teachers are more interested in using unfair means to obtain additional marks. Parents and examination staff are involved in these incidences of misconduct. Thus, examination leads to an unreliable measure in testing student-teachers' memory on recalling knowledge.

The majority of student-teachers from the interview data reported that it is the responsibility of teachers to conduct both formal and informal assessments to monitor student-teachers' understanding and use that information to guide future instruction. The results of the assessments can help teachers to determine whether student-teachers are learning, and will achieve the desired outcomes. Thus, assessment should be an engaging process to grab the student-teachers' attention. If it is, then teachers can informally assess whether student-teachers are beginning to understand the concepts being taught. If they are not doing so, then student-teachers should spend more time exploring these concepts. Thus, the teachers' and student-teachers' responses from the questionnaire and interviews on the domain of assessment and correlations of learning outcomes provide an insight into how the ways in which intended curricula are implemented affect student-teachers' learning.

Teachers and student-teachers also expressed perceptions indicating that changes to the pattern of assessment can bring useful changes to the curriculum. Thus, if assessment offers rewards for some classroom activities, useful changes could be made to both the

curriculum and to teaching approaches. Therefore, a discussion on teachers' and student-teachers' views shows that implementing changes in curriculum and assessment to introduce challenging teaching methods made difficult in the current situation of the current curriculum and assessment techniques. If the assessment system cannot be altered, this hinders the implementation of inquiry-based pedagogy methods in ITE.

8.4.3 Challenges with regard to Preparation in Adopting Inquiry-based Pedagogy

8.4.3.1 Lack of Teachers' Preparedness to Inquiry-based Pedagogy

A finding in this study is that the majority of the teachers find inquiry-based approaches difficult to adopt in ITE. This is consistent with Fisher et al. (2009) who found that student-teachers and teachers both need background knowledge before they can effectively learn science content using inquiry methods. Background knowledge is therefore one of the most important prerequisites of learning in science. The importance of building background knowledge using inquiry puts an emphasis on the reduction of the expected memorization of facts. Rather, it presents science as a range of processes that validate and extend real-world understandings (Fisher et al., 2009).

It was found that most teachers were of the opinion that inquiry is not one of their prioritised teaching methods and that it does not seem workable. They think that inquiry is one of the best teaching methods in science, but not necessarily the best or the sole valid method of teaching. This is because the majority of teachers lack exposure to professional development programmes using inquiry-based approaches (e.g. Memon, 2007; Halai, 2010; Khan, 2010; Mohammed, 2008). According to Pakistan's Educational Statistics for 2008-2009 (Academy of Educational Planning and Management, 2009), over 90% of the teachers working in public-sector schools in Pakistan are trained in and have participated in professional development programmes. Unfortunately, the impact of teacher training is not reflected in their student-teachers' achievements. A number of factors are responsible for the poor quality of these training programmes, especially in Pakistani public-sector institutes. The quality of education imparted by universities in teacher education in general and public-sector universities in particular are criticized in terms of poor training programmes and of their implementation (Majeed, 2009; Ahmed, 2012). Furthermore, another factor that contributes to ineffective implementation of these training programmes in Pakistan are not monitored and evaluated through research or any other follow-up means. Monitoring can provide means of feedback on the progress of teachers and also

provides insights into whether or not the programme needs to be adapted in some way or the other. In fact, teacher-educators should be thoroughly prepared to make revision in adopting a new pedagogy.

As discussed here, the professional development of teachers is often restricted rather than extended, therefore, teachers feel isolated and constrained. Also the in-service courses are often one day trainings like a one shot experience that has few meaningful benefits. However, it is unproductive to leave teacher-educators without support and at the same time to expect them to be effective teacher-educators. Therefore, the public sector institutions of teacher education in Pakistan seem to fail to bring a positive trend of using inquiry in teacher education. Teacher education institutions in the public sector exist in their own right; they do not exist to serve society. The valuable resources which are invested in teacher education are being wasted because the outputs in terms of student-teachers' learning remain poor and are not achieved desirably (e.g. Abbas, 2011).

It was also found that some of the teachers received professional development related to planning instructions and about the use of information technology but not on inquiry-based approaches. As found in other research (Marcus et al., 2009), teachers learn pedagogical skills and practices through professional development to enhance their student-teachers' abilities. It can be noted however that the present study found that 64% of the teachers had never received any training in curriculum design and assessment technique using inquiry-based pedagogy. This shows that they like to teach with inquiry-based pedagogy but they lack the relevant training to use inquiry-based approaches.

Likewise in this study, the majority of teachers agreed that inquiry-based pedagogy should be part of their professional development (e.g. Fernandez et al., 2003). Professional development centring on the different aspects of inquiry-based pedagogy encourages collaboration among teachers in their preparation of inquiry-based pedagogies. The prior literature reported that the teachers' involvement in professional development opportunities provided a means for change (e.g. Zohar et al., 2001).

The findings in this study indicate that teacher-educators and student-teachers face dilemmas when inquiry-based instruction is practiced, which many times are due to their own views and values related to student-teachers and teaching (Anderson, 2002). The prior literature reported that teachers prefer to teach using the same method with which they were taught (Ahmed, 2009; Majeed, 2009; Ahmed, 2012). This contention is supported by Volkmann et al. (2005) who also pointed out that doubts about teaching inquiry-based

science could stem from teacher-educators' own understanding, and the presence or otherwise of the values that support inquiry. The teacher and student-teachers' preparation in adopting inquiry seems to be poor (Halai et al., 2004; Shah, 2000). Also it was found that understanding of the key ideas of science is important. In the Pakistani education system, teachers are more likely to have no professional development concerning pedagogical knowledge. Teachers are trained with a strong amount of subject knowledge (from textbooks) and, consequently, lack a procedural understanding of science.

Also, providing opportunities for student-teachers to both develop and apply that scientific understanding in designing inquiry-based learning is a big challenge. The student-teachers' lack of previous knowledge or the opportunity to develop it means they are unable to complete meaningful investigations. I agree that the task of preparing teachers for inquiry teaching is much bigger than the technical matters involved. This is even though teachers need to learn how to teach constructively, acquire new assessment competencies, learn new teaching roles, learn how to put student-teachers in new roles and foster new forms of work (Sandoval, 2005). In preparing their lessons in class, teachers tended to promote content coverage and encourage their own student-teachers to use a lecture-style of teaching. Student-teachers aim to develop as scientific, literate people and this relates to their understanding of inquiry-based learning.

Before this study, it was rare to find an examination in the context of ITE in Pakistan of the fact that student-teachers may not have the readiness to learn inquiry-based method (So et al., 2005). This is also a concern for teachers and student-teachers that teaching in public sector organisations in Pakistan does not prepare student-teachers to face challenging methods like inquiry and they lack in confidence in using these methods. Data shows that most student-teachers have studied in public sector schools and teachers have too; therefore, they teach the way they learn. Student-teachers also want to learn the same way they have been taught in their school. They also develop on the way through as a person (Darling-Hammond, 2002). They did not have an open and comfortable environment in university either; this is unfortunate, as the more open the learning environment is, the more self-regulative student-teachers have to be. Hence student-teachers' ability and levels of readiness become other major concerns that may have hindered the positive views of some teachers in relation to inquiry-based learning.

This study finds that most student-teachers lack genuine interest in inquiry-based approaches because of an insecurity about their knowledge of science content and about the process of inquiry (e.g. Hayes, 2002). This is because most student-teachers are

uncomfortable with their science content knowledge (Ali, 2008; Ahmed, 2012; Mohammed, 2006). Also, their main anxiety was that they knew little about the process of inquiry-based pedagogy. The student-teachers reflected concern at having difficulties with thinking abilities in the classroom generally as there is a great deal of complexity involved in understanding inquiry-based activities related to the topic. Teachers and student-teachers agreed that they can more easily learn observable ideas via inquiry-based instruction than by ideas considered theoretically. An example given by teachers was that inquiry-based instructions in Chemistry are likely to be effective for showing many student-teachers that chemical reaction rates depend on the concentrations of reactants. On the other hand, inquiry-based methods seem weak as a means towards helping most student-teachers understand how scientists explain phenomena, for example nuclear reactions, the kinetic-molecular theory, etc.

Discussing the student-teachers' specific views further revealed that they worried about their weaknesses in science content knowledge in relation to using inquiry-based pedagogy; their concern was also that they knew less about the process of inquiry and this might confuse them when they attempted to practice it. This assumption of the student-teachers is consistent as literature indicates that both science content knowledge and science pedagogical skills are needed (e.g. Darling-Hammond & Youngs, 2002). In Pakistan, teacher quality is determined by the level of professional competencies which is a concept inclusive of the knowledge, understanding, skills, and attitudes a person brings to the teaching profession. Teacher are lacking in content knowledge in science is consistent with the literature that teachers should be skilled sufficiently in science content (Weiss et al., 2002). In ITE in Pakistan, teachers without the required level of professional competence are recruited based on merit in their academic achievement rather than their professional competence (Nizamani et al., 1998; Khan, 2012; Ahmed, 2009; Majeed, 2009; Ahmed, 2012). That is why, as mentioned above, teachers generally behave or teach in the same way that they were taught.

This study found that teachers' and student-teachers' shared a concern that inquiry-based pedagogy could only be used in ITE in a Pakistani classroom if teachers are trained/skilled and student-teachers are able enough to do that. Their views indicate that only skilled teachers and able student-teachers could use inquiry-based pedagogy that potentially improves their academic achievements. This raises two important questions: how can we describe skilled teachers and able student-teachers? Secondly, this suggests that inquiry-based pedagogy is of very limited value if only a tiny minority are capable of using it.

Little examination of this facet has been carried out prior to this study on ITE in Pakistan (Akhter, 2009). Although, inquiry-based learning is useful method, the majority of teacher-educators and student-teachers lack in confidence in implementing in classroom. Thus, teachers' readiness in using inquiry is low; and their inadequate understanding of inquiry-based pedagogy on how to teach using inquiry-based approaches hinders their ability to update their practice to new teaching methods. Therefore, inquiry-based assessment could possibly bring teachers in using inquiry-based approaches.

8.4.3.2 Lack of Teacher-educators' Autonomy in Adopting Inquiry-based Pedagogy

As seen in Chapter 6 and 7, an important finding from the interviews was that the teachers lack autonomy in choosing to adopt inquiry-base approaches to their teaching. Also, the choice of teaching method depends on the curriculum and assessment in ITE at the University of X. For this, teacher-educators of science use a mix of teaching strategies to teach science. A teacher is expected to be aware of the origins and the consequences of their own decisions, actions, behaviours and the realities that may constrain these actions (Luke, 2009). I agree that the classroom is an enormously complex place requiring vast teacher knowledge and understanding as well as skills and abilities in coping with emerging problems. Thus, the teacher should be the main person who can control and change both their actions and the constraints they face, and who is able to solve problems associated with pedagogy and practice. Given the nature of teachers' work, they should not be dependent on a fixed body of knowledge; rather, their teaching and technical skills and experiences in different work contexts are the sources from which teachers can derive new insights and understanding (Darling-Hammond, 2002).

An important finding of this study is that teachers lack autonomy, in addition in that their teaching is influenced by the particular culture and society within which they operate, i.e. ITE in Pakistan at the University of X. This underscores the need for recognizing the links between political, socio-economic contexts and teacher education, within which the teachers develop and work (e.g., Mohammed, 2006; Majeed, 2009; Ahmed, 2012; Khan & Saeed, 2009; Hussain, 2010). Teachers' own pedagogical views, behaviours and practices are grounded in their individual personalities. In this context, teacher education and development could be regarded as individual development and to a great extent it is affected by social-cultural and political forces.

The findings indicate that both teachers and student-teachers tend to focus on the acquisition of the teaching skills which will be required to deal with routine situations inside the classroom. However, this view fails to recognize the dynamics of the classroom, teachers' personal make-up, and life and family circumstances. Thus, changing the teacher is to change the person the teacher is (Hargreaves, 1991a). This is because in real teaching, the classroom is dynamic and uncertain and the answers to teaching problems are not a simple process. Thus teachers must exercise their wisdom of practice. Similarly, Dewey (1964) suggested that education programmes should produce student-teachers who are thoughtful about educational theory and principles rather than only being skilled in routines, copiers, and followers of tradition.

This study has found that the struggles teachers encountered in implementing inquiry-based approaches were related to their inability to let go of their authority to control and direct student-teacher learning. Dependency on authority and control resulted in their reluctance to go with student-teachers' interests or to allow student-teachers to lead the curriculum, and discomfort with establishing a form of reduced teacher control and authority in the classroom (Hayes, 2002; Anderson, 2002). Teachers in a traditional Pakistani classroom mostly use a standard lecture method and thus lack technical autonomy. Also, any unresolved conflicts among teachers may hinder their autonomy. That is because cultural dilemmas stem from teachers' views and their perceived need to prepare student-teachers for the next grade level for which they consider that the textbook could be the best and the easiest tool for teaching and learning. Teachers' work is examined more actively and dynamically in an inquiry-based process than via traditional teaching (Hayes, 2002). Within the classroom, teachers enjoy a relatively high degree of privacy and autonomy. Teachers do not work under constant supervision and their student-teachers can work with relative autonomy. Although inquiry teaching is a lot of work for teachers, it also leads the teachers to work individually and interactively with student-teachers.

Discussing the teachers' and student-teachers' views further revealed that the university's culture also contributes to the centralized structure of the administration of the university (Ahmed, 2009; Majeed, 2009; Khan and Saeed, 2009; Hussain, 2010). Thus, teachers and student-teachers were of opinion that the university administrative structure imposes constraint on teachers' autonomy in implementing a new teaching method. Hence, the development of an inquiry-based approach and the new curriculum may be strongly affected by the views of the university's staff, instead of the views of the teachers. As

discussed in Chapter 4, traditional local classrooms emphasize a teacher-centred pedagogy.

It is also found in this study that, in practice, teachers and students both use and appreciate lecture-based methods in the classroom. In cases where they use inquiry-based approaches, teachers are required to be more autonomous in doing so, because a traditional, centralized structure logically gives less support to a student-centred teaching method. Maintaining classroom order, discipline and efficiency with the dissemination of knowledge are therefore still the major concerns teachers' face in relation to the university administration.

Instead, the standpoint in relation to inquiry-based learning of the university is established. Although standardized test and pre-packaged materials have been used in the University of X, it is the administration of the teachers which has decided the importance and usage of such tools. In other words, the teachers possessed a low level of autonomy to adjust the curriculum, assessment and designing measures to improve learning. Therefore, when the teachers at the University of X expressed more positive views of inquiry-based learning, they came up with more positive measures in developing inquiry-based learning practices. Such autonomy does not only apply to decisions on what to teach or how to teach in lessons, but it also applies to planning for implementing inquiry-based activities, assessment of student-teachers' learning, the usage of standardized tests, pre-packaged materials, extra-curricular activities and the evaluation and improvement of the curriculum. It is still a concern of teacher-educators and students-teachers if they are able to achieve any improvement if the culture works against the teachers' efforts. Despite teachers' professional limitations, teacher-educators need to reflect, and need to continue to reflect, about how they can help student-teachers to be more secure, confident and progressive teachers.

8.5 Chapter Summary

This chapter began by returning to the main research questions and discussing the results in relation to them. It aimed to clarify, interpret and discuss these and link them to the previous studies. In this chapter, I have attempted to discuss the results of the study in the light of the research questions and the data gathered. This chapter started with RQ1 and attempted to answer what the teachers' and student-teachers' perceptions of the role and the importance of inquiry-based pedagogy in ITE in Pakistan. Based on the findings in Chapter 6, this chapter has attempted to define the fundamental components of inquiry-based learning. Furthermore, this chapter has discussed the student-teachers' and teachers'

perceptions of questioning as one of the main components of inquiry, learning using inquiry, and the contribution of science method courses in developing inquiry. This chapter then discussed RQ1, on the role of teachers and the implications when inquiry is practised.

The chapter then presented a discussion on RQ2. This started with a discussion on the teachers' and student-teachers' views on developing science literacy and its connection with inquiry. The findings were consistent with the prior literature on inquiry where it is perceived positively in developing science literacy and as helping student-teachers to understand science in the context of their daily lives.

Subsequently, RQ3 is discussed in light of the findings on the challenges to inquiry when inquiry is practised in initial science teacher education. Also, it has been revealed that inquiry-based pedagogies may be helpful for teachers' professional and pedagogical development in ITE. Discussing the teachers' and student-teachers' perceptions of the challenges in adopting inquiry-based approaches further, the chapter elaborated on the views which had been expressed regarding the lack of teachers' autonomy and teachers' and student-teachers' preparations for using inquiry. All the challenges to teachers and student-teachers indicate that when inquiry-based approaches are practiced, inquiry is a good method to use but it is not always workable, and faces many constraints. Inquiry-based approaches are not encouraged by the whole university infrastructure. Moreover, the chapter discussed that teaching and learning practices seem to have failed thus far to develop student-teachers in ITE in Pakistan so that they are active and science literate and can build a better quality of teaching and learning in Pakistan.

In conclusion, the discussion on the findings which drew them together with the prior literature and theory also suggested a supportive plan for the development of pedagogies in teachers and student-teachers. The next chapter, Chapter 9, will provide an overall conclusion and recommendations for the University of X, and in particular the teachers, curriculum and assessment and for policy makers generally. The next chapter concludes the thesis, presents some of its main findings, suggests the limitations and implications of the research and recommends some possible future directions for research. These recommendations will encourage developing inquiry-based pedagogy in ITE, strengthening research culture, and other related points which might help further pedagogical development.

Chapter 9

Conclusions

9.1 Introduction

This chapter presents an overall summary of the research which has been carried out in this study, and the main findings, implications and contribution of this research as well as some suggestions for future research.

9.2 Summary of the Research Aim and Main Research Questions

This research study has aimed to investigate student-teachers' and teachers' perceptions of inquiry-based pedagogy in ITE at a Pakistani university. It has looked at evidence of the kinds of knowledge and experience accrued by teachers and student-teachers at the University of X as well as their views on inquiry-based teaching, their views on inquiry in relation to science literacy, and the challenges they face when they practice inquiry-based pedagogy. It has to be recognised that the study has focussed on opinions of teacher-educators and student teachers. There is confidence that the study has captured what they think. However, there is no certainty that what they think is an accurate picture of the reality of the usefulness or otherwise (and, indeed, the effectiveness or otherwise) of inquiry-based learning.

The research has focused on three main research questions in order to explore the teachers' and student-teachers' perceptions of inquiry-based pedagogy in ITE in Pakistan, the development of science literacy using inquiry-based pedagogy in teachers and student-teachers; and the challenges inherent in the implementation of inquiry-based pedagogy at the University of X. As was shown in Chapter 1, these questions were the main research focus and have influenced the overall structure of the thesis.

9.3 Conclusions from the Literature Review

Research indicates that teacher-educators and student-teachers have had very little exposure to inquiry-based pedagogy and that they therefore lack understanding of the process of using inquiry-based approaches to teach science. The literature justifies the

focus on establishing what the perceptions of teachers and student-teachers are regarding the role and importance of inquiry-based approaches to learning science in a science teacher education programme in Pakistan. The importance of the perceptions of the teachers and student-teachers of inquiry-based approaches to learning is developed in light of the fact that every teacher and student-teacher is likely to say that it is important to promote inquiry in science teacher education; however, what is meant by inquiry-based approaches will differ in definitions and, importantly, in practice. The prior research also indicates that science methods courses can improve the personal science teaching to student-teachers in science. However, the literature suggests that inquiry-based approaches are problematic in ITE, in particular in Pakistan, and it is therefore possible that inquiry cannot be uniformly implemented in the teaching of these courses.

The literature also indicates some evidence regarding teachers' and student-teachers' perspectives of the contribution of the science method methods course to developing their understanding of inquiry-based pedagogy in ITE in Pakistan, and to the development of their pedagogical strategies for teaching science through inquiry. Research shows that inquiry develops thinking in student-teachers (Abell, 2006; Doecke et al., 2008). Also, teacher-educators and student-teachers begin to shape their viewpoints about learning and teaching science at this stage; their perceptions of their experiences on the science education methods course can provide valuable information for their teaching of science as inquiry. Thus, the findings from this research are expected to help with the improved design of pedagogical experiences for teachers and student-teachers in their professional learning experiences.

9.4 Overall Chapter by Chapter Summary

As was set out in Chapter 1, this research thesis is organised into seven chapters: the first chapter presented an introduction to the research thesis along with the main research questions, Chapter 2 focused on presenting and illustrating the relevant background information about Pakistani teacher education, policy, the challenges in teacher education in Pakistan and a profile of the University of X. Chapter 3 discussed the problems involved in defining inquiry-based pedagogy, and significant points in developing an argument for and against inquiry in order to provide a wide research field in relation to inquiry-based pedagogy in science. Chapter 4 presented the teaching methods in ITE in Pakistan. Chapter 5 presented the methodological choices which were made and the difficulties faced by this research. Chapter 6 and Chapter 7 presented the research steps of the analysis, the main

findings from the questionnaires and interviews. Chapter 8 presented a discussion of the findings from interview and questionnaire data in relation to the research questions and the literature. This final Chapter 9 concludes the overall research process by presenting recommendations and suggestions for future research.

9.5 Summary of the Main Research Findings in Pakistan

The results of this study as presented in Chapter 5 and 6, i.e. the main research findings, came from both questionnaires and interviews, which went through different stages of quantitative data analysis and qualitative content analysis. For example, the questionnaire data was channelled through different themes of analysis, tables, and questions. As a result, the major findings emerged regarding inquiry-based pedagogy as perceived by the teachers and student-teachers. This section summarises some of the overall research findings and presents the main implications of the research.

The results of this study indicated that the majority of teachers reported their perceptions of inquiry and inquiry-based pedagogy. Their responses indicated that they appreciated the benefits of teaching their student-teachers in science using inquiry-based pedagogies. Teachers' perceptions of the value of inquiry-based pedagogical instruction were that it can encourage student-teachers to become interested in learning, develop an understanding of procedure in science and become literate in science. The participants reported their intent to use inquiry-based pedagogy to teach science although they mainly use question in their own classroom. Student-teachers also recognise the importance of inquiry and inquiry-based pedagogy in ITE; they consider the value inquiry and inquiry-based learning in science. However, teachers and students also encounter several challenges when inquiry is practiced in the classroom, such as a lack of resources, insufficient time with a lengthy curriculum and a lack of university support when inquiry is practised.

The findings indicate that when teachers' inquiry-based experiences and instructional strategies are built upon by learning from a science methods course, teachers overcome their apprehensions about teaching science because inquiry-based approaches is considered capable of inculcating interest in science and critical thinking in student-teachers. Moreover, teachers appreciate their role as a facilitator of science learning. However, this research concludes that teacher-educators' understanding is inadequate about inquiry-based pedagogy. Although teacher-educators appreciate the importance of inquiry-based pedagogy to learning at a verbal level or a theoretical level, such acceptance may not be in

conflict with teachers' deeper perceptions. However, the evidence suggests that what they do is not necessarily what they say they do in the classroom. This is not to suggest dishonesty in their responses. It is an illustration what Danili (2004) described as the-reality-aspiration problem.

- The majority of teachers appreciate the role and importance of inquiry-based pedagogy in ITE although they limit the use of inquiry up to questioning about the previous knowledge. Nonetheless, most of the teachers teach the way they have always done or they were taught from their schooling, some teachers have turned to inquiry-based teaching to some extent.
- A lack of training, pedagogical knowledge and skills development within the University impacts upon the science teachers' teaching practices and choices.
- The poor facilities and resources within the University of X influence the teaching and learning processes and does not allows teacher-educators to use inquiry-based pedagogy.
- The poor levels of readiness and lack of collaboration among teachers and also between student-teachers and teachers mean that they cannot use inquiry confidently.
- Teachers and student-teachers are seldom exposed to inquiry-based pedagogies but the interest of teachers is the main push towards using inquiry-based pedagogy.
- Education culture in university has a strong influence, as teachers find it hard to apply inquiry-based methods and methodologies to their teaching, and the majority of teachers try to teach in the same way they learned.

9.6 Contributions to knowledge and the Research Implications

Although this is a mere snapshot due to the length of this report and the focus on a specific context in ITE in Pakistan, the study contributes significantly to the existing literature, and a number of compelling issues were highlighted. At the beginning of this study, a number of criticisms of inquiry-based pedagogy were put forward in terms of defining inquiry-base pedagogy, and various terms from the literature that arise ambiguities in making a solitary understanding of inquiry. As has been stated, this study did not aim to defend directly inquiry-based pedagogy (or prove/disapprove the effectiveness of inquiry-based pedagogy in ITE in Pakistan) in the contemporary situation of teaching at the University of X but it has provided interesting insights, through teacher-educators' and student-teachers'

perceptions. Thus, according to what we have learned from the research framework, research findings, and discussion, inquiry-based pedagogy is necessarily seen a useful approach to teaching and learning in ITE at the University of X.

As it was noted in Chapter 6 and 7, the majority of teacher-educators' and student-teachers' perceptions indicate that they have insufficient understanding of inquiry. Their use of inquiry-based activities is limited up to the questioning to their students about their previous knowledge. Although, it is important to note that they appreciate developing their teaching and being able to learn more about inquiry-based pedagogy. Teacher-educators and student-teachers have been facing cultural and situational difficulties; for example, lack of resources, lack of university support, and examination-based assessment at the University of X which may limit the implementation of inquiry-based pedagogy.

Therefore, this point, about teachers seeking development in ITE, can be used in support of encouraging those teachers to apply inquiry-based pedagogy in ITE, particularly, by turning examination into inquiry-based assessment. For example, teachers could be trained; they could collaborate to share their plans for teaching using inquiry-based pedagogies, also, have more autonomy in assessing their students, and this process could encourage them to develop their teaching styles and capabilities.

In addition, teacher-educators' and student-teachers' perceptions of inquiry-based pedagogy raise some key issues, in the context of practical implementation:

- Inquiry-based learning will not be easy to implement without university policies and curricula that support an inquiry-based pedagogy avoiding the need to teach student-teachers how to prepare for examinations.
- There is a pressing need to re-think assessment policies and assessment methods so that there are clear rewards for the outcomes from inquiry-based learning.
- It is clear that the conceptualisation of inquiry-based learning by teacher-educators is very inadequate. If inquiry-based learning is to take root in university life, there has to be some agreement on what constitutes such learning. The idea that inquiry-based learning is characterised as a process drive by enquiry *may* offer a key.
- This raises the question of the training of teachers. In turn, that raises the issue of who trains the teachers. Indeed, there is clear evidence that quality training does not necessarily generate changes in practice; no matter how committed the teachers are to implement such changes (El-Sawaf, 2007).

There are some good indications behind the scenes that could be used to support these views, such as the overall impressions towards development among the well-trained and female teacher-educators; those were found keen in using inquiry-based pedagogy.

9.6.1 Implications to Pedagogy

The most important finding of the present study is teachers' and students' perceptions of inquiry and inquiry-based pedagogy, especially, when the teachers with their limited understanding and limited use of inquiry have been facing requirements to change their daily teaching practices/methods in the classroom. Such a finding may simply be a reminder for teacher-educators and student-teachers to reflect their own perceptions of the importance of inquiry-based pedagogy.

The study also revealed that the administration, the education culture, examinations; lack of resources, and lack of readiness of the student-teachers at the University of X influence teacher-educators' perceptions. Therefore, each of these areas should be studied carefully, in order to draw a complete picture of the necessary preparation and support for using inquiry-based learning in classrooms. On the one hand, this would provide a point of reference for the University of X when leading the assessment change, especially, using more inquiry-based assessment. For example, the University of X should alter its traditional assessment tools to evaluate student-teachers' inquiry-based learning. As it has been discussed in the literature and chapter 8, the standardized examination (internal and external), especially those heavily relying on learning textbook content by heart, created a major difficulty for teachers in using the inquiry approach as well, as student-teachers do not recognise the benefits of inquiry-based pedagogy if they are not assessed for their ability to develop its use.

In the University of X, teachers' and students' perceptions has revealed that background constraints, especially concerning their limited understanding o inquiry-base pedagogy, lack of resources have affected the teachers' and the student-teachers' willingness and motivation to use inquiry-based pedagogy. In terms of feedback to the University of X, several suggestions may be useful, in areas such as administration, the training of teachers, the teachers' and student-teachers' readiness, and possible changes to examination.

Since inquiry-based activities require teachers to have more time to prepare and the activities themselves need more time to finish within the curriculum compared to traditional teachers' lecture methods, examination system must come along with adjustments to the amount of curriculum content and teaching time available. The University of X should not expect teachers to cover the same amount of curriculum content by using the same amount of teaching time and simply alter their teaching approach from traditional teachers' lecturing to inquiry-based learning. In addition to the problem of teaching time, the teacher to the student-teacher ratio is another major consideration, since leading an inquiry-based lesson requires more effort from teachers in facilitating student-teachers' inquiry. In terms of preparing teachers and student-teachers, the university administration should fully understand the importance of teachers' perceptions of inquiry. So, more education promoting inquiry-based strategies are needed if the university plans to promote inquiry-based curricula. Such training should at least cover the existing common practices and procedures of an inquiry-based lesson, and the pedagogical requirements of inquiry-based learning for teacher-educators and for student-teachers.

However, the teachers in this study did not often teach inquiry-based lessons in their science classes and their use of inquiry is limited. Therefore, it is possible that their initial experiences of teaching science in their own practice might be negative. In addition, it is conceivable that these teachers might not get support from the university administration; also, there has been inconsistency across other subjects and their fellow teachers in terms of implementing inquiry-based science in their classrooms which could also have a negative consequence on their readiness to teach science in this way.

9.6.2 Implications for Curriculum and Assessment

The findings from this study have implications for the design of the science courses, involving the curriculum and assessment, in order to introduce an inquiry-based form of instruction.

Specifically, the findings of this research study suggest that teacher-educators like the idea inquiry-based learning, are somewhat confused on what it involves and show considerable hesitation that they can implement such a teaching strategy. Additionally, teachers, as well as student-teachers, suggest that inquiry-based science pedagogy taught in the science methods course helps them to conceptualize their own pedagogy in science and to start defining and accepting their changing role as a facilitator.

This study found that no matter what the University of X authorities decide in relation to any alteration in the curriculum and assessment, any innovation would encounter difficulties with resources, assessment and university system; therefore inquiry-based pedagogy is not an exception. Nevertheless, the positive perceptions of teachers and student-teachers could help them to overcome the difficulties and solve problems creatively. Therefore, before asking all teachers to implement inquiry-based pedagogy in their teaching, more and deeper education, training and better resource availability are musts for the teacher-educators as well as student-teachers.

9.7 Strengths of the Study

This study has the following strengths:

- In the study, a mixed methods approach was used (teacher and student-teacher questionnaires; interviews with teachers and focus groups with student-teachers) which provided rich data in the context of the study.
- The quantitative and qualitative methods complemented each other and facilitated the gathering of in-depth information about the perceptions of teachers and student-teachers of inquiry-base pedagogy in initial science teacher education. Moreover, mixed data allows a comparison within groups of teachers and groups of student-teachers; also between the teachers' and student-teachers' data from the questionnaires.
- This is an innovative study investigating the teacher-educators' and student-teachers' perceptions of inquiry-based pedagogy in their professional teaching and learning experiences in ITE at a university specializing in teacher education.
- In particular, the study provided student-teachers and teachers with the opportunity to express their point of view and make it heard by the University, policy makers, faculties, teachers, and decision makers, higher education authorities and the research community.

To the best of my knowledge, this study is the first attempt to explore the perceptions of teacher-educators and student-teachers of inquiry-based pedagogy in ITE in Pakistan. The questionnaires and interviews generated a lot of data exploring inquiry-based pedagogy in ITE in Pakistan. It has been a good experience to obtain the findings in the statistical analysis of the questionnaires and in the qualitative analysis of the interviews.

9.8 Researcher's Recommendations

During the process of producing this research thesis, I encountered some different teaching and learning situations. According to the findings of this research thesis, I would recommend and encourage the Pakistani teachers and student-teachers at the University to consider the following ideas:

- There is clearly a need to develop a shared understanding of what constitutes inquiry-based learning. This has to involve senior managers in the university, it has to involve heads of departments, and it has to involve practising teachers. Perhaps, a member of staff needs to be seconded out for a short time, to master the literature on the subject and develop a policy document. Perhaps, also there is a need for a university-wide conference to hear from those who have grasped what inquiry-based learning means and involves, as well as giving opportunities for sharing and discussion.
- The whole area of assessment needs re-considered. Currently, the rewards come from the correct recall of memorised information. New forms of assessment need to be introduced and this will require skilful training. This will involve both university-wide policies as well as the practicalities of how to measure skills beyond recall.
- It would be useful if interested teachers could get together to discuss their classroom difficulties and student-teachers' interest in learning. Through this sort of activity, teachers might pick up more ideas and fresh views towards their classroom situations. I recommend that teachers begin discussing the classroom difficulties they face and try to read up on, and find out about, the possible solutions. Through this sort of activity, teachers will be engaged in understanding the problems and finding solutions to them.
- I would recommend that the head of the department arranges regular academic meetings to discuss practices in inquiry-based pedagogies (and other relevant pedagogies), and teachers and student-teachers' difficulties when inquiry is practised, and to take suggestions from the teachers.
- Finally, I would recommend taking a bottom-up rather than a top-down approach. This could occur through giving more freedom and autonomy to teachers' suggestions and by starting to build future plans from the existing situation instead of following instructions from the top.

9.9 Limitations of the Study and Suggestions for Future Research

The study has a number of limitations. Therefore, its findings must be interpreted in relation to the following limitations:

Looking first at the actual fieldwork undertaken, several issues are apparent:

(a) The research had to be restricted to one campus of a university, making generalisation not easy. The work was undertaken as a time when students were busy with exams and teachers were also busy with the invigilation and marking of exams, putting pressure on participants. The university studied is based in Lahore and is newly established, with limited resources. This might limit the generalisability of outcomes, suggesting further wider studies

(b) The study explored the perceptions of teachers and student-teachers using a mixed methods approach, with only questionnaires and interviews as tools. For future research the individual portraits or life stories, field notes or student-teachers' diaries, focus groups, and observation of science classes would all be likely to produce richer data to study. In addition, interviews with lab supervisors, and heads of departments in the science departments would give further illustrative insights.

(c) It would be very useful to develop some inquiry-based learning 'lessons' that could be tried out under carefully controlled conditions and the learning outcomes compared with those obtained for parallel groups of students taught more traditionally. This would identify the strengths, weaknesses and problems of the inquiry-based learning approach

9.10 Suggested Topics for Future Research

Following (c) above, a follow-up research study should be conducted by developing time efficient and paper-based material for inquiry-based learning with the teachers to look at their actual behaviours, real teaching of inquiry-based pedagogy and measure the outcomes of inquiry-based pedagogy in teaching of science. Also, a research study could be useful to explore how teachers prepare their inquiry-based lessons and assessment in using inquiry-based activities.

Moreover, I would strongly encourage more research into the teachers' pedagogical knowledge, and professional development. This point will be really helpful for future researchers who wish to examine the relationship between pedagogy and professional development in Pakistan.

9.11 Research's Final Thoughts: Contribution

Based on the findings of this research study, the contribution to the body of existing research brought by this thesis is that the research data and analysis of the questionnaires and interviews show that teacher-educators and student-teachers' understanding is inadequate and limited about inquiry and inquiry-based pedagogy though they both appreciate the value of inquiry-based pedagogy in ITE at the University of X. No research has previously been done in this area; particularly, at the University of X in Pakistan, this indicates that the study clearly contributes to the development of pedagogy in ITE at the University of X in Pakistan. Moreover, the findings of this thesis greatly improve our knowledge of the inquiry-based pedagogy of Pakistani teacher-educators and student-teachers.

Before obtaining these findings, I anticipated that the science teachers teaching science courses and the teaching method course would show a good level of understanding, knowledge and idea of inquiry-based pedagogy through their perceptions. Instead, I found that the education culture in university, assessment system and current teaching are not only the main causes that influence teacher-educators' choice of teaching method; rather it is the extent of teacher-educators' awareness and readiness of pedagogical knowledge. Some of the teachers, particularly young teachers, and most female teachers showed their knowledge of inquiry-based pedagogy; they have expressed ideas as to how they could carry out inquiry-based activities in their science classes in the present curriculum and assessment and how their exposure to it in the past enables them to do inquiry.

The teacher-educators and student-teachers pointed out that their understanding of inquiry-based pedagogy is that almost all teachers and student-teachers are likely to say that it is important to promote inquiry-based approaches in science teacher education; however, there may be differences in what is meant by inquiry-based learning in their real practices in classroom. I am pointing out that their teaching methods in science courses and examination-based assessment necessarily limit the quality of their professional practices,

but change is possible, so long as the interest in implementing and developing inquiry-based pedagogy exists.

In spite of all the barriers to inquiry-based pedagogy, inquiry will open up the development of pedagogy and help in filling the gap between pedagogy and practice. Therefore, inquiry-based pedagogy could be a good start to develop pedagogy and improve student-teachers' learning as well as teacher-educators' professional teaching practices in ITE.

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Appendices
Appendix A

University of Glasgow | School of Education

This survey seeks to explore various aspects of science teaching as part of Initial Teacher Education.

Each questionnaire form will be treated with total confidentiality.

It is hoped that the outcomes will assist in future planning.

Survey for Science Teacher-educators

Part 1: Can You tell me about yourself

1. Are you? ☐ Male ☐ Female

2. What is your age group? ☐ 24-30 ☐ 30-40 ☐ 40-50 ☐ above 50

3. What is the highest level of qualification you have?

☐ MSc in Science ☐ Masters in Education ☐ Current student (MPhil/PhD)

☐ PhD in Educational Studies ☐ PhD in Science

4. How many years have you been teaching at the university?

☐ Less than a year ☐ 1-5 years ☐ 6-10 years ☐ More than 10 years (*how many: ……*)

5. What courses do you teach?

☐ Science Courses ☐ Teaching methods Courses ☐ both type of courses

6. What training have you received in the past five years?
(Tick as many as apply)

☐ Professional development training

☐ Presentation skills (eg. how to give effective lectures)

☐ Hands-on (inquiry-based) science activities

☐ Skills for assessing students

☐ Inquiry-based pedagogy

☐ Computer skills (e.g. spreadsheets, data capture)

☐ No training offered

Part 2: About How You Teach in the Sciences

This part of the questionnaire explores your views about the teaching of science and how you help students to learn science. I am interested to know what you do to teach science effectively in Initial Science Teacher Education. Please answer honestly according to your own views, experiences and opinions.

Tick one box on each line:

SA	Strongly Agree
A	Agree
D	Disagree
SD	Strongly Disagree

7. In general, what are <u>your views about teaching science</u>?

	Views	SA	A	D	SD
(a)	I enjoy teaching science				
(b)	I like to expand my subject knowledge of science to be effective in my teaching				
(c)	My aim is to make my students question what they learn				
(d)	I want my students to be able to recall information accurately				
(e)	I like to vary my teaching style according to the student's needs				

8. How would you rate <u>your own methods of teaching science</u>?

	Views	SA	A	D	SD
(a)	I usually initiate the science topic by inquiring about students' previous knowledge				
(b)	When teaching science, I usually welcome students' scientifically orientated questions				
(c)	I like to do hands-on science activities to engage students interests in science				
(d)	I find it difficult to involve students in scientific investigations				
(e)	I like to generate the active involvement of students in science investigation				
(f)	I like to raise student curiosity by giving them time to explore the explanations of scientific phenomenon				

9. Here are some aims for learning in the sciences
Tick the <u>three</u> which you consider as most important

- ☐ To enable students to understand the key ideas of science
- ☐ To allow students to see how scientific discoveries have made an impact on society
- ☐ To enable students to understand how scientific discoveries take place
- ☐ To train and develop the science teacher for the future
- ☐ To enable students to know all the important facts of science
- ☐ To enable students to understand the place of experimentation in gaining understanding
- ☐ To enable students to see the major contribution sciences have made in the world
- ☐ To train and develop the scientists for the future

Part 3: Three Ways of Thinking

Inquiry-based Pedagogy

Definition: A way of teaching that helps students achieve science understanding by combining scientific knowledge with reasoning and thinking skills. The role of the teacher is to act more as a facilitator of learning.

Scientific Literacy

Definition: Knowing and understanding scientific concepts and science processes so that students are equipped for personal decision making, participation in civic and cultural affairs, and economic productivity.

Procedural Understanding

Definition: Describes the understanding of ideas about how the sciences gather evidence, which underpins an understanding of how to proceed in scientific investigations.

The next questions explore how you see these ideas.

10. What are your <u>views on Inquiry-based Pedagogy in science in Initial Science Teacher Education</u>?

	Views	SA	A	D	SD
(a)	I believe that an inquiry-based pedagogy in science to teaching does not result in much learning				
(b)	I like the idea of being a facilitator of learning by allowing the students to learn in groups				
(c)	I feel that an inquiry-based pedagogy in science is a more effective style of teaching science rather than lecturing				
(d)	I think inquiry-based pedagogy in science will benefit students who are only seeking the right answers				
(e)	I think that an inquiry-based pedagogy in science should be used in initial teacher education				
(g)	Teachers should be taught how to use inquiry approaches in science				
(g)	I think that inquiry-based pedagogy in science will help produce better science literacy				
(h)	I think that an inquiry-based pedagogy will help develop procedural understanding				
(i)	Skills in handling open-ended problems are critical for my students				
(j)	I think that ways of thinking are more important what we understand				
(k)	I think that an inquiry-based pedagogy in science will encourage critical thinking				

11. Thinking of your teaching of your own students, place ONE tick on each line to show how important or otherwise each of the following are to you.

	The aim for my students is to develop …..	*Essential*	*Very important*	*Of some importance*	*Not important*
(a)	Science subject knowledge				
(b)	Abilities to carry out experiments properly				
(c)	Procedural knowledge of science (how science works)				
(d)	Scientific literacy				
(e)	Understanding of the key ideas of science				
(f)	Skills in passing examinations in the sciences successfully				
(g)	Positive attitudes towards science				
(h)	Ability to think critically and challenge ideas				

Part 4: More about Inquiry-based Pedagogy in science and Learning

12. Think of your own teaching and your own students

	Views	SA	A	D	SD
(a)	I should like to develop a more inquiry-based style of teaching				
(c)	I should like to see the library and the internet used more in science teaching				
(d)	My student are not mature enough to learn using an inquiry-based approach				
(e)	Examinations mostly test the ability to recall information				
(f)	Science learning at school needs to engage the students in themes affecting our lifestyles today				
(g)	I should like to develop experimental work which illustrates how science operates				
(h)	Inquiry-based learning will need much more time				
(i)	National Examinations must change to assess skills of understanding and of thinking				
(j)	It is not possible to test students for their abilities in inquiry-based skills				
(k)	I could not have access to enough resources to teach using an inquiry-based method				
(l)	Inquiry-based approaches will work well only with the most able students				

13. What are the <u>key barriers</u> in seeking to develop an inquiry-based approach in science?
Tick one box on each line

		Cannot be Overcome	*Serious Barrier*	*A Minor Problem*	*Easily Solved*
(a)	There is insufficient time				
(b)	Will not give good examination results				
(c)	Leaves the curriculum unstructured				
(d)	Makes classroom management very difficult				
(e)	There is not enough equipment to teach this way				
(f)	Universities would not support it				
(g)	The method is not consistent with the way other subjects are taught				
(h)	The learners will be left confused				
(i)	I have not been taught using an inquiry-based approach very much				

15. If you wish discuss the ideas further and are happy to be involved in a brief informal interview, please provide your contact details

Name: .....

Email: ..... or phone: .....

Thank you for your Help

Appendix B

University of Glasgow | School of Education

This survey seeks to explore various aspects of science teaching as part of Initial Teacher Education.

Each questionnaire form will be treated with total confidentiality.

It is hoped that the outcomes will assist in future planning.

Survey for Science Student-Teacher

Part 1: Can you tell me a little about yourself

1. **Are you?** ☐ Male ☐ Female
2. **Type of school you studied at?** ☐ Private ☐ Public
3. **The language of instruction in your school?** ☐ English ☐ Urdu
4. **In which year you are?**

☐ 1st year ☐ 2nd year ☐ 3nd year

5. **Which of these courses you have been studying?**

☐ Science Courses ☐ Teaching methods Course ☐ both type of courses

********** **********

Here are three aspects of science learning

Inquiry-based pedagogy

Definition: A way of teaching that helps students achieve science understanding by combining scientific knowledge with reasoning and thinking skills. The role of the teacher is to act more as a facilitator of learning.

Scientific Literacy

Definition: Knowing and understanding scientific concepts and science processes so that students are equipped for personal decision making, participation in civic and cultural affairs, and economic productivity

Procedural Understanding

Definition: Describes the understanding of ideas about how the sciences gather evidence, which underpins an understanding of how to proceed in scientific investigations

Next questions explore how you see these ideas.

Part 2 About how you learn in the Sciences

This part of the questionnaire explores your views on science and experiences about learning sciences.
I am interested to know how you learn science in your Initial Science Teacher Education.
Please answer honestly according to your own views, experiences and opinions.

Tick one box on each line:

SA Strongly Agree
A Agree
D Disagree
SD Strongly Disagree

6. In general, what are your views about learning sciences?

	Views	SA	A	D	SD
(a)	I enjoy learning science as a subject				
(b)	I enjoy solving open-ended science problems				
(c)	I am curious to explore science more				
(d)	I only enjoy science when I am doing experiments				
(e)	I only like memorising subject knowledge in science courses				
(f)	I find open-ended science problems very difficult				
(g)	I feel science is very important in all aspects of life				
(h)	Learning science through inquiry-based activities in science appeals to me				
(i)	I do not think I should learn as well if I was taught using an inquiry-based approach				

7. Think about the way your teacher works in your Initial Science Teacher Education courses.

	Views	SA	A	D	SD
(a)	Acts as a facilitator in the science classroom				
(b)	Presents the science content as material to be memorised				
(c)	Encourages me whether I solve science problem correctly or not				
(d)	Welcomes my scientifically oriented questions				
(e)	Motivates me to seek the answers to open-ended science problems				
(f)	Involves me in too much written work in science				
(g)	Involves me through hands-on science activities in scientific investigations				
(h)	Sets test and examinations that allow me to show all I can recall				
(i)	Teaches the science mainly through lecturing				

8. Here are some aims for learning in the sciences
Tick the three which you consider as most important

☐ To enable students to understand the key ideas of science

☐ To allow students to see how scientific discoveries have made an impact on society

☐ To enable students to understand how scientific discoveries take place

☐ To enable students to know all the important facts of science

☐ To train and develop the science teacher for the future

☐ To enable students to understand the place of experimentation in gaining understanding

☐ To enable students to see the major contribution sciences have made in the world

☐ To train and develop the scientists for the future

Part 3: This explores how you see inquiry-based learning

9. How do you think inquiry-based learning might help learning?

	Views	SA	A	D	SD
(a)	Enables me to learn how to identify and ask appropriate questions/science problems				
(b)	Enables me to only seek the right solutions to science problems				
(c)	Allows me to explore science concepts on my own				
(d)	Enhances my curiosity to involve me in open-ended science investigations				
(e)	Enables me to use appropriate equipment/material to analyze and interpret data				
(f)	Enables me to take ownership of my learning during scientific investigations				
(g)	Encourages a thought-out solution when I do practical work in science investigation				
(h)	Develops my critical thinking to evaluate the evidence in scientific investigations				

10. How do you as a science student-teacher perceive <u>the role of Inquiry-based pedagogy in science in developing scientific literacy in students</u>?

	Views	SA	A	D	SD
(a)	Enables me to see science as a subject that educates me as a scientifically literate person				
(b)	Enables me to understand the use of science and its applications in my daily life				
(c)	Enhances my understanding of the procedure of scientific investigation				
(d)	Provides me with opportunities to gain insights into scientific concepts				
(e)	Enables me draw evidence-based conclusions about science-related issues				
(g)	Enables me to use reference science journals, the internet, and the library to research science information				
(h)	Improves my understanding of ideas associated with the interpretation of data in science experiments				

11. Thinking of inquiry-based pedagogy, place ONE tick on each line to show how important or otherwise each of the following are to you.

	The aim for my students is to develop …..	*Essential*	*Very important*	*Of some importance*	*Not important*
(a)	Science subject knowledge				
(b)	Abilities to carry out experiments properly				
(c)	Procedural knowledge of science (how science works)				
(d)	Scientific literacy				
(e)	Understanding of the key ideas of science				
(f)	Skills in passing examinations in the sciences successfully				
(g)	Positive attitudes towards science				
(h)	Ability to think critically and challenge ideas				

Part 4: This focuses on the way you might like to teach in the real-world of schools.

12. Think of inquiry-based pedagogy in science and the practicalities of teaching in science

	Views	SA	A	D	SD
(a)	I should like to develop a more inquiry-based style of teaching				
(b)	I should like to see the library and the internet used more in science teaching				
(c)	Examinations mostly test the ability to recall information				
(e)	Inquiry-based learning will need much more time				
(f)	National Examinations must change to assess skills of understanding and of thinking				
(g)	I should like to develop experimental work which illustrates how science operates				
(h)	It is not possible to assess students for their abilities in inquiry-based skills				
(i)	I could never have access to enough resources to teach using an inquiry-based method				
(j)	Inquiry-based approaches will work well only with the most able students				

13. What are the <u>key barriers</u> in seeking to develop scientific inquiry-based approach?
Tick one box on each line

		Cannot be Overcome	*Serious Barrier*	*A Minor Problem*	*Easily Solved*
(a)	There is insufficient time				
(b)	Will not give good examination results				
(c)	Leaves the curriculum unstructured				
(d)	Makes classroom management very difficult				
(e)	There is not enough equipment to teach this way				
(f)	Universities would not support it				
(g)	The method is not consistent with the way other subjects are taught				
(h)	The learners will be left confused				
(i)	I have not been taught using an inquiry-based approach very much				

14. If you wish discuss the ideas further and are happy to be involved in a focus group interview, please provide your contact details:

Name: ……..

Email: …… or

phone:

……

Thank you for your Help

Appendix C

Interview protocol for Science Teacher-Educators

Through this interview, I am interested to explore what you as a science teacher-educator think about certain aspects of inquiry-based pedagogy in science in Initial Science Teacher Education. This interview allows flexibility to change the sequence and material of questions.

Introduction

- Read through Plain Language statement
- Explain the ethics
- Acquire the signed consent form
- Explain to interviewee Interviews will be audio-taped with your permission and will last for approximately 40 minutes.
- Start the interview
- Introduce myself and then interviewees introduction

Interviewee's Background Information

- Year/s of experience?
- Courses taught in the current semester?
- What courses you have been taught?

Interview Questions

1. **Would you please tell me about your experiences of teaching science in initial science teacher education programme?**

    a) Do you enjoy teaching science?
    b) Describe what an effective science lesson is like in your classroom and why you think it is effective.
    c) What is the most rewarding aspect of teaching science in your opinion?
    d) What is the most frustrating aspect of teaching science in your opinion?
2. **How did the science teaching methods courses or science course you taught at university influence your views about teaching of science?**
3. **What is your understanding of an Inquiry-based pedagogy?**
4. **In your opinion, what are the basic elements of Inquiry-based pedagogy in science?**
5. **Think of your own teaching and the 'Inquiry Approach to Teaching in science':**

- What a typical an Inquiry-based lesson is like in your classroom.
- What is your role as a teacher-educator?
- How do you think science students learn science best?
- How do you use resources to develop the understanding of the procedure in scientific investigation?
- What do you think there a particular reason why you could not use Inquiry-based pedagogy in science very much?

6. **In your opinion, how an Inquiry-based pedagogy is related with the role of science in initial science teacher education?**
7. **What is your understanding of scientific investigation?**
   - **How do you attempt to realise the impact of Inquiry-based pedagogy in science on scientific investigations?**

8. **What is your understanding of Scientific Literacy?**

   a) What do you think the role of the Inquiry-based pedagogy in science in developing scientific literacy is?
   b) Do you consider that the Inquiry-based pedagogy in science aims to educate student to be scientifically literate citizens, or effective science teachers, scientists or all of the above?

9. **What do you understand about "procedural knowledge" in scientific investigations"?**

   - What is your opinion on how the Inquiry-based pedagogy in science relates students' procedural knowledge to scientific investigation?

10. **What do you think are the benefits when the** Inquiry-based pedagogy in science **to teaching is practised?**

    - Do you think that Inquiry approach to teaching is the best way to teach science? Why or why not?

11. **What do you think are the difficulties when the** Inquiry-based pedagogy in science **is practised?**

    a) What do you identify the most important challenges for you?
    b) What is your opinion about the science curriculum and Inquiry-based pedagogy?
    c) What is your opinion about the relationship between the Inquiry-based pedagogy in science courses and classroom management in the science classroom?
    d) What is your opinion about the relationship between the Inquiry-based pedagogy in science courses and assessment in the science classroom?

Appendix D

University of Glasgow | School of Education

Focus Group protocol for science student-teachers

This focus group interview allows flexibility to change the sequence and material of questions.

Introduction

- Read through Plain Language statement
- Explain the ethics
- Acquire the signed consent form
- Explain to interviewees that the interview will be audio-taped with their permission and last for approximately 50 minutes.
- Start the interview
- Introduce myself and then interviewees introduction

Interviewee's Background Information

- Year of study?
- Courses in the current semester?
- What courses they have been studied?

Interview Questions

1. Do you like science?
2. What do you think of your own teacher's teaching in science?
3. What do you think how students learn the science best?
4. How did the teaching methods of science courses you took in university influence your views about learning of science?
5. What is your understanding of the Inquiry-based pedagogy?
6. What is your opinion how scientific inquiry-based pedagogy helps learning sciences in Initial Science Teacher Education?
7. How do you attempt to realize the impact of Inquiry-based pedagogy to scientific investigations?
8. What is your understanding of scientific literacy?
9. What do you think of the role of Inquiry-base pedagogy in developing scientific literacy?
10. Would you please tell me your understanding of the 'procedural knowledge'?
11. How do you understand the relationship between procedural knowledge and scientific inquiry?
12. What do you think of inquiry-base pedagogy and practicalities of teaching as a future teacher?
13. Would you please tell me the key barriers which impede your learning when Inquiry-based pedagogy in science is practiced? What do you think is the most important barrier?

Appendix E

Plain Language Statement for Teachers-educators

1. Project Title

An Investigation of Pakistani University Teachers' and Students' perceptions of Inquiry-based Pedagogy in their Professional learning Experiences in Initial Teacher Education

Researcher: Nasrin Akhter
PhD Student

2. Invitation paragraph

You are being invited to take part in this PhD research, which I am undertaking at University of Glasgow, UK. Before you decide, it is important for you to understand why the research is being done and what it will involve. Please read the following information carefully. Take time to decide whether or not you wish to take part. Ask me if there is anything that is not clear or if you would like more information.

Thank you for reading this.

3. Purpose of the study

This research aims to explore the role and importance of Scientific Inquiry-based pedagogy in the teaching of science in initial science teacher education in Pakistan. This research seeks to explore the science teacher-educators' understanding of the importance of Scientific Inquiry in developing scientific literacy.

4. Benefits of the study

The current study is an interesting area in the field of science teaching as there is little research being done on this subject matter, particularly in initial science teacher education in Pakistan. Your participation in this research study might help teacher-educators to evaluate whether the Scientific Inquiry-based pedagogy is effective in helping student-teachers understand the inquiry form of science instructional strategies.

5. Why you have been chosen?

You are being approached because you are a science teacher-educator. You are the teacher-educator at a professional Education University (specialized in education) and are part of a wider population in University of Xin the Punjab province (Pakistan).

6. What would be expected of you?

Your participation is entirely voluntary and even if you decide to take part in this research, you can withdraw your participation at any time without giving any reason. You will participate in a questionnaire survey. You should record a response which best represents your opinion as there is no right or wrong answer. The questionnaire should take approximately **40** minutes to complete.

Afterwards, if you agreed, you would be invited to be part of further research in an interview. The interviews will be conducted on the university campus at a mutually agreed date and location. The interview will be audio-taped. The interview will last for approximately 40 minutes. The interview questions will require you to expand more on the responses you gave in the questionnaire. The interviews explores your views and experiences of teaching of science,

your opinions of the role of Scientific Inquiry-based pedagogy, and the importance of *Scientific Inquiry* in developing *Scientific Literacy*.

7**. Confidentiality of the participants**
Responses to the questionnaire will be completely anonymous. Your name will not be mentioned in the written report based on the findings of the questionnaire and interview. In addition, the data given by you will be kept in the locked filing cabinets at University of Glasgow, UK. The data will be destroyed once research results have been obtained.

8. The results of the research
After the final data analysis, a summary of the research finding will be made available to you if you request it and an electronic copy of my thesis will be available from the University of Glasgow Library. The results of this research will be written up as a PhD thesis. Please note that your details will not be mentioned anywhere in future publication. You will be referred to by pseudonym in any publication arising from the research.

9. Who is organizing and funding the research?
This research project is funded under the faculty development program by the Higher Education Commission of Pakistan and being supervised by the school of Education, University of Glasgow, United Kingdom.

10. Ethics
This research has been reviewed and approved by Ethics Committees of School of Education, University of Glasgow, UK.

11. Contact for further information
If you have any more questions or would like additional information about the research, you can contact me (Miss Nasrin Akhter) directly by email on n.akhter.1@research.gla.ac.uk

If you have any concerns relating to the conduct of the research then you should contact the School of Education Ethics Mrs Irene McQueen, her email address is: Irene.McQueen@glasgow.ac.uk

If you decide to participate, please fill in the consent form which is attached with this letter. Irrespective of your decision of being part of this study, thank you for devoting some time to reading the information provided and considering its contents.

This information sheet is yours to keep.

Appendix F

University of Glasgow | School of Education

Title of Project:
An Investigation of Pakistani University Teachers' and Students' perceptions of Inquiry-based Pedagogy in their Professional learning Experiences in Initial Teacher Education
Participant: Science teacher-educator

1. I confirm that I have read and understand the Plain Language Statement for the above study and have had the opportunity to ask questions.
2. I understand that my participation in completing the questionnaire and in individual interview is voluntary and that I am free to withdraw at any time, without giving any reason.
3. I know that the interview will be audio-taped with my permission.
4. I understand that my name and other data will not be revealed to anybody other than the researcher. I also understand that this research will use pseudonym in any of publications arising from this research I am involved in.
5. I consent to (Please tick **Yes** or **No**)

   i. Complete the questionnaire Yes/No
   ii. Being interviewed Yes/No
   iii. The interview being audio tape-recorded Yes/No

Name of Participant	*Date*	*Signature*
Researcher	*Date*	*Signature*

Appendix G

University of Glasgow | School of Education

Plain Language Statement for Student-teachers

1. Project Title

An Investigation of Pakistani University Teachers' and Students' perceptions of Inquiry-based Pedagogy in their Professional learning Experiences in Initial Teacher Education

Researcher: Nasrin Akhter
PhD Student

2. Invitation paragraph

You are being invited to take part in this PhD research, which I am undertaking at University of Glasgow, UK. Before you decide, it is important for you to understand why the research is being done and what it will involve. Please read the following information carefully. Take time to decide whether or not you wish to take part. Ask me if there is anything that is not clear or if you would like more information.

Thank you for reading this.

3. Purpose of the study

This research aims to explore the role and importance of Scientific Inquiry-based pedagogy in the teaching of science in initial science teacher education in Pakistan. This research seeks to explore the science teacher-educators' understanding of the importance of Scientific Inquiry in developing scientific literacy.

4. Why you have been chosen?

You are being approached because you are science student-teacher. You are the student of a professional Education University (specialized in Education) and are part of a wider population in University of Xin Punjab province (Pakistan). It is assured that your decision to participate will not affect your grades in any way.

5. What would be expected of you?

Your participation is entirely voluntary and even if you decide to take part in this research, you can withdraw your participation at any time without giving any reason. You will participate in a questionnaire survey. You should record a response which best represents your opinion, there is no right or wrong answer. The questionnaire should take approximately 40 minutes to complete.

Afterwards, if you agreed, you would be invited to be part of further research in a focus group interview. The focus group interviews will be conducted on the university campus at a mutually agreed date and location. The focus group interview will be audio-taped and will last for approximately 50 minutes. The focus group interview questions will require you to expand more on the responses you gave in the questionnaire.

6. Confidentiality of the participants

Your response to the questionnaire and focus group interview will be completely anonymous. Your name will not be mentioned in the written report based on the findings of the questionnaire and focus group interview. In addition, the data given by you will be kept in the locked filing cabinets at University of Glasgow, UK. The data will be destroyed

once research results have been obtained.

7. The results of the research

After the final data analysis, a summary of the research finding will be made available to you if you request it and an electronic copy of my thesis will be available from the University of Glasgow Library. The results of this research will be written up as a PhD thesis. Please note that your details will not be mentioned anywhere in future publication. You will be referred to by pseudonym in any publication arising from the research.

8. Who is organizing and funding the research?

This research project is funded under the faculty development program by the Higher Education Commission of Pakistan and being supervised by the school of Education, University of Glasgow, United Kingdom.

9. Ethics

This research has been reviewed and approved by Ethics Committees of School of Education, University of Glasgow, UK.

10. Contact for further information

If you have any more questions or would like additional information about the research, you can contact me (Miss Nasrin Akhter) directly by email on nasrin_cs2005@hotmail.com

If you have any concerns relating to the conduct of the research then you should contact the School of Education Ethics Mrs Irene McQueen, her email address is: Irene.McQueen@glasgow.ac.uk

If you decide to participate, please fill in the consent form which is attached with this letter. Irrespective of your decision of being part of this study, thank you for devoting some time to reading the information provided and considering its contents.

Thank very much for reading and this information sheet is yours to keep.

Appendix H

University of Glasgow | School of Education

Title of Project:

An Investigation of Pakistani University Teachers' and Students' perceptions of Inquiry-based Pedagogy in their Professional learning Experiences in Initial Teacher Education

Participant: Science student-teacher

2. I confirm that I have read and understand the Plain Language Statement for the above study and have had the opportunity to ask questions.
6. I understand that my participation in completing the questionnaire and in focus group interview is voluntary and that I am free to withdraw at any time, without giving any reason.
7. I know that the interview will be audio-taped with my permission.
8. I understand that my name and other data will not be revealed to anybody other than the researcher. I also understand that this research will use pseudonym in any of publications arising from this research I am involved in.
9. As a student, I understand that my participation/non-participation in this research study will not have any effect on my examination or grades.
10. I consent to (Please tick **Yes** or **No**)

iv.	Complete the questionnaire	Yes/No
v.	Being involved in a focus group discussion	Yes/No
vi.	The focus group interview being audio tape-recorded	Yes/No

Name of Participant	*Date*	*Signature*
Researcher	*Date*	*Signature*

Appendix I

University of Glasgow | College of Social Sciences

Ethics Committee for Non Clinical Research Involving Human Subjects

EAP4 NOTIFICATION OF ETHICS APPLICATION OUTCOME

Application Type: Resubmission
(select as appropriate)

Application Number: EA1815R
Please add R to the end of the application number if this review is for a resubmitted application.

Applicant's Name: Nasrin Akhter

Project Title: Teaching Science in Pakistan: an investigation of the extent to which science teacher – educators in a university in Punjab province encourage their students to develop an inquiry-based pedagogy

Date Application Reviewed: 9th March 2011

APPLICATION OUTCOME

(A) Fully Approved
(select from drop down as appropriate)

Start Date of Approval: 9 March 2011 End Date of Approval: 5 January 2013

If the applicant has been given approval with amendments required, this means they can proceed with their data collection, with effect from the date of approval. The College Ethics Committee expects the applicant to act responsibly in addressing the recommended amendments. **The amendments should be submitted to the Research Office** for completion of the applicant's ethics file. An acknowledgement that all requested amendments have been made will be made within three weeks of receipt.

(B) Application is Not Approved at this time ☐

Please note the comments below and provide further information where requested. The full application should then be resubmitted to the Research Office via e-mail to Terri.Hume@glasgow.ac.uk.

(C) Select Option
(select as appropriate)
This section only applies to applicants whose original application was approved but required amendments.

Major Recommendations

Not applicable.

Minor Recommendations

Not applicable.

Please retain this notification for future reference. If you have any queries please do not hesitate to contact Terri Hume, Ethics & Research Secretary, in Room 104, Florentine House, 53 Hillhead Street, Glasgow G12 8QF.

Appendix J
A letter of Permission for Data Collection

UNIVERSITY OF EDUCATION, LAHORE

No. UE/R/2010/ 2215
June 01, 2010

Ms. Nasrin Akhter
PhD Foreign Scholarship awardee
University of Glasgow, UK

Subject: **Permission to collect data from the University of Education, Lahore**

Please, refer to your request via e-mail dated 24.05.2010 regarding above cited subject.

I have been directed to inform that your request to collect data from UE students enrolled in BSc BEd programme and teachers in UE Campuses has been acceded to, subject to the condition that the collected information will be used for research purpose only.

Prof. Dr. Muhammad Saeed Akhtar
Acting Registrar

cc.

1. SO to the Vice Chancellor, University of Education, Lahore
2. Office copy

College Road, Township, Lahore, Pakistan Tel: +92 42 3521 6530 Fax: + 92 42 9926 2226

Appendix K
Interview Transcripts

T8 Interview, Date: 5th April 2011

Introduction by Interviewer: I would like to explain a few points before I start the interview. The purpose of this interview is to find out your views and opinions about the role and importance of inquiry-based pedagogy in Initial Science Teacher Education. The results of this research will be written up as a thesis. Your name will not be mentioned in the transcripts and in the written report based on the findings of the interview, so your responses will be completely anonymous. This interview is semi-structured in style and I could be flexible in the sequence and order of questions. So it is not a test and there is no right or wrong answer. You are allowed to say anything you wish to.

Qualification: PhD and Post Doctorate in Zoology Courses you teach: Zoology Gender: Male
Years of Experiences: 12 years (2 years at university) Age group: 40-45

1. **Could you please tell me about your experiences of teaching science in initial science teacher education program?**

T8: I started teaching in schools first. I have been teaching science for 12 years. I have been teaching at this university since 2009. I have been a school teacher since before my PhD. I did my post-doc from a good research-based American University. So I noticed a great difference in teaching in this university when I joined after my post doctorate. The majority of students coming in this university are from poor family background or low social-economic status families. Also, the students do not have excellent academic achievements. Our students aim to be teachers and get a job as soon they can. Their intention/aim is not to learn science deeply; nor to be researchers in science. Unfortunately, we do not have students with good/high achievements in this university. Highly able students do not come to be a teacher. They join medical colleges or Engineering degrees. In this university, we have the remaining population of students, those unable to get admission elsewhere. So they better choose to be a teacher or just want admission in university. Unfortunately, in our culture/education system, it is assumed that who cannot become scientist/engineer/doctor, could go into the teaching profession.

a) **Do you enjoy your teaching in science?**

T8: To a great extent, I enjoy teaching science. After leaving my school job, I worked as a zoologist and now I am basically a researcher. I have worked in an American university as a zoologist and was a funded researcher as part of my post doctorate. I joined university with a passion to teach and encourage researchers but I found the actual experience to be quite the opposite of my expectations. The university runs a teacher developer programme. I try to do the best I can, and I aim to see my students developing a deep learning of science.

b) **Describe what an effective science lesson is like in your classroom and why you think it is effective.**

T8: I ask students questions. I engage them in small group discussions. I encourage students to ask me questions. I praise them if they take the initiative in taking part in classroom activities.

c) **What is the most rewarding aspect of teaching science in your opinion?**

T8: I learn from my students. I learn from all my teaching and the time I spend with my students. I also learn new things with students; I also get new stuff to read so as a teacher I feel that I am a lifelong learner. I think that my learning through my teaching is the rewarding aspect of my teaching.

d) **What is the most frustrating aspect of teaching science in your opinion?**

T8: I feel irritated when I do not have sufficient resources to teach in the classroom. It seems impossible to teach using inquiry in such circumstances. I also feel frustrated when I do not get desired responses from students when inquiry-based strategies are used with them. They do not reflect them proactive in responding or still remains passive.

2. **How did the science teaching methods courses or science course you taught at university influence your views about teaching of science?**

T8: I started my teaching from school. I learned throughout from all of my experiences of teaching. This really influences on my teaching of science and I improved a lot. In university, I teach zoology courses. I did not teach science method course. My teaching style involve students, they participate in class, discuss in groups and reflect the conclusion of their discussion. I am not an orthodox or stereotype teacher. Teaching Science method course is part of teacher education programme and it is different with the substantial knowledge of any science course we are teaching. Sometime, I feel that I am confused by teacher education course or science course make confused students with this course. Students have interest in science course show little interest in teaching methodology knowledge as it should be. I think university should establish an organised set of courses; students should study in each semester.

3. **What is your understanding of <u>an Inquiry-based pedagogy</u>?**

T8: Inquiry is a method of teaching that helps students achieves science understanding deeply. Students could develop reasoning and thinking skills. Students do not memorise though understand the concepts, and construct their understanding/knowledge; that is the desired outcome to achieve by students. I argue that

inquiry-based teaching is tricky in our teacher education. As I mentioned, the people who are coming to teach at public sector universities, are not trained to use it. They most probably have not studied through inquiry-based teaching. Also, students are also not or a little prepared for using inquiry from their school background. Even they are not ready to use it. I would say that they are not willing to use it. The teacher is working at elementary schools is currently not using inquiry very much.

4. in your opinion, what are the basic elements of Inquiry-based pedagogy in science?

T8: Inquiry includes a range of activities, questions could motivate students to be active and find the answers; field work activities, solving open-ended problem. Students could get a chance to demonstrate their ideas and develop their thinking and sharing their ideas. I enjoy field-work activities with my students when I plan a learning trip. I would say that if teacher is prepared and willing to do it then teacher could engage students using inquiry.

5. Think of your own teaching and <u>the 'Inquiry Approach to Teaching in science':</u>

a) **What a typical an Inquiry-based lesson is like in your classroom.**

T8: Many things could be focused in teaching an inquiry-based lesson in the classroom to develop the understanding of scientific concepts. I do in my zoology lessons. I arrange quizzes to engage students in looking for the answer. I assign question/problem and make groups and give time to discuss in a group and bring a solution. I personally believe that students learn best in groups; they learn to collaborate; they learn from each other. I mostly arrange group discussions.

b) **What is your role as a teacher-educator?**

T8: I vary my role during my teaching; try to be an effective teacher as a guide or a facilitator; some time a lecturer. I think I cannot teach all with inquiry; or it depends on topic, some topics in zoology needs explanation. I enjoy explaining but I am not a dictator in the class. I am a polite person. It depends on the topic or sometimes on the class size at what extent I encourage the use of inquiry though I do not allow my students to go wrong in discipline. Some teachers believe that students are better disciplined in a lecture setting so lecture is the best method to teach them. Students come from villages and poor background; not well prepared with a friendly teaching environment. So our students become confused; not ready for it and are not proactive and be responsive immediately.

c) **How do you think science students learn science best?**

T8: I believe that students learn through activities; and also when they discuss in group. I think they learn best in groups. As I said we have students coming with low academic achievements and not very able. The group discussion is the best idea with them. Low confident students get a chance to develop their confidence. They share and reflecting their ideas. I manage group talks among students without any resources so it is convenient for a teacher.

d) H**ow do you use resources to develop the understanding of the procedure in scientific investigation?**

T8: I believe that students work in hands-on activities and really learn best. I must say that resources are required for activities in Lab and during scientific investigation. I am teaching biology that's why I prefer to use Lab resources and equipment to demonstrate in Lab as well as class if I required.

e) What do you think there is a particular reason <u>why you could not use Inquiry-based pedagogy in science</u> very much?

T8: I like to teach using inquiry personally though there are several constraints. I think there are certain problem for example that lack of resources, short of time and insufficient space for laboratory. These problems do not allow me to use inquiry-based teaching very much.

6. In your opinion, how an Inquiry-based pedagogy is related with the role of science in initial science teacher education?

T8: Inquiry is really an excellent method of teaching. It makes student an understanding of the basic phenomena of science. Application of science comes through scientific method so understanding of science is very important for students. I agree that inquiry-based pedagogy do the same role as scientific method does. Scientific method develops a positive attitude through a procedure and it is basically part of scientific inquiry.

7. What is your understanding of scientific investigation?

T8: scientific investigation is the process to explore scientific phenomena through a procedure. Scientific inquiry plays a very important role. It is the process of exploration of science that students need to understand though students do with resources or without resources.

a) **How do you attempt to realise the impact of Inquiry approach in science on scientific investigations?**

T8: inquiry-based pedagogy involves students with the process of science. I believe that scientific investigation is the real essence of learning and understanding of science. So I think inquiry-based instruction leads towards the exploring and discovering science. Inquiry-based activities led our students to develop an understanding of science method and also develop a positive attitude towards science applications. There is a concern to think that we need a proper environment and resources to do scientific investigation in our Labs. Otherwise inquiry-based pedagogy is a frustrating experience.

8. What is your understanding of scientific <u>Literacy</u>?

T8: I think scientific literacy is a person's ability to understand science and apply it to the wider world. So it

must be a part of learning in science as well as teaching… so that our student could be aware of the use of science in their daily life. Furthermore, what I understand that scientific literacy is about knowing and understanding scientific concepts, applications, and processes so that students should be equipped with science literacy. No one can ignore the role of science and significance of science in providing luxuries and making life easier. Inquiry really could play a significant role in developing science literacy in our students.

When we give students in open-ended problem to solve in biology ; I encourage them to read books, article, journals, look at recent research using internet and other papers, watch national Geographic and relevant TV programmes. These all readings develop their understanding, and thinking. They become able to overcome superstitions or common-sense understandings. I have said that majority of our students are coming from village backgrounds and from working class, their parents are illiterate so they become superstitious the way they are brought up. Science literacy plays a worthy role in improving their thinking and help them to be scientific minded.

a) What do you think the role of the Inquiry-based pedagogy in science in developing scientific literacy is?

T8: The importance of inquiry in developing science literacy is very obvious; particularly, we cannot ignore it. The more inquiry-based activities student use, they are more engaged in developing scientific literacy because they understand how science is applicable in their daily life. Inquiry-based pedagogies and activities helps students in decision-making, even develop an understanding of civic and cultural affairs, and economic productivity relevant with type progress of science.

b) Do you consider that the Inquiry-based pedagogy in science aims to educate student to be scientifically literate citizens, or effective science teachers, scientists or all of the above?

T8: I would say that our initial teacher education is developing students as science teacher… only science teachers. Our students have low achievement in University of x. The students who got high marks want to go to better ranked universities. This university is a relatively new one so we are in the process of developing scientific research culture. We are in the process of getting resources to develop our good standardized laboratories in pure sciences such as Botany and Zoology. We are also building a structure to meet the standards of good science education. We focus only at the moment to train our students to be science teachers though that is not only the aim. Our focus should develop the students have a deep understanding of science concepts. I think it will take time in this university for our students to develop their scientific literacy, or become scientists or specialists, or to go to fields other than teaching in job market.

Although there are other issues to be discussed; our science program is not only science, students are given teacher education so this B.Sc. B.Ed. course is a mix of science education and teacher education. It is confusing for science teachers what we are producing after all. Those who have interest in science, they cannot show good progress in teacher education though they have to study these teacher education courses. So outcome is not to develop them a perfect teacher or a science teacher. Another great concern is the quality of teacher education… our students are not developed as competent enough teachers to be offered jobs from highly paid private schools. So they ultimately get jobs in public sector schools where the selection-criteria are their exam-Marks rather their teaching qualities. I am not against teacher education program; of course it is an attraction of university for students to join this programme if they want to be science teacher; but I like if university offer a separate teacher education degree for students after their undergraduate like B.Ed. or PGDE in science. The students should have a separate undergraduate science degree in Zoology or other science areas. I believe scientific inquiry in teaching of zoology could be more effective but cannot be used in teaching of Teacher education courses; might be some other activities... furthermore; if I have a good student in zoology, I would not refer him to be only a science teacher unless he wants to be a science teacher.

9. What do you understand about "procedural knowledge" in scientific investigations"?

T8: I think that procedural understanding is helpful in understanding of science process/concepts in a systematic way. It tells students how the sciences gather evidence, test it and conclude/ develop theories in science. In short, it develops an understanding of how to carry on in scientific investigations.

a) **What is your opinion on how the Inquiry-based pedagogy in science relates students' procedural knowledge to scientific investigation? How would you explain?**

T8: I think inquiry-based pedagogy is very helpful. Its importance in developing procedural understanding in scientific investigation cannot be ignored. Students follow instruction step by step and understand the process. Students often design and direct their own tasks. Students make observations, develop hypotheses about phenomena, and devise tests to investigate their hypotheses.

10. What do you think are the benefits when the Inquiry-based pedagogy in science to teaching is practiced?

T8: The learning using inquiry-based activities leads them towards learning. I believe that students learn in groups and take the advantage of cooperative learning. They share responsibility within the group for answering questions, and use a scientific approach to solving problems.

a) **Do you think that the Scientific Inquiry approach to teaching is the best way to teach science? Why or why not?**

T8: Ideally, it is the only best method of teaching in science at undergraduate level in this university. Nonetheless practically, it is one of the ways among all other teaching methods. I believe that students being taught in effective inquiry-based learning environments improve skills and exhibit more positive attitudes toward science. Though the concerns are how to implement inquiry successfully where there are numbers of constraints impeding the effective use of inquiry-based pedagogy.

11. What do you think are the difficulties when the Inquiry-based pedagogy in science is practiced?

a) **What do you identify the most important challenges for you?**

T8: I think that the biggest challenge is teacher's willingness; if teacher is not ready to use inquiry-based pedagogy. They are neither prepared nor trained priory. So it is still a concern that our teachers seem not willing to use it. I think that teacher should understand how inquiry works (understanding of inquiry-based process) and how inquiry improves students' learning in science. If teacher understand of the importance of inquiry in science then they motivate to use inquiry.

b) **What is your opinion about the science curriculum and Inquiry-based pedagogy?**

T8: Without trainings, teacher seems not ready to use inquiry in their teaching of science. I feel that I would lecture because it seems an easy job for me. Inquiry-based instruction requires a unique approach. As with all classroom activities, however, the use of sound instructional techniques is critical to students' learning. A great concern is that some topics are in Zoology curricula, we need to provide a lot of information so inquiry or hands-on activities seems not possible. The main components of a degree program at university are **pedagogy, curriculum and assessment**. Unfortunately, the teachers are not the party to control them or develop these. Some other agencies take their part to develop curriculum and assessment; it seems funny that nobody paid attention to pedagogy…..uumm… even **university code of practice** says that teaching should be inquiry-led…

It is teacher who struggle hard to post inquiry-based pedagogy without any incentive but outcome is not desired. Further teachers think their working hours should be increased if they use inquiry. Also our students should be prepared/ (already from school) so they understand the process of inquiry-based pedagogy. Otherwise I see that inquiry-based teaching either be a disaster for teachers or might confuse students at a great deal.

c) **What is your opinion about the relationship between the Inquiry-based pedagogy and classroom management in the science classroom?**

T8: I think student best work in group. My personal opinion is that best learning happens in group discussions. They share and develop confidence and collaborate with each other's. Inquiry-based pedagogy motivates the low confident students to improve or those students shy to participate in discussion and reflecting their ideas. Uum…Although over-populated classroom and insufficient space for laboratories are obstructing teachers to use inquiry conveniently; they still seem unwilling to use inquiry.

d) **What is your opinion about the relationship between the Inquiry-based pedagogy in science courses and assessment in the science classroom?**

T8: Exam-based assessment leads our students to the rote. They memories information and score high. I think that exams are not really about learning things…. Exams do give teachers very little chance to involve our students in open-ended problem/inquiry-led activities in zoology.

It seems to me that there is no role of teachers in assessment. Only exam (semester-wise) and further external exam (annually) is applied to assess students. Exam-based assessment will reward those who memorise the science knowledge even they do not understand it. It is obvious that exams test memory or what extent students are good at recalling information. Ummm amazingly, our female students proved themselves very good in exams and they have been achieving record-breaking marks. On the contrary, our female students are not proactive in solving open-ended problems, thinking ideas and understanding of the science procedures. Interestingly, boys show interest in solving open-ended problem and field trips though they do not work hard on reading and library work. So the dilemma is that our female public sector schools are getting better teachers but our male public schools are looking for competent male teachers. Because the teacher's basic criteria is their marks in which girls seems higher scorer than males. I think pattern of assessment should be enough changed to assess learning so that our gender-separated school could receive a proper number of teachers that they should require. I realized that teacher and learner both are quite away from the process of assessment. I think that teacher should be given sufficient chance to assess the students' learning using inquiry-based assessment and inquiry-based skills.

Qualification: M.Sc. Physics, **M.Phil** Solid State Physics **Courses you teach:** Physics and Teaching Methods of Science
Gender: Female **Years of Experiences:** 23 years **Age group:** 45-50

1. **Would you please tell me about your experiences f teaching science in initial science teacher education programme?**

T12: I have been teaching in this university for seven years. Before joining this university, I taught at an Undergraduate Science College. In the Science College, with undergraduate students, I had prepared students with national curriculum and national assessment. I worked in semester system for the first time so it was a different experience for me. The assessment and curriculum is different in this university than other colleges. Initially, it was a confusing as well as challenging experience for me. When I get the understanding of education system at university, I started enjoying my teaching experience.

Would you like to share you how do you enjoy teaching science?

T12: I enjoy my teaching very much; in fact I love teaching science. As being experienced with inquiry-based pedagogy, I usually have fun. I involve my students in a way that I do not realize that it is time for the class to end; sometimes my students have had to tell me that the class should be finished.

a) **Describe what an effective science lesson is like in your classroom and why you think it is effective.**

T12: I think I use mostly the lecture method of teaching in general science colleges. I have been teaching through a variety of methods here in University of Education; particularly inquiry-based pedagogy. I think that if students really want to teach in the future then students must learn through inquiry-based pedagogy.

b) **What is the most rewarding aspect of teaching science in your opinion?**

T12: I feel a great pleasure when I get feedback from my students. Particularly after finishing their undergraduate degrees, they get a job, get success in their career then they occasionally come and let me know about their success. I feel that I really contributed in achieving the aim of their life and in developing their career.

c) **What is the most frustrating aspect of teaching science in your opinion?**

T12: There are several things about my job that make me irritated. Some new courses are introduced in university. I am assigned to teach these courses. Suddenly I was asked to do this. This make me irritated if I am not prepared or these course are not according to my area of interest. I do not see any incentive for this work. Lack of appreciation is also a frustrating aspect. Umm….For many years, I have not been offered any training for my professional development. I am also working as an exam-controller. Because my workload is high, I was not spared for training or any other research activity, which all other colleagues' especially male colleagues are taking part in my department.

2. **How did the science teaching methods courses or science course you taught at university influence your views about teaching of science?**

T12: I have taught physics and also **teaching methods of science courses** at undergraduate level. I really learn how to teach effectively. I learn through these courses as well as from my student how they pick the teaching method and how they perceive they could use it in their future teaching. I think my teaching practice/the period I taught influenced my performance when I started teaching Method course. I have taught teaching method of science. During the teaching of this course, I have learned a range of skills I could use with students. Although I have never been trained professionally to teach this course I took interest myself and started teaching. I involve the whole class in hands on activities. I believe Inquiry-based pedagogy teaching method is really interesting though a bit challenging in the teaching of science. I also noticed that our students enjoy this course and they learn a range of teaching skills.

3. **What is your understanding of <u>Inquiry-based pedagogy</u>?**

T12: Inquiry-based teaching is a pedagogical approach that invites students to explore academic/scientific content by investigating, and answering questions. Students solve problems independently and learn deeply. This approach puts students' questions at the centre of the curriculum; it does not impose the curriculum on them. It is neither a teacher-oriented teaching session nor a lecture that could be imposed on students. Inquiry-based pedagogy involves the entire students. I believe that during lectures students can become withdrawn, tired and lose their concentration in the topic because they are listening and not interacting, whereas Inquiry-based pedagogy involves all the learners in the learning process; especially in clarifying the concept and removing students' misconceptions. I believe that Inquiry-based pedagogy is the best method for students' to learn science.

4. **In your opinion, what are the basic elements of Inquiry-based pedagogy in science?**

T12: Due to the lack of resources in Inquiry-based pedagogy I do inquiry-based activities in my classroom such as asking questions, and involving the students' in small group discussions. I encourage the students to share the solutions with each other.

5. **Think of your own teaching and <u>the 'Inquiry-based pedagogy approach to Teaching in science':</u>**

a) **What a typical Inquiry-based pedagogy lesson is like in your classroom.**

T12: I make sure that all of the students are involved in activities and scientific investigations; these activities enhance their curiosity and they reflect on their results. Students work in cooperation, communicate with each other and share ideas. Particularly, I realized the importance of Inquiry-based activities when I taught a **teaching method course in physics and mathematics** and now I am teaching a **method course in science**. I frequently involve students using inquiry-based activities.

b) **What is your role as a teacher-educator? How you would explain…**

T12: I am more likely a facilitator. The role of the teacher in an inquiry-based classroom is quite different from that of a teacher in a conventional classroom. Instead of providing direct instruction to students, I help students generate their own content-related questions and guide the investigation that follows. Because my role of the teacher in an inquiry-based classroom is unconventional and also inconsistent with other teachers, it is sometimes misunderstood. Administrators, parents, or even students may not recognize the hard work that goes into planning and implementing an inquiry-based approach. In fact, it may seem that teachers "aren't doing anything" as students struggle to formulate questions and seek out answers. Classroom management is also misunderstood as students in small groups learn and talk to each other.

My students expect polite and nice behaviour from me, particularly female students. I notice that students respect me because of my nice behaviour. Ummm….In ITE programme in university of Education, the majority of students are female. They come from middle class or low economy or working class families, they have a desire to be teachers and it is easy to get jobs in the teaching profession in female public sector schools. Females feel more comfortable doing a teaching job. As the majority of students belong to rural areas and have low economic status, they have a lack of confidence. Particularly, I feel that I really have to guide female students, not only to teach them science concepts but also to assist their personal development. The role of female-teacher is expected to be more of a moral guide than a male teacher. Female students also expect a happy relationship with female teachers rather than male teachers. Because of the culture, male teachers can exhibit reserved behaviour or hesitation towards females' students in class.

c) **How do you think science students learn science best?**

T12: I think students learn science best through experiments and through hands-on, practical methods. Especial in physics, students learn best in lab work when they do experiments themselves. The use of questioning and classroom quizzes is very useful to make them active and participate in the classroom. Also, inquiry helps to develop a range of skills, develops thinking about the phenomenon of science and decision power in students. Unfortunately, the problem is assessment. Students are more concerned about the end result and in obtaining good marks and this is why students do not always show an interest in learning to use problem solving and investigation of the solution of problems.

d) **How do you use resources to develop the understanding of the procedure in scientific investigation?**

T12: Resources are the central part of scientific inquiry, in particular the apparatus used in the lab environment. In regards to other resources in science class, I think it is vital to have trained teachers and specialist lab instructors. In university, the majority of our teachers are selected on their excellent academic achievements or first class degrees but they cannot teach very well. They do not have highly or positive intentions to teach. There are also ill-trained Lab instructors/attendants so they do not take part in Lab and class work effectively. I think that trained teacher and specialized staff better use resources and inquiry-based pedagogy in ITE.

What do you think there is a particular reason <u>why you could not use Inquiry-based pedagogy -based pedagogy in science</u> very much?

T12: I have been taught inquiry-based pedagogy. I noticed that students reflect on the answers, think, and answer according to their understanding. The majority of these students are actively involved using inquiry-based pedagogy, but some were not involved. I feel they did not understand properly the procedure of inquiry-based pedagogy. A great concern is that our students are afraid to take initiative; they lack confidence to participate in an inquiry-based class. In particular, our female students can be hesitant to participate in the class even if we only have a small number of male students. Oh….On the contrary, sometime females are more proactive in participation based activities in the classroom than male students. The students are also not prepared to use inquiry proactively from their school education. They need to be motivated to use their initiative, confidence and to take an active part. I think inquiry is the best way to do this but teachers have to struggle hard and spend some time to achieve the desired outcome with students using inquiry-based pedagogy.

6. **In your opinion, how is Inquiry-based pedagogy related with the role of science in initial science teacher education?**

T12: I think that inquiry-based pedagogy is all about how scientific method works. Inquiry-based pedagogy develops those skills i.e. thinking, investigating and exploring science, understanding application of science; that our science students are required to develop in order to be an effective science teacher.

7. **What is your understanding of scientific investigation?**

T12: I think it involves students carrying out scientific process systematically. Unfortunately, we are unable to engage students in open-ended science investigations properly. Our Lab-experiments practice gives them little chance to work independently. They learn by partaking in standard experiments, where the results are already known.

What is your understanding of the impact of the Inquiry-based pedagogy approach on scientific investigations?

T12: I think Inquiry-based pedagogy does have a great impact on scientific investigation though the concern is that our pre-service teachers are not involved in sufficient practical work which should be a basic requirement.

8. **What is your understanding of <u>Scientific Literacy</u>?**

T12: I understand that scientific literacy is an understanding of the process and application of science.

a) What do you think the role of <u>the Inquiry-based pedagogy in science in developing scientific literacy is</u>?

T12: I think Inquiry-based pedagogy develops a scientific approach/attitude in students. It makes students think like a scientist and think critically about the nature of science. I strongly believe that our pre-service teachers should be a scientific-literate person. Students should be developing scientific literacy in their future teaching. Nonetheless, teachers should encourage students to develop a research culture. Students should be encouraged to read journals, and newspapers. They should also be choosing assignments and be encouraged to think independently and develop their own lines of argument. This is the real learning of application of science that inquiry-based pedagogy could do though it seems to me that university should support strongly. Teachers should be trained and curricula should be structured according to the inquiry-based pedagogy.

b) Do you consider that the Inquiry-based pedagogy in science aims to educate students to be scientifically literate citizens, or effective science teachers, scientists or all of the above?

T12: We are developing science teachers. This university is an institute of teacher education and the students most often join the university when they are in need of joining the field for job opportunities; they want to be a teacher by choice so this way; we are fulfilling the requirement of country; providing good science teachers through our B.S.Ed. program. I agree that our students should be scientifically literate and that they should understand the need of application of science in society.

The majority of our pre-service teachers are female. In fact, majority of our students belongs to low-economy or working class or are coming from rural areas. They are not brought up in a highly educated way because their parents are not well educated or may be from the working class. I feel that our students are prepared to recall information but do not have a proper understanding of scientific methods and sometimes have superstitious thoughts. I also work as a **girls' hostel warden;** I lives in university accommodation next door to Hostel. I have been through many examples when girls screamed at night or they misunderstood appliances of science. They thought superstitiously. For example, when exams are near, a couple of girls became faint or feel very weak because of the stress of exam. I had to call on their parents so that they could take their daughters back home. They misunderstood, thought superstitiously (being afraid of some magic or spell), and refuse to bring them back in Hostel.

I strongly recommend that our female students should be encouraged to read widely, watch TV for informative programmes/channels not for only entertainment. It is not the part of the teacher to force them to do this. The Mothers' should also encourage their daughters to read and go to library. Many females' students complain that their parents discourage them to read digest/magazines or books other than the syllabus. Our female students should develop a positive attitude towards science. In our culture females have a great responsibility; they will be our future teachers as well as future mothers. If their thinking should be developed positively and scientifically, then they could bring up their future generation in a proper educated way. I believe that scientific literacy among females should be necessarily developed.

9. **What do you understand about "procedural knowledge" in scientific investigations?"**

T12: I think that procedural understanding is the learner understands of how science works especially in experiments in Physics that I teach. The problem we have is that the class sizes are very big so scientific investigation is hard to arrange. I think it's a better idea to make them more involved in the understanding of procedures.

a) **What is your opinion on how the <u>Inquiry-based pedagogy -based pedagogy in science relates students' procedural knowledge to scientific investigation</u>?**

T12: I strongly agree that inquiry-based pedagogy develops the understanding of the procedural knowledge science investigation. Science students can understand the procedure of science even without demonstration. I think that understanding of the science procedure is more important than attending Laboratory. This is how students understand the application of science in practical life.

10. **What do you think are the <u>benefits when the Inquiry-based pedagogy-based pedagogy in science to teaching</u> is practiced?**

T12: I think Inquiry-based pedagogy is very interesting approach. I choose to use an inquiry-based approach, try to provide rich experiences that provoke students' thinking and curiosity; to plan questioning sequences; to manage multiple student investigations at the same time; to continuously assess the progress of each

student as they work toward their solution or final product; and to respond in-the moment to students' emerging queries and discoveries. When the students' are on a school placement, they use inquiry based teaching strategies and get a chance to teach using inquiry. They enjoy their exposure to teaching using inquiry. I observed through teaching practice that student-teachers enjoy teaching when they use Inquiry-based pedagogy in their school placement teaching experiences. I learn from my mentoring experiences that I as an educator encourage our student to use inquiry-based teaching method.

a) **Do you think that the Scientific Inquiry-based pedagogy approach to teaching is the best way to teach science? Why or why not?**

T12: I believe that my science instruction should reflect the way that science is practiced in the real world. While it isn't always practical or effective to use inquiry as the only teaching method, inquiry should have a high-flying place in every science classroom. When students are active participants in asking questions, designing procedures, carrying out investigations, and analyzing data, they take responsibility for their own learning, and begin to think like scientists. I agree that it is the best way of learning as well as teaching especially when we have pre-service teachers as our students so they learn using inquiry-based teaching. They are better to use Inquiry-based pedagogy in their future teaching of the sciences and they will be a confident learners as well as effective science teachers. They do not need to cram or to rely too heavily on written learning and can learn not to fear exams but I argue that assessment should be Inquiry-based pedagogy.

11. **What do you think are the difficulties when the Inquiry-based pedagogy in science is practiced?**

T12: There are a lot of problems; first of all our teachers seem to be having problems when they use inquiry-based pedagogy because of lack of resources, time and raining. Teachers are low paid and sometimes they have to travel from a distance. Particularly female teacher have to look after their family/ family issues. Unhappily, the situation in the country is not very secure or progressive and people do not seem to be inspired to work hard and accept the challenges. I do not feel comfortable when I am absent from my home. I am always worried about my children. It seems to me that female teachers do not seem to accept challenges in their teaching. A teaching job in university is itself very challenging. It seems to me that a typical lecturer and mother (neither a researcher nor come with a research degree) is hesitant to accept challenges in her job. Due to these reasons we female educators cannot accept challenges in our teaching. I also say that universities have a lack of good and trained science teachers to use inquiry-based approach that is a new and challenging approach to teach especially for females.

a) **What do you identify the most important challenges for you?**

T12: I think inquiry-based pedagogy does not seem part of our overall curriculum, assessment, the time, and resources. Another dilemma is that our students are not prepared to use inquiry. Our teacher is not trained, also most of the time teachers do not have a support from a university. We are assigned big classes (usually, there are more than 45 students). Therefore, we do not have any other choice but to employ the lecture method. The major concern is that assessment has a very small part in inquiry-based strategies. This university is a new university and is looking for student population to develop this university and raise funds. It seems to me that there are several things running at the moment leading toward a haphazard structure. Subsequently, we have overpopulated classes and a lack of resources and are troubled with massive exams.

b) **What is your opinion about the science curriculum and Inquiry-based pedagogy?**

T12: The curriculum is the main concern. It seems to me that curriculum has no space to use inquiry-based pedagogy. I think that some specific chapters should be restructured and inquiry-based activities should be included. I think Physics could be best taught using inquiry and teachers could make use of inquiry-based pedagogy. Though the entire curriculum is hard to revise, for example, we cannot teach **Atomic Nuclear Reactor** using inquiry-based activity. If the curriculum would restructure and support inquiry-based pedagogy then almost every teacher would most probably plan to use inquiry-based pedagogy.

c) **What is your opinion about the relationship between the Inquiry-based pedagogy in science courses and classroom management in the science classroom?**

T12: It has been observed in my classroom that my students are better managed/involved using inquiry-based pedagogy. I like to use Inquiry-based pedagogy. I involved my students, they think and discuss in groups, and they also develop their confidence. I think when students collaborate with the teacher then they understand better and develop a rapport with the teacher. Although in our university, classes are over-populated so our teachers prefer to lecture to manage/control class so that discipline could be maintained; I think it is up to a teacher. If teacher is motivated then they could definitely use inquiry-based pedagogy.

d) **What is your opinion about the relationship between the Inquiry-based pedagogy -based pedagogy in science courses and assessment in the science classroom?**

T12: I assign students to do assignment/ presentations on subjects that interest them, and pose a science problem, investigate solution. I tried to do inquiry-based assessment. I noticed that students take a lot of interest and enjoy their work. They become more creative and develop their own ideas, share it and present in the class. Although it makes my job more complex and I have to spend more time in preparation. Though, the majority of our teachers also encourage students to memorize content.

Appendix L

Focus Group Transcripts

Focus Group 1 Recording: April 12, 2011, 14: 00 PM

Focus Group 2 Recording: April 18, 2011, 11: 00 AM

1. What do you think about teaching of your teachers?

G1-S1: I think that teachers should develop a friendly relationship. Teachers can understand the need of students. Teachers can interact with students and students learn in a better way. Teacher should develop students' thinking so that students learn in that way deeply and not simply follow teacher's notes. I think that teachers usually do not develop interaction with students.

G1-S2: In real, teachers get annoyed by questions; do not respond them nicely rather discourage them on asking question. Teachers should understand students' problems and try to make the process of teaching according to the level of understanding of students even if the teacher have a PhD and some specialist knowledge, they should teach according to the level of their students and understand how students can learn in a beneficial way so that students learn and develop their thinking and ideas.

G1-S3: Teachers involve students in many activities and experiments, particularly when teaching science. And if experiments are not necessary, then they can do demonstrations instead. I believe that students learn through visuals and hands-on experiences; I like when teachers teach us using visual aids.

G1-S1: Teacher should involve student-teachers in learning science. For example, we are taught by teachers that has PhD. Sometimes we cannot understand how they are attempting to convey to us. I think inquiry-based methods are effective to make teacher as a facilitator that and understand student-teachers' needs.

G1-S2: I agree with this, it should be expected that a teacher involves students in the learning process and make them engage with questions and hands-on learning processes also encourages them to collaborate so that they work creatively and share their own ideas.

G1-S3: I believe that teachers and students have a distance but not differences between them. They both have certain boundaries but they are working together in the classroom. I see our teachers do not like many questions in the classroom; if students ask many questions, teachers suggest that they should first search for the answer from books and from the previous topics they have been taught. Teachers just want to lecture in the classroom.

G1-S4: Questions and answers are compulsory but teacher should not push to find only the answers. Questions are basic components of inquiry based learning but learning happens through various ways, through experiments and by doing hands on activities. I would appreciate teacher's role in those activities that I mentioned but unfortunately our teachers lecture and demonstrate the information. I think we cannot expect any other relationship with our teacher except that which consigns us to the role of their attentive listener.

G1-S1: I think teaching is a two way process and the teacher involves students in learning of science so teacher should pause and see how students are responding to the action of teacher and get feedback from students. The teacher should learn how students learn more effectively and respond to students' questions according to their level of understanding. We have a teacher that possesses a PhD and sometimes we cannot understand their way of teaching and the information that they are attempting to convey to us. So the teacher should instead understand that we are undergraduate students and we do not understand a PhD. so I think the teacher should take the responsibility of at least effective teaching and notice whether students are learning really or not.

G2-S1: I think that teachers should be prepared to manage a classroom with students who have a brain to think. Teachers should not be irritated by the students' questions; even they should be prepared for the students' queries according to their level of understanding.

G2-S2: I think the communication between the teacher and students should be excellent in order to provide a platform where both the teacher and student can interact and, subsequently, learn usually teachers discourage questions so I would say that teacher should instead welcome questions and respond to them.

G2-S1: Teachers and students should have a good relationship so that students feel able to be frank enough to tell their problems to the teacher. Teachers should be both friendly and polite so that their students can interact with them without any hesitation.

G2-S4: Sometimes, teachers get annoyed with students' questions; sometimes only gifted and first-row sitters participate. Therefore, teachers appreciate only those student-teachers. All student-teachers rather not only a few student-teachers should be encouraged so that everyone develops confidence.

2. What do you think how students learn science best?

G1-S1: I think activities, experiments and hands on are better ways of learning

G1-S2: I think students learn best when they involved fully in the learning process and they interact, share their ideas.

G1-S3: I think experiments and hands on activities in science are especially beneficial.

G1-S4: Interaction with teacher and students and more involvement in understanding the scientific concepts

and when we explore ourselves and think about how science works.
G1-S2: I would agree that observation and experiments are beneficial so we get deep learning, though it is more time consuming.
G1-S4: I learn best when the concept is clear to me, when I get stuck at a question I try to find the answer and I explore through various sources until I find the solution and then I understand the concept and learn it best and permanently.
G1-S3: I think I learn best when I explore science myself and I search information found on the internet, library and other sources of information. This way I learn best and gain more knowledge that could be applied practically.
G1-S2: when I learn about aspects of science, I am always curious to know more so I think learning in science brings curiosity and it is always more interesting when we do practical work, especially field work in scenic locations. I like going in fields, such as when we go on plant and zoo trips.
G1-S3: I think we should be taught with the latest methods and involve more practical work; we should be engaged with the latest research.
G1-S1: I think that our teacher should be able to teach and explain the scientific concepts; properly engaging students in the class. Because science is interesting and develops curiosity; teacher explains well then it is a more deep and interesting learning experience. I think learning in science is more interesting and I like science. I have chosen science by choice and I want to continue my study in science. I think it is different from learning any other subject. It involves creativity and you have to learn things and discover them yourself. I believe that scientific knowledge has been updated with time. Now more creativity and curiosity for better learning is involved; only book reading and recalling science information is not necessary at this time.
G2-S2: I think activity based learning is effective in class learning should involve the students as then they can express their reflections and interaction should be part of the class.
G2-S1: I think when we deeply understand the concepts, this makes deep learning possible.
G2-S2: I learn best science through observation and practical experiments
G2-S1: I agree with all the points and I would say that our own involvement is necessary and we learn science most effectively when we are involved more than only informing is that can be recalled.
G2-S2: I agree what others are saying we learn best through practical experiments.
3. How did the teaching methods of science courses you took in university influence your views about learning of science?
G1-S1: Well I have not studied on teaching science method courses and I think that I should not be a teacher; what teaching I have observed here is what informs my opinion; I should not be a future teacher I saw my teachers as a lecturer and I do not see any other method. So I would do only what I have seen my teachers doing. I do not think I could be an effective teacher as the need of learners is required.
G1-S4: I think this teaching method course has been helpful for us to know about the teaching method of science generally and how to teach science students effectively, with interactions and collaborations and developing their thinking motivate them in exploring science themselves. I believe how much students explore the science themselves through clarifying their concepts; they get much deeper understanding of the concepts, so learning occurs.
G1-S3: The teacher provides us with notes to follow and then deliver their lectures in English but we are not too proficient in understanding English so we cannot understand the lectures and this leads to an unsatisfactory learning experience. So I think teacher should prepare their lessons according to the needs of students in order to satisfy them.
G1-S2: we are coming from higher secondary education and have just started our higher degrees and do not understand how things are going in the semester system so I do not think the teacher should do only a lecture according to the circumstances. They should involve through hands-on and other activities and consider our opinions when I think of how I would operate as a teacher, I think I'd try to be an interactive and inquiring teacher, involve my student in how they learn science best. Their needs could be fulfilled in their learning.
G2-S1: When teacher teaches they must understand the level of understanding of students and they should teach according to the understanding and requirements of the students.
G2-S2: We are learning and studying more tough courses than our teachers and we are involved in more practical task as our teacher has done when they were students.
G2-S2: I had no interest in the teaching profession but with the passage of time after learning teaching method courses, and also observing my own teachers I am now interested in becoming a teacher. I think it is now my profession of choice.
4. What is your understanding of Inquiry-based Pedagogy?
G1-S1: Inquiry-based methods involve students learning science through hands-on activities and seeking solutions of questions.
G1-S2: Inquiry involves students mainly in questions. We could be involved in a range of inquiry-based activities thought not in actual.
G1-S3: I think these are really the best methods and they enhance students' interaction with others in the classroom and help them develop confidence as they think of answers and share the ideas and learn more.

G1-S4: We have a large number of students and busy classes and it is up to the teacher how he involves the students how teacher involve all the students in classroom if inquiry is only question and more likely questioning then everyone should be involved in question individually as well as in groups.
G1-S4: I feel that inquiry-based activities bring an ease in understanding science concepts, not only exploring answers of science questions, also think solution. I would add inquiry is a teaching method that encourages collaboration. Teacher should guide students or facilitate students till the end of class and interact with the students. I think there should be structured conversations between student and teacher and they focus on the topic when inquiry is used. Teacher should not do; assign a problem to students and then leave the classroom as students are busy in solving that problem so teacher's role is very important in implementing inquiry and how he manage classroom using inquiry based activities.
G1-S4: I think this teaching method course has been helpful to let us know about a range of teaching methods of science generally and how to teach science effectively by involving students, collaborations; developing their thinking to explore science.
G1-S3: I think it is a better approach than the method that fosters memorization. It involves in activities and exploring knowledge themselves and this method marked students avoid from rote and leads to ward meaningful learning.
G1-S4: The knowledge is enhanced and practical information is involved but I argue that all the students are not involved and it is teacher because sometime teacher get irritated when students are asking questions; sometime only the more active and first row sitters participate but the teacher just appreciates them and again is stuck with their lecture and does not involve all the students. I appreciate the use of inquiry-based activities but it should be planned and well organised; more than a few students should be encouraged or not inquiry. It must involve all students and encourage to all class so that they develop confidence and share their thinking through questions.
G2-S4: Inquiry is a method that produces a discovery and in the process involves students in learning. I consider this to be the best method of learning science and it clarifies the concept and we do not learn by rote we learn as we have done science practically.
G2-S1: Communication and interaction with teachers and peers make student more confident and they think to find out the solution of science base problems. We do not have much use of inquiry in our classes. Although Students also try to avoid when inquiry-based activities are used. They want to be explained.
G2-S1: I develop my concepts what an effective teaching method should be taught when I was exposed to the teaching strategies exhibited in the science methods course. I understand how learning happens in students through activities. This course helped me formulating my own pedagogical strategies.
G2-S2: I think that inquiry learning is better understanding of scientific facts through science investigations and through inquiring information.
5. What is your opinion how inquiry-based pedagogy in science helps learning sciences in Initial science teacher Education? How it is related with the role of science?
G1-S1: Through inquiry, I think we better learn investigations in science and how to explore science with interest and I think that I want to go to research side so inquiry develops me a better researcher in science. Inquiry develops the research skills that we need to develop in science to explore further. Inquiry also develops scientific attitude that is necessary in science investigation so I think umm. Inquiry is helpful in gaining a deep learning of science.
G1-S2: We learn how to think critically and then we use our thinking skills in experiments and then share our ideas. I think that inquiry bring a collaborative network for us and this way we develop more practical knowledge and thinking skills.
G1-S3: Using inquiry, we were initially anxious in responding inquiry-based activities though we developed interest with passage of time.
G1-S4: I learn best when the concept is clear to me, I explore through various sources until I find the solution. When I stuck at a question I struggle to seek answer. I understand concept in inquiry-based sessions and learn it with an interest.
G1-S4: Inquiry-based methods make us having fun that makes science interesting. This is really exciting and engages them in understanding science problems. I think that Inquiry influences and we cannot get in-depth knowledge and thinking without inquiry based learning. I believe that inquiry is going into depth; it is not only investigating the problem and find the answer or pointing out where information is.
G2-S1: It is commonly believed that science student-teachers are mostly book-worms so they do not participate in co-curricular activities; also they are not confident and not interactive. I think that inquiry involves learner so they participate in talks and share their ideas. So we have fun in learning in inquiry methods. Inquiry develops thinking skills that enable us to solve science problems. Inquiry also brings interaction with teachers and students and makes us more interactive and this way student can build their confidence.
G2-S1: I feel motivated when teacher involves me using inquiry-based methods. Mostly female teachers are very cooperative, encouraging and interacting.
G2-S2: I think when we deeply understand the concepts using inquiry-based activities, this makes learning. I learn science best through observation and practical experiments in science that makes me active. We learn

science most effectively by doing using inquiry-based activities quite.
G2-S3: I really enjoy my experiences when I am involved in fieldwork.
G2-S4: Learning is a slow process and I believe that we learn better when we understand the concepts clearly; we focus on the meaning of concepts instead of just rote-learning the facts. I think inquiry based leaning enables us to learn meaningfully and I believe that it is useful learning.
6. How do you attempt to realise the impact of Inquiry-based pedagogy to scientific investigations?
G1-S1: I think when a student learns through experiments then they learn deeply and their understanding of concepts is clearer than what just lectures can provide. So I believe that inquiry has a very positive impact on scientific investigation.
G1-S2: I think I learn best when I explore science myself. Inquiry-based methods are ways to explore science through investigating and experimenting. So it is always interesting when I do experiments especially field work such as zoo trips.
G1-S3: Using inquiry-based learning students become active and they take part in experiment.
G1-S4: When we think to solve problems. We get stuck and think again search again until we find the solution so inquiry develops critical thinking and analytical skills that should be developed for useful scientific research so we can then use these skills practically.
G1-S4: What I understand through this question that inquiry helps in the process of scientific investigation. Scientific investigation is done using a scientific method. Opening the concept does not require much thinking; I think that it is important how to discover it; and an understanding of the investigative procedure and testing the scientific theories are important. So I believe that scientific investigation relies on the process of inquiry and it works how science works.
G2-S2: I think inquiry is a method that could be used to obtain multiple outcomes. It is to discover science how science concepts are explored and theories are formulated.
G2-S1: I believe that scientific investigation is the same process as inquiry based approach is in science they both work in the same manner; inquiry also works similar to how science works. I agree that we do effective scientific investigation by using inquiry.
G2-S2: I think I understand concepts better using inquiry because it involves practical work. I think inquiry is the real essence of scientific investigation.
G2-S3: In inquiry-based sessions, I realize that how much more interesting and fun in science can be if inquiry-based instructional strategies are used rather than lecturing and memorizing of text for examination.
7. What is your understanding of scientific literacy?
G1-S1: I think inquiry-based leaning enables us to learn meaningfully. Scientific literacy is the understanding of scientific phenomena in daily life and usefulness of applications of science in the real world and it also connects with the applicability of science with the development of society.
G1-S2: inquiry develops thinking when you analyse the practical and go until it finishes and develops thinking with this scientific investigation and understanding the scientific process. So I think it is the same role that we need to develop Scientific Literacy.
G1-S4: Inquiry-based activities help us in understanding the science processes and products and tell us how important science plays a role in our daily life as well as useful for society.
G1-S3: Inquiry-based instructional strategies include all the components develop our understating of science and applicability of science through our observation in daily life experiments. We seek solution of problem that we cannot by knowing only books. Using inquiry, we construct ideas to explore solution of science problem. Thus, inquiry develops a literacy of science so I feel inquiry and science literacy are strongly connected to each other.
G1-S4: I believe that inquiry is very beneficial in science. So we do not learn not only what text means rather, we enhance our understanding. Scientific Literacy makes us realise that how thinking are happening in our daily life and tell us how important science plays a role in our dial life and at what extent it is useful for as common man as well as society.
G2-S1: Using inquiry, we get a chance to explore rather than pushes toward rote learning. I think it is an understanding of science in our daily life; when a person is born then they begin getting literacy of this universe; it is all learning of life because our life is based in science but I think that formal scientific literacy is about human capability of understanding of our surroundings. Therefore, I believe that all society should be scientific literate.
G2-S2: I think it is basically a practical outcome what we learn in science and we use it in our daily life. We could see the benefits of science in society and also development of scientific attitude. I believe that science should be more interested if you understand science with innovations and your own thinking and how it is helpful in the society; how a common man is using science in daily life.
8. **What do you think of the role of Inquiry-base pedagogy in developing scientific literacy?**
G1-S1: Using inquiry, student-teachers' understanding of science investigation and science concepts is clearer than in sole lectures.
G1-S2: I think that procedural understanding, inquiry and science literacy are interrelated with each other. Scientific Literacy and inquiry are together and they are not complete without each other; inquiry in science plays an effective role in understanding the nature of science and science application in the society.

G1-S4: Inquiry develops thinking critically in science processes; indeed, we learn to think critically, and rationally. This enables us to solve problems. Inquiry method is about increasing our understanding and practical approach toward science so inquiry methods including all the components develops and enhances our understating of science and applicability of science through our observation and daily life experiments. I believe that inquiry and Scientific Literacy are directly related to each other.
G1-S3: It is important how to discover it or examine or test the problem to interpret the solution; scientific investigation relies on the process of inquiry-based pedagogy. Inquiry in science works as how science works. So, inquiry helps in understanding the process of scientific investigation.
G1-S4: Using inquiry, we learn best on how we break up a complex concept into small ones, get into it, construct the meaning and understand it meaningfully. I think inquiry involves in practical investigations in science and develops critical thinking. That should not only for understanding the scientific concepts but also engage with the applicability of science for the usefulness of society.
G2-S1: Inquiry-based methods initially a difficult experience but gradually develops investigative skills with a continuing practice.
G2-S2: I add to this point that that there should be focus on the understanding of applicability of science; not only reading and recalling scientific concepts. So we should go through science journals and recent publication of science so that we could know what is going in science throughout the world.
G2-S3: I think inquiry enhances procedural knowledge of science by a systematic procedure; more by doing as a real understanding of science.
G2-S4: Most lecture session do not let us do our own constructed activities, therefore, we got a fewer opportunities to develop a critical thinking.

9. Would you please tell me your understanding of the 'procedural knowledge'?

G1-S1: Inquiry is useful in developing thinking in science processes. I believe that inquiry brings a way to go into a depth in investigating. Science experiment happens with a procedural understanding.
G1-S2: It is the procedure of scientific investigation and is an understanding how science happens.
G1-S3: It is a step by step procedure or way of doing experiments.
G1-S4: It is a proper and structured way of doing science. There are certain steps we do science so we understand how result in a conclusion experiment and we understand how it worked.
G1-S4: I think that the procedural understanding is the understanding of ideas about evidence, which underpin an understanding of how to proceed. The term procedural understanding has been used to distinguish ideas about evidence from other more traditional substantive ideas. We have argued that lacking ideas about evidence prevents students from exhibiting an understanding of how to proceed in scientific investigation.
G2-S1: It is a step to step procedure to explore the science or conduct an experiment. It is a real process of science occurring; some time we learn through a demonstration.
G2-S2: procedural understanding is an understanding of anything systematically in science. I believe everywhere in society.
G2-S3: Inquiry-based sessions helped enhancing open-ended and unguided activities encouraging seeking knowledge; It has been a bit uneasy initially because we are not reasonably involved in open-ended, though we develop an understanding from structured inquiries and this helped to be reflective and think critically.
G2-S4: I think that procedural understanding is helpful in describing the understanding of ideas about how the sciences gather evidence, which underpins an understanding of how to process in scientific investigations.

10. How do you understand the relationship between procedural knowledge and scientific inquiry?

G1-S1: It is a positive impact from inquiry on procedural understanding.
G1-S2: It is a procedural process and learns step to step through inquiry.
G1-S3: When we are taught using inquiry then we learn procedure through demonstration. I think it gets a better understanding because we learn through visuals and are involved in thinking and brain storming through questions.
G1-S4: I think inquiry clarifies our concept and we do an experiment/procedure with clarifies concepts and we learn better and deeply.
G1-S3: I agree that inquiry enhanced procedural knowledge. It also happens as science happens so it is a deep learning of science.
G1-S4: I think that PK, Inquiry and a scientific literacy are interrelated with each other so inquiry develop Scientific Literacy and PK and we understand the usefulness of scenic and its application in real life so sciences is not only a thing we could do in laboratories whereas we understand the concept of science in our society.
G1-S2: I add here that science experiments we could understand the demonstration and fieldwork and this is more effective and deep learning so inquiry enhance declarative knowledge and well as procedural knowledge.
G1-S1: I think if you really understand what you are doing in science and why you are doing this how you are processing science then it is a meaningful process in science so I think inquiry is really helpful in developing procedural understanding.

G1-S2: I think inquiry brings a more practical approach in the learning of science and this is highly related to enhance procedural understanding.
G2-S1: I think a scientific inquiry procedure is the same as a procedural understanding of science.
G2-S2: I think inquiry is a method that involves me in learning more than any other method. I think inquiry brings a lot of interest in learning science especially when I interact with others and participate in cooperative learning.
G2-S4: Most lecture session do not let us do our own constructed activities so we got no or less chances to be reflective or develop a critical thinking.
11. What do you think of inquiry-base pedagogy and practicalities of teaching as a future teacher?
G1-S1: I want to be a teacher and I would involve my students using inquiry based activities.
G1-S3: I think I will be a teacher and I care for my students with the thought that they should develop scientifically literate.
G1-S4: I would like to be teacher I think I am a teacher by choice and I teach my students with care and passion that they learn science with an understanding of the applicability of science.
G1-S2: I do not want to be teacher but I agree that students here not should aim to develop only teachers they should also develop scientifically literate.
G1-S4: I would be a teacher in future with active teaching style that involves my students. I will be a teacher and I would like to use inquiry based methods and I want to make my learner inquiry based.
G1-S1: I think it is highly motivated to teach using inquiry and brings wealth of knowledge for teacher as well so would live to use inquiry.
G1-S3: If I would be teacher then I prefer to use inquiry. I think there is no teaching of science without teaching through inquiry-based teaching.
G1-S4: I add that inquiry brings knowledge with understanding and interest. I feel that that I could make the dullest students in my class active in my experiment session, therefore, I prefer encouraging students to use inquiry-base teaching my peers.
G2-S1: if I will be a teacher then I want to be a student facilitator and not only a lecturer. I would like to provide them more hands-on activities so that they could learn science best.
G2-S2: I would like to be a teacher; involve my students in questions and hands-on. I would like to be a teacher as I have been teaching in private schools and I taught over there. I think it is continues process of getting information … It is lifelong learning and makes me motivated to achieve something.
12. Would you please tell me the key barriers which impede your learning when Inquiry-based pedagogy in science is practiced?
G1-S1: The major barrier is time, and lack of resources and also lack of science activities outside of the curriculum. They do not focus the use of inquiry very much.
G1-S2: Firstly, we do not have laboratories equipped sufficiently to do inquiry- based in each session. Secondly, if we have resources those are not properly used. Thirdly, it seems teachers are not trained in using recourses even if they have.
G1-S4: we do not have sufficient equipment in laboratories for each student working in there, so instead the teacher demonstrates because they do not find inquiry method to be particularly convenient for big classes. This makes it uneasy so I think the major barrier is lack of resources and also time is a barrier. Sometimes the teacher tries to finish soon and ask us to do at home even we have not finished or did not understand the concept properly.
G1-S3: I believe that teachers require more time to prepare their sessions and it seems impossible with too lengthy curriculum.
G1-S4: we have also problem that our teacher is also not willing to be involved students in inquiry used activities they want to lecture only if students ask question they behave negatively and ask student to listen them first and keep quote sometime they scold students. The questioning by students is not to disturb teacher it is to clarify the concept for students.
G1-S1: Young teachers seem to work hard and teach more effectively than older. Young seems used inquiry-based teaching, though elderly teachers lecture. I further say that teacher should clarify what approach she is using in his teacher so that students could be mentally prepare and better involve in the learning process so student's understanding for the effective practice of inquiry is also necessary.
G1-S4: I argue here that our system is structured in way that we are in a race to follow our curriculum and assessment those do not support inquiry based approach in teaching and not in learning. The science courses/curriculum is so lengthy and there is a lot of information to recall and memorise that students and teacher both are busy and have not time for inquiry based sessions. Additionally, our assessment system tightly binds us with exam and we have not chance to do inquiry based assessment.
G1-S4: Additionally, our assessment method tightly binds us with exam and we have very little chance getting involved using inquiry-based assessment. Also, there is no university support and there is no good policy on the use of methodology for teaching teacher teaches the way they want and there is not feedback for teachers. We have two types of exam external and internal, so, this keeps us busy in memorising lectures throughout the semesters.

G1-S3: Students appreciate that teachers-prepared notes help them to pass exams. Therefore, using inquiry, students do not benefit. I believe that use of inquiry is not based on the struggle of teacher. Other factors like facilities, incentives, equipment, sufficient resources and university support should be available do that students and teacher both could do their best.
G1-S4: I think that teachers do not want to do this I have been teaching in a private school so the principal always encourages good teaching they want their students to be taught using inquiry based methods as when students are active and they learn very well and more involve the was high but students are learned well and they are satisfied but in public sector. Our teachers do not want to struggle and of course they are not paid well and they think that the teaching profession is a tired one and only those people who are not so competent to be scientific and go into industry they come in teaching.
G1-S1: It is noted that young teachers do struggle and teachers more effectively and they are more dedicated to their teaching jobs but the elderly and other are near to retire they sent to lecture and they speak more and they behave as orthodox so I think our teacher just want us as a learner.
G1-S1: Teachers should clarify what approach she is using in class so that students get ready for that. Especially, students at their first year are not confident in using inquiry-based strategies. Students should be enough prepared to understand the process of inquiry to attain learning outcome. The biggest problem is short of time I think even teacher want encourage and implement using inquiry then problem with insufficient time cannot be used. There is also big classes messed up with students and small classroom seem big constraints top provide healthy environment to inquiry-based pedagogy.
G1-S3: I argue that we could engage big classes and slow learners better in learning using inquiry; this could develop interest and bring a variety of activities so that learners could do something of their own interest.
G1-S4: I see that our classes are messed up with high number of students and students are coming from public sector schools they are not prepared for using inquiry so the first thing is that I must say that our students is not ready for the use of inquiry-based teaching and secondly consequently out teacher is not prepared as well as willing for the use of inquiry. Here inquiry based teaching seems a bit impossible but we have to see that inquiry based teaching is the most desirable method of teaching in the 21st century to make out students to meet the requirement of modern era.
G1-S4: The government is not bringing something it is true that young also do but the teaching here especially but I argue that people sent their children into private school where Education is expensive but a good structure and system. Teachers and students are facilitated and teachers really spend time on students' learning and assessment and try to make assessment effective so that learner could learn from their mistakes. I agree that inquiry is a more challenging method of teaching but we need for our teachers to come and recommend the changes in courses, assessment and method of teaching which they think they need in practical in the class so that they could teach effectively and achieve the desired outcome in the learning of students.
G1-S2: Our teachers are not skilled in using inquiry-based methods; they do not seem equipped with the knowledge how to conduct inquiry-based methods. Teachers should be trained enough in using inquiry-based methods. The first thing I would argue here is that we always blame our teacher in a way that implies that it is only a teacher's responsibility to develop learning in students. If a teacher is responsible for everything then we have to pay our teacher a lot and use more facilities but we do not so our education system is not so supportive for teachers. My second argument is; if teachers do everything for students and considered the responsible for all learning of students then there is a question: how can we be practical and active learners in class if we do not learn to be independent thinker and decision makers.
G1-S3: Unfortunately, students are unaware the process of inquiry. We feel nervous how to participate when inquiry is used.
G2-S1: Curriculum offers a lot of information to recall and memorize. Examinations test memory and do not assess learning.
G2-S2: Our teachers are pushed to lectures than inquiry-based activities because time is too short with lengthy curriculum. We see that our teacher is dependent on the curriculum and assessment so he do not want to get rid of these methods so he delivers the knowledge like throwing something and feels that his duty/job is done but the learning outcomes are ignored and it is noticed how students are good in getting marks and what students are producing good results for which teacher class.
G2-S1: I would add that we have other constraints like lengthy curriculum and no time for practical learning and if we are involved in inquiry just in question, assignment field work activities. Sometime it seems that the teacher does not want to lecture so they involve us in those activities and do not stay with us to motivate us and facilitate use. They look as if they want an easy way to pass the time in the class.
G2-S2: I think our education system needs a revolution and revolution is always brought by the young teachers so we should not wait for the government to change things but instead our young leaders in the teaching profession will change the system and bring a good education system for us.
G2-S1: I would add here that we have many problems such as a shortage of time, and our course outline is so lengthy and overcrowded classes. Sometimes, it is hard listening lecture and the main thing is that our teacher is not prepared and trained in using inquiry. It is hard to involve all students in the classroom using inquiry as all student are at different level of understanding and show different attitude. As we have big classroom

sometime teacher use speaker for the lecture in the hall. So we have no chance of questioning. It is up to teacher how she could involve students in different activities so that all the students could be involved actively. I think teacher should be trained and prepared for the use of inquiry-based activities.

G2-S3: University does not help using inquiry-based activities rather it should encourage teachers to use inquiry. We got used to lecture methods and also big classes minimize students' questions. I want to recommend that the teacher should be trained and first learn how inquiry-based teaching functions. So the teacher should first be taught how inquiry-based work and also make understanding of the process.

G2-S2: I think assessment and curriculum both are not in line with inquiry-based learning. Assessment does not support learning because we recall a lot of information in a short time in our test. We are the entire time bust in mid-term and final term examinations. We have no proper laboratories and lesser opportunities to get involved in experiments.

Appendix M

Comparisons of the courses taught by teacher-educators

No	Views	Group	Of some importance	Important	Very Important	Essential	χ^2	df	p
Q12(b)	Abilities to carry out experiments properly	**ST**	2	0	12	14	6.1	2	P<.05
		BT	1	0	17	4			
		BT	1	0	12	9			
Q12(e)	Understanding of the key ideas of science	**ST**	1	0	8	19	6.6	2	P<.05
		BT	1	0	14	7			
Q12(h)	Ability to think critically and challenge ideas	**ST**	2	0	9	17	5.5	1	P<.05
		BT	0	0	16	6			

Table 6.20: The frequency of distribution by courses taught

Comparisons by courses studied by student-teachers

No	Views	Group	Easily solved	A minor Problem	Serious Barrier	Cannot be Overcome	χ^2	df	p
Q13(g)	The method is not consistent with the way other subjects are taught	**ST**	11	58	61	16	9.8	3	P<.05
		BT	58	128	173	74			

Table 6.21: The frequency of distribution by courses studied

No	Views	Group	SD	D	A	SA	χ^2	df	p
Q6(e)	I only like memorising subject knowledge in science courses	**ST**	14	40	57	34	7.6	3	P<.05
		BT	60	158	138	77			
		BT	32	144	172	86			
Q6(i)	I do not think I should learn as well if I was taught using an inquiry-based approach	**ST**	13	62	47	21	8.2	3	P<.05
		BT	33	136	183	82			
		BT	16	39	204	174			
Q8(b)	Enables me to only seek the right solutions to science problems	**ST**	1	18	85	41	10.1	2	P<.01
		BT	9	101	233	91			
Q6(i)	I do not think I should learn as well if I was taught using an inquiry-based approach	**ST**	13	62	47	21	8.2	3	P<.05
		BT	33	136	183	82			

Table 6.22: The frequency of distribution by courses studied

Comparison by years of study of student-teachers

No	Views	Group	SD	D	A	SA	χ^2	df	p
Q6(a)	I enjoy learning science as a subject	**1st year**	0	5	40	48	13.0	4	P<.05
		2nd year	7	14	130	89			
		3rd year	4	11	103	129			
Q6 (f)	I find open-ended science problems very difficult	**1st year**	5	33	34	21	16.4	6	P<.05
		2nd year	12	103	84	41			
		3rd year	17	66	118	46			
Q7(i)	Teaches the science mainly through lecturing	**1st year**	2	16	36	37	13.6	4	P<.011
		2nd year	25	38	88	86			
		3rd year	13	19	102	108			
Q9(c)	Allows me to explore science concepts on my own	**1st year**	2	22	55	14	29.9	6	P<.001
		2nd year	5	24	112	98			
		3rd year	6	53	102	85			

Table 6.22: The frequency of distribution by years of study

Appendix N

Relationship between inquiry and other measures within the teacher-educators' questionnaire

Views	Correlation Coefficient	P
Q8 (a) I enjoy teaching science Q8 (b) I like to expand my subject knowledge of science to be effective in my teaching	0.40	P<.01
Q8 (a) I like to involve student-teachers in solving open-ended science problems Q8 (e) I like to generate the active involvement of student-teachers in science investigation	0.42	P<.001
Q8 (e) There is not enough equipment to teach this way Q8 (f) Universities would not support it	0.32	P<.01
Q8 (b) I like to do hands-on science activities to engage student-teachers interests in science Q8 (d) I want my student-teachers to be able to recall information accurately	0.35	P<.05
Q8 (b) I like to expand my subject knowledge of science to be effective in my teaching Q8 (f) My aim is to make my student-teachers question what they learn	0.43	P<.05
Q9 (e) I like to generate the active involvement of student-teachers in science investigation Q9 (f) I like to raise student-teacher curiosity by giving them time to explore the explanations of scientific phenomenon	0.60	P<.001
Q11 (h) I think that an inquiry-based pedagogy will help develop procedural understanding Q11 (g) I think that inquiry-based pedagogy in science will help produce better science literacy	0.40	P<.05
Q11 (g) I think that inquiry-based pedagogy in science will help produce better science literacy Q11 (j) I think that ways of thinking are more important what we understand	0.45	P<.001
Q11 (g) I think that inquiry-based pedagogy in science will help produce better science literacy Q11(k) I think that an inquiry-based pedagogy in science will encourage critical thinking	0.40	P<.01
Q9(f) I like to raise student-teacher curiosity by giving them time to explore the explanations of scientific phenomenon Q11 (j) The ways of thinking are more important what we understand	0.39	P<.001
Q10 (f) I like to raise student-teacher curiosity by giving them time to explore the explanations of scientific phenomenon Q12 (h) Ability to think critically and challenge ideas	0.46	P<.001
Q8 (b) I like to expand my subject knowledge of science to be effective in my teaching Q13 (c) I should like to see the library and the internet used more in science teaching	0.49	P<.001
Q13 (c) I should like to see the library and the internet used more in science teaching Q13 (a) I should like to develop a more inquiry-based style of teaching	0.35	P<.001
Q14 (a) Makes classroom management very difficult Q14 (h) The learners will be left confused	0.38	P<.001
Q14 (h) The learners will be left confused Q14 (i) I have not been taught using an inquiry-based approach very much	0.42	P<.001
Q14 (h) The learners will be left confused	0.56	P<.001

Q14 (b) Will not give good examination results		
Q14 (g) The method is not consistent with the way other subjects are taught Q14 (d) Makes classroom management very difficult	0.41	P<.001
Q14 (f) Universities would not support it Q14 (a) The learners will be left confused	0.35	P<.001
Q14 (d) Makes classroom management very difficult Q14 (e)There is not enough equipment to teach this way	0.32	P<.001

Table 6.24: The correlations within the teacher-educators' questionnaire

Relationship of inquiry and other measures within the student-teachers' questionnaire

Views	**Correlation**	**P**
Q6 (e) I only like memorizing subject knowledge in science courses Q6 (g) I feel science is very important in all aspects of life	0.29	P<.001
Q7 (d) welcomes my scientifically oriented questions Q7 (e) Motivates me to seek the answers to open-ended science problems	0.35	P<.001
Q7 (f) Involves me in too much written work in science Q7 (c) Encourages me whether I solve science problem	0.35	P<.001
Q7 (g) Involves me through hands-on science activities in scientific investigations Q7 (e) Motivates me to seek the answers to open-ended science problems	0.28	P<.001
Q9 (c) Allows me to explore science concepts on my own Q9 (d) Enhances my curiosity to involve me in open-ended science investigations	0.26	P<.001
Q9 (h) Develops my critical thinking to evaluate the evidence in scientific investigations Q9 (d) Enhances my curiosity to involve me in open-ended science investigations	0.26	P<.001
Q10 (d) Provides me with opportunities to gain insights into scientific concepts Q10 (f) Enhances my understanding of the procedure of scientific investigation	0.30	P<.001
Q10 (e) Enables me draw evidence-based conclusions about science-related issues Q10 (f) Enhances my understanding of the procedure of scientific investigation	0.30	P<.001
Q13 (b) Will not give good examination results Q13 (a) There is insufficient time	0.23	P<.001
Q13 (g) The method is not consistent with the way other subjects are taught Q13 (a) There is insufficient time	0.25	P<.001
Q13 (h) The learners will be left confused Q13 (b) Will not give good examination results	0.29	P<.001

Table 6.25: The correlations within the student-teachers' questionnaire

Appendix O

Contingency Test

This chi-square test is commonly used in analysing data where two groups or variables are compared (Reid, 2006). Each of the variables may have two or more categories which are independent from each other. The data for this comparison is generated from the frequencies in the categories. In this study, the chi-square as a contingency test was used, for example, to compare two or more independent samples for example, year groups, gender, or ages. The data is generated from one population group. An example is presented here from Table 6.15 as below:

Male	0	4	7	4
Female	0	1	27	7

(Actual data above)

	SD	D	A	SA	N
Male (experimental)	0 (0)	4 (1.5)	7 (10.2)	4 (3.3)	**15**
Female (experimental)	0 (0)	1 (3.5)	27 (23.8)	7(7.7)	**35**
Totals	**0**	**5**	**34**	**11**	**50**

(Expected frequencies above in brackets)

The expected frequencies are shown in brackets ( ), and are calculated as follows:

e.g. 1.5= (15/50) x 5

$\chi 2 = 7.56$

At two degrees of freedom, this is significant at 1%.

The degree of freedom (df) must be stated for any calculated chi-square value. The value of the degree of freedom for any analysis is obtained from the following calculations:

df = (r-1) x (c-1)

*Where **r** is the number of rows and **c** is the number of columns in the contingency table.*

Limitations on the Use of $\chi 2$

It is known that when values within a category are small, there is a chance that the calculation of $\chi 2$ may occasionally produce inflated results which may lead to wrong interpretations. It is safe to impose a 10% or 5% limit on all categories. When the category falls below either of these, then categories are grouped and the df falls accordingly.

Correlation

It frequently happens that two measurements relate to each other: a high value in one is associated with a high value in the other. The extent to which any two measurements are related in this way is shown by calculating the correlation coefficient (Reid, 2006; Pryce, 2005). There are three ways` of calculating a correlation coefficient, depending on the type of measurement:

(a) With integer data, Pearson correlation is used. This assumes an approximately normal distribution.

(b) With ordered data, Spearman correlation is used. This does not assume a normal distribution.

(c) With ordered data where there are only a small number of categories, **Kendall's Tau-b** correlation is used. This does not assume a normal distribution.

Sometimes, the two variables to be related use different types of measurement. In this case, none of the methods is perfect and it is better to use more than one and compare outcomes. It is possible to use a Pearson correlation when one variable is integer and other is dichotomous. The coefficient is now called a point biserial coefficient. In this study, Kendall's Tau-b is used because of all the variables are ordinal.

Factor Analysis

When a large number of measurements are made with a sample of people, the outcomes of these measurements may correlate with each other. The patterns of correlations obtained can sometimes arise because of some underlying reasons. Factor analysis examines all the measurements in all the variables with the entire sample and explores whether there is some simple structure of variables which can offer an exploration for the data obtained (Reid, 2006). Principal Components Analysis is one method to explore the underlying structure. If possible, any structure should account for around 70% of the variance and the Scree Plot suggest the number of variables needed in the structure. The underlying structure is described in terms of components (factors) and the correlations of each of the original measurements are referred to as "loadings". Each original measurement preferably should load highly onto a very small number of components. The actual nature of the components can only be determined by the researcher following exploration of each measurement and the way it loads onto the factors.