Science and Mathematics Education Centre

Learning Environments of Technology Supported Secondary Science Classrooms: A Study in an Indian School

Adit Gupta

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DECLARATION

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Adit Gupta **Date**

ABSTRACT

Science teaching at the secondary level can be made more effective with the judicious utilization of a multi-media approach involving modern information and communication technologies that is entering the Indian educational system in general and the schools in Jammu region (J&K State), in particular, surely but slowly. A major impact of technology today in the field of education is that at all levels classrooms are becoming technology-rich learning environments and as such there is a need to conduct research to study the learning environments of technology-supported classrooms.

The study described in this thesis utilized the Technology-Rich, Outcomes-Focused Learning Environment Inventory (TROFLEI), to study the perceptions of students' actual and preferred classroom learning environment in a technology-supported science classroom at the secondary level in an Indian school situation. An important aspect of this research was to determine the reliability and validity of this scale for use in Indian classroom settings. An attitude scale derived from the Test for Science Related Attitudes (TOSRA) for studying the attitude of students towards science was also employed and lastly the Questionnaire on Teacher Interaction (QTI) was used to analyze the teacher-student interactions in a technology-supported science classroom environment. Data for research were collected from 700 secondary students in a co-educational Indian school in the city of Jammu. The study reported that the TROFLEI and the QTI were reliable and valid instruments for assessing the psychosocial learning environments in a technology-supported classroom and the teacher-student interactions in such environments. Significant associations are also reported between the students' perceptions of their technology-supported learning environment and their perceptions of the teacher-student interactions with three learner outcomes; attitude towards science, academic efficacy and academic achievement. Significant gender differences in technology-supported learning environments have also been reported in this study. This research study happens to be the first of its kind in this region and should provide a thrust towards the use of technology-supported classrooms for effectively teaching other school subjects.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Everyone needs an education in science in order to understand the world and to be a good citizen and good worker. Scientists, leaders in government, industrialists, and the public in general need to be able to understand scientific problems and to make good judgements about them. We need scientifically literate and informed people to make decisions about such things as major government projects in space exploration and medical science; health problems, environmental and pollution problems, such as air and water pollution; diseases such as cancer or tuberculosis and epidemics; or the possible effects of chemical pesticides upon us and our environment.

More and more people will need science in their work, and they must depend on teachers to help them get the knowledge they will need. Each new breakthrough or the expanding frontier of science and technology, and the public's need to be informed, require a never-ending supply of well-trained people. This is also true in engineering, medicine and other fields related to science. The next generation of youngsters, as it passes through school, must be as well educated in and about science to enable them to prosper in our democratic society. Moreover, the ever increasing scientific and technological progress challenges man's ingenuity to improve his methods of processing, retrieving and reporting all sorts of scientific information. In a sense, we need a 'new breed' of people who can combine science with other talents, as for example, the scientist, librarian and the science reporter.

Good science teaching is one of the most valuable ways to meet this urgent need for science-educated citizens and workers. Enthusiastic, intelligent, and well-educated science teachers inspire and prepare students to investigate the great questions of science and the questions raised by the scientific discoveries which affect us and our society. Mainly through the inspiration of devoted science teachers, great numbers of students develop lifelong scientific interests and learn to appreciate and understand the nature of science and its usefulness to mankind (Ediger & Rao, 1996).

I have been associated with the educational process at the school level for the last 14 years in Jammu which is part of the state of Jammu and Kashmir situated in the northern part of India, first as a science teacher at the secondary level and then as the principal of a higher secondary school during the course of which, I have observed the teaching styles and methodology used by various science teachers in the classroom and found that General Science (a combination of Physics, Chemistry and Biology) in schools is usually taught by a lecture method. The usual practice followed by science teachers in local schools is to emphasize learning through rote memory. This makes the science classes dull and monotonous thereby reducing the level of interest and curiosity amongst the students. The teacher will find it difficult to maintain the attention of the students in the classroom and would thus lead to reduced motivation levels amongst the students. I have also observed that teachers sometime use non-interactive teaching aids such as charts, models, etc. and find it difficult to explain certain scientific concepts to the students. Also, there is very little emphasis on the use of multimedia technology to arouse the imagination and provide scientific and up-to-date information to enrich the knowledge of students. Thus to attain the objectives of teaching science in a classroom, students need learning opportunities which capture and maintain learner attention. Unless the students' interest is being maintained, the chances are that learning will not accrue as it should. Hence it is important that the science teacher provides initiating experiences which engage the learner actively as it is important for students to attend to what is being presented for more optimal learning to occur (Ediger, 1997).

I have been experimenting with a number of methodologies and tools for improving the classroom learning environment especially in science at various levels in the school so that the interest and curiosity of the students is maintained and learning is enhanced. It was observed that when technology was integrated with day-to-day teaching and learning in the science classroom the students were found to be more curious and interested in learning. The teachers also found it convenient to prepare and deliver the lessons using multimedia technology and the classroom environment became more interactive and lively. These small experiments with technology in light of the modern educational trends over the years motivated me to conduct research, to understand the effects of technology on teaching science at the school level and thus formed the basis for the present study. This study was also personally important to me because the use of modern information and communication technologies in promoting science education in schools is almost non-existent, particularly in the state of Jammu and Kashmir and it could contribute to the overall development of science education in the state and is likely to benefit a large number of students across diverse school levels.

From a researcher's point of view, I was interested in understanding the psychosocial learning environments that exist in a classroom where technology is integrated in the teaching learning process. I was also interested in assessing the attitudes of students towards science when studying in a technology-supported classroom. Since the teacher is the central figure in any classroom environment and interacts with the students for a longer period of time, it was also of interest to understand and assess the teacher-student interactions in terms of how students perceive their relationship with the teacher in a classroom where technology is used in the teaching of science.

1.2 IMPACT OF TECHNOLOGY ON CLASSROOM LEARNING

As digital technology resources pervade schools and classrooms, educators are beginning to rethink the nature of teaching and learning and refocus education from teacher to student and from teaching to learning (Owston, 1997). Unlike workers of the industrial age who were expected to acquire most of the knowledge necessary for mastery of a skill or job prior to performing the job, the information-age worker is expected to process large amounts of information on the job and create the knowledge needed to solve a problem or make a decision. Therefore, today's learners must think critically, analyze and synthesize information to solve technical, social, economic, political, and scientific problems, and work productively in groups (Grabinger & Dunlap, 1996). Unfortunately, conventional classroom instruction often fails to expose students to examples and problems that make knowledge relevant to them (Collins, Brown, & Holum, 1991).

To create teaching and learning environments that enable students to become effective and highly-skilled technologists, problem solvers, researchers, and communicators requires powerful, high-end technologies in the classroom as well as teachers adroit in utilizing these technology tools. Clearly, the low-end computer technology frequently found in K-12 classrooms, and especially in elementary school classrooms, is not sufficient to support the storage, presentation, and interaction requirements to deploy these powerful teaching and learning environments (Hannafin, Hill, & Land, 1997).

Current research on learning suggests that the real power of technology in the classroom is embedded in its potential to facilitate basic changes in the way teaching and learning occurs in the classroom. The effective and appropriate integration of technology in the classroom creates a dynamic learning environment where students are active participants in the learning process. There are indications that this style of learning results in improved academic achievement, improved attendance, and improved behaviour (e.g., see Dwyer, 1995; Mann & Shafer, 1997, 2002). Schacter (1999) analyzed several large-scale studies on the impact and effectiveness of instructional computing and found positive gains in student achievement on researcher constructed tests, standardized tests, and national tests. Studies also suggest that students in technology-infused classrooms are better able to perform multiple problems and carry out complex reasoning tasks (e.g., see Hopson, Simms, & Knezek, 2001, 2002; Van Dusen & Worthen, 1995; Wiburg, 1995).

Technology takes a special place as a powerful tool in classroom learning. Children's traditional classroom tools - pencils, notebooks, and texts - are still vital, but for children to assemble and modify their ideas, access and study information, they are inadequate. Computers, videos, and other technologies help children in understanding new concepts and trying out novel ideas. Thus it is important to understand that it is not what equipment is used in the classroom, but how that equipment is used that will make the difference. Technology must be thought of as an integral component of the curriculum, a tool that can be used with almost any content. Computers can be used as writing tools, spreadsheets, and scientific problem-solvers. Technology makes possible the instant exchange of information between classrooms as well as individual students; it allows instant access to databases and online information services; and provides multimedia technical resources such as interactive audio and video. Technology also allows for transforming of pre-existing educational materials across media formats: print, static illustrations, still and digital photographs, digital audio, still and motion video, still and motion film, animations, computer graphics, and hypermedia can all be accessed and combined in novel ways (Strommen & Lincoln, 1992).

Educators argue that new learning and teaching strategies may have to be introduced to prepare students to become independent learners. Technology may provide an opportunity to introduce such strategies. Through the use of technology, teachers can provide opportunities for the students to learn, think critically and have discussions with their peers supported by ICT. Bitter and Pierson (2002) consider that technology is an agent of change and appropriate use of technologies can make learning for students more interesting and enriching and prepare them for the demands of the workplace. Therefore, it is important that educators seriously consider matching the appropriate use of technology with content to maximize the student's potential in learning. Sharp (2002) envisaged that teachers will be "teaching" less and it is up to educators to inspire, motivate, and excite students about the use of technology for learning.

Over the years the role of technology in education has also dramatically changed. Rose and Fernlund (1997) wrote that during the 1980s, computer-assisted instruction (CAI) was an important part of classroom use. Teachers, department chairs, and district technology coordinators purchased commercial and public domain programs in the subject areas, stored on one or more floppy disks, including drill and practice programs, tutorials, simulations, and games. During the next decade there were four major changes that improved the application of technology in education: (1) the decline of the use of floppy disks, replaced by the enhanced storage capability of CD-ROMs and videodiscs; (2) enhanced interactivity in software in which students play a more active role; (3) sophisticated graphics, video clips, colour and sound, creating a multimedia presentation no longer dominated by screens of text; and (4) the growing marriage of technology and telecommunications, allowing a seamless transition from single computer use to collaborative work with distant partners and access to Internet-based sources.

Ediger and Rao (1996) emphasised that for a successful marriage between technology and education it is important that technology needs to be matched with the chosen objectives of instruction in lesson plans and units of study. After the use of technology in teaching and learning situations, the teacher should measure what pupils have learned. The results should be given in numerical terms and not as vague subjective data. The objective results must be reported to parents to indicate learner achievement in the school curriculum. There need to be definite plans to integrate technology into the school curriculum. This should not be left to chance, but rather quality goals and plans have to be developed to use technology to its fullest capacity in teaching and learning situations. Teachers need to have easy access to technology in lesson plan and teaching unit construction. A teacher trained in the use of technology alone can educate children for more optimal achievement.

Thus it is evident that the role of technology in bringing about a revolution in every aspect of education cannot be undermined. However, care should be taken so that there is no over indulgence in technology otherwise the humanistic aspect in education could be the sufferer.

1.3 FIELD OF LEARNING ENVIRONMENT

Research and evaluation in science education have relied heavily on the assessment of academic achievement and other valued learning outcomes. However these measures cannot give a complete picture of the educational process. Because students spend up to 15,000 hours at school by the time they finish senior high school (Rutter, Maughan, Mortimore, Ouston, & Smith 1979), students have a large stake in what happens to them at school and their reactions to and perceptions of their school experiences are significant. Remarkable progress has been made in conceptualising, assessing and investigating the determinants and effects of social and psychological aspects of the learning environments of classrooms and schools.

This study draws on and contributes to the field of learning environments (Fraser, 1994, 1998a). Contemporary research on school environments partly owes inspiration to Lewin's (1936) seminal work in non-educational settings, which recognised that both the environment and its interaction with characteristics of the individual are potent determinants of human behaviour. Since then, the notion of person-environment fit has been elucidated in education by Stern (1970) in which the degree of person-environment congruence is related to student outcomes, whereas Walberg (1981) has proposed a model of educational productivity in which the educational environment is one of nine determinants of student outcome. Research specifically on classroom learning environments took off about 30 years ago with the work of Walberg (1979) and Moos (1974) which spawned many, diverse research programs around the world (Fraser, 1994, 1998a) and led to the creation of *Learning Environments Research: An International Journal* (Fraser, 1998b). Although earlier work often used questionnaires to assess learning environments, the productive combination of qualitative and quantitative methods is a hallmark of the field today (Tobin & Fraser, 1998).

Not only has learning environments research expanded remarkably over the past few decades on the international scene, but also Asian researchers have made important and distinct contributions particularly over the previous decade. Asian researchers have cross-validated the main contemporary learning environment questionnaires that originated in the west and have undertaken careful translations and adaptations for use in the Chinese, Korean, Malay and Indonesian languages. Asian studies have successfully replicated Western research in establishing consistent associations between the learning environment and student outcomes, in using learning environment assessments in evaluation of education programmes and in identifying determinants of learning environments (Fraser, 2002).

Past research on learning environments provides numerous research traditions, conceptual models and research methods that are relevant to the present study. The present study draws on the rich resource of diverse, valid, economical and widely-applicable assessment instruments that are available in the field of learning environments (Fraser, 1998b). Also, the study draws on past evaluations of educational innovations (Chandra & Fisher, 2005; Chang & Fisher, 2003; Khine & Fisher, 2003; Zandvliet, 2003) from the field of computer-based learning environments. This study is particularly influenced by the research studies on technology-rich learning environments which have illustrated the effectiveness of the use of technology in teaching science and its relationship with selected learner outcomes (Aldridge, Dorman, & Fraser, 2004; Aldridge & Fraser, 2003).

The inclusion of learning environment instruments and measures provide an effective methodology for investigating the impact of the use of technology in teaching science at the secondary level and also in understanding the quality of the teacher-student interactions in such classrooms. While such instruments provide important information about student perceptions of the teaching/learning environment they have also been linked with other cognitive and affective student learning outcomes (e.g., attitude towards science, academic efficacy and academic achievement). When taken together with the other methodologies used in this study, information about the learning environment in classrooms helps to provide a more holistic picture of the 'ecology' of these new environments created by the introduction of information and communication technologies (Zandvliet, 2003).

It has been aptly observed by Fraser that there is considerable optimism internationally that the integration of information communication technology (ICT) into the learning environments will provide teachers with the means to manage efficiently the diverse educational provisions needed to optimize each individual student's outcomes. In many educational settings, ICT is becoming more common place and, in some cases, the integration of ICT into the learning environment is becoming a major thrust. However it is important that our optimism about the efficacy of technology-rich learning environments is accompanied by systematic research and evaluation.

1.4 SCIENCE EDUCATION IN INDIA

The development of science in India was greatly accelerated after independence (August 1947). In 1950, the Government of India appointed a Planning Commission for preparing a blueprint of all-round economic development. In 1954, the Indian Parliament accepted socialism as a political goal. Declaring these objectives, great emphasis was laid on the development of science and technology on all fronts. In

1957, the Government took one step further in adopting a *National Science Policy Resolution* that envisaged the cultivation of science and scientific research in all its aspects, assured an adequate supply, within the country, of research scientists of highest quality through an intensive programme of training, promised the availability of conditions and an atmosphere of academic freedom in which the creative talent of men and women would find full scope in scientific activity. The resolution thus reaffirmed the government decision to encourage science and develop a healthy scientific community as a sound basis after a balanced economic development.

The All India Seminar on the teaching of science in secondary schools held in 1956 , dealt with almost all the problems facing the inclusion of General Science as a core subject for the Higher Secondary Classes. It was the first to touch almost all the aspects concerning the teaching of science in schools i.e. syllabus, equipment and apparatus, method of examination, teaching aids in science and other allied topics like Text-Books, Science Clubs, Museums, etc. It suggested a unique and uniform system of science teaching for the entire country, suited to its needs and resources.

In view of the rapid influence of science on society and of the Government policies, it was felt that both the scientists and the politicians should be brought to a common platform to formulate new policies and procedures in accordance with scientific developments. The Parliamentarians must be acquainted with developments of science and technology and with the scientific viewpoint. The Indian Parliamentary and Scientific Committee was set up in August, 1961, under the Chairmanship of Late Shri Lal Bahadur Shastri. It took up, in early 1962 the study of the problem of science education in schools to find out the relationship between the policies and decisions of the centre and the states and the courses offered in the schools. It also studied the allied problems of:

1) Growth of school population
2) Shortage of qualified teachers
3) Accelerated achievements in science
4) The demand for increase in technically trained manpower
5) Growing importance of science in the affairs of mankind
6) Changes in the processes and goals of science

7) The views held by different thinkers in regard to the structure of the school system and the content necessary for education of youth.

In 1962, the experts of the UNESCO Planning Commission visited India on technical assistance projects. They worked on the problems and gave their recommendations on different issues of science education in secondary schools. Three reports were prepared by the team, which gave the total picture of Science and Mathematics Education in India and suggested ways to improve it. As a follow up program of the report of UNESCO Planning Commission, the Department of Science Education in the National Council took up pilot projects of preparing new curriculum, text books, teachers' guides, etc. To start with, these experimental projects were started in about 20 selected schools in Delhi.

After a number of years of deliberations and experimentation with the introduction of science in to the school curriculum, the Kothari Education Commission (1964-66) was setup which gave the necessary recommendations for inclusion of science as a compulsory subject in schools across the country. The recommendations of this commission were implemented in 1975 when *Science for All* (SFA) was introduced as a part of general education during the first ten years of schooling. The recommendations of this committee were:

1. Science and mathematics should be taught on a compulsory basis to all pupils as a part of general education during the first ten years of schooling.

2. In the lower primary classes, science teaching should be related to the child's environment. The Roman alphabets should be taught in class IV to facilitate understanding of internationally accepted symbols of scientific measurement and use of maps, charts and statistical tests.

3. At the higher primary stage, emphasis should be on the acquisition of knowledge and the ability to think logically, to draw conclusions and to make decisions at a higher level. A disciplinary approach to the teaching of science will be more effective than the general science approach.

4. A science corner in lower primary school and a laboratory-cum-lecture room in higher primary schools are minimum essential requirements.

5. At the lower secondary stage, science should be developed as a discipline of the mind. The newer concepts of Physics, Chemistry and Biology and the experimental approach to the learning of science should be stressed.

6. Sciences courses, as an advanced level, may be provided for talented students in selected lower secondary schools with necessary facilities of staff and laboratory.

7. Science teaching should be linked to agriculture in rural areas and to technology in urban areas.

8. The methods of teaching science should be modernized, stressing the investigatory approach and the understanding of the basic principles. Guide materials should be made available to help teachers adopt the approach. Laboratory work will need considerable improvement. There should be flexibility in the curriculum in order to cater to the special needs of the gifted pupils.

9. The development of science must drive its nourishment from our cultural and spiritual heritage and not bypass it.

10. At the university level, better conditions for research should be provided.

The recommendations of this commission were implemented throughout the country and feedback was collected from various working groups. However, with the advancement and modernisation in the field of education the Government of India, after a gap of 20 years, came up with the National Policy on Education in 1986 which laid special emphasis on science education in schools at all levels. The main emphasis of this policy was that the quality of science teaching requires to be improved considerably so as to achieve its purpose and objectives, i.e. to understand the basic principles, to develop problem solving, analytical skills and ability to apply them to the problems of everyday life besides promoting the spirit of enquiry and experimentation.

To further promote science education in schools, the Government of India established the National Council for Educational Research and Training (NCERT), which was an apex resource organisation setup in order to assist and advise the central and state governments on academic matters related to school education. Developmental activities in school education constitute an important function of the NCERT. The major developmental activities include development and renewal of curricula and instructional materials for various levels of school education and making them relevant to changing needs of children and society. The innovative developmental activities include development of curricula and instructional materials in school education in the area of pre-school education, formal and non-formal education, vocationalisation of education and teacher education. Developmental activities are also undertaken in the domains of educational technology, population education, and education of the disabled and other special groups.

Being an apex national body for research in school education, the NCERT performs the important functions of conducting and supporting research and offering training in educational research methodology. The sixth survey of educational research was conducted by the NCERT for research studies conducted in India from the year 1993 to 2000. This study was published in the year 2006 and contained reference to research studies conducted in the area of science education. This survey highlighted that in India, as in several other countries, learning science is not as popular as it should be and too few students choose to continue with science into higher education and to a career. Science in Indian schools has often been criticized for being too prescribed, impersonal and lacking in opportunity for personal judgements and creativity. Science has been reduced to a series of small, apparently trivial activities and pieces of knowledge unrelated to the world in which students are growing up. There is a growing acceptance among science education reformers that the processes of doing science should not be separated from scientific content and that the aims of science education should be clearly spelt out (Dewal, 2006).

Learning science is never only about learning to know the natural world. Students also learn how the social world is perceived. Science education necessarily contains values. Science has to be recontextualised in order to be meaningful in schools. Science education practices have a potential for socializing students. From a cultural perspective, students with different world-views may attend classes wherein the context of science may be in conflict with their backgrounds (Dewal, 2006).

As per the survey, students entering the science classroom have a number of previous experiences, ideas, beliefs and expectations about the natural world. The content taught in the classroom is interpreted in the light of this prior knowledge. Even after formal instruction, student's spontaneous conceptions often remain at variance with accepted scientific ideas. These have been labelled alternative conceptions. Research all over the world has gone into uncovering alternative conceptions in different groups of students, and drawing their implications for learning.

In the Sixth Survey of Educational Research, a total of 120 research studies in the field of science education were recorded. The tally of 120 studies is miniscule and does not reflect favourable on the existing and increasing growth in the number of schools, colleges, universities and institutions along with the large number of persons, in the form of teachers, lecturers, readers, professors, teacher-educators, full-scale researchers and other academic staff who are involved in science education (Dewal, 2006). Table 1.1 indicates one possible categorization of research studies conducted in the area of science education during the period of the survey.

Table 1.1

Studies on Science Education in India as per Sixth Survey of Educational Research

FREQUENCY OF STUDIES IN VARIOUS AREAS OF SCIENCE EDUCATION		
Areas of Science Education	No. of Studies	(%)
Students attitudes towards science	13	11
Cognitive studies of science	39	32
Teaching material	18	15
Science teaching	23	19
Environmental factors	7	6
Achievement of students in science subjects	6	5
Creativity	3	3
Gender issues in science teaching	6	5
Miscellaneous	5	4
Total	120	100

From these data it is clear that the number of research studies in the field of science education is much less and studies concerning learning environments research are almost negligible. In light of the deficiencies pointed out by this survey, the research study described in this thesis is likely to contribute significantly to the research studies on science education both in quantitative and qualitative terms highlighting the role of technology in improving science education in Indian schools at the secondary level.

However, a number of initiatives have been taken to enhance the quality of research in the field of science education since the year 2000 both in qualitative and quantitative terms. Institutes like the Homi Bhabha Centre for Science Education (HBCSE), Indian Institute of Science (IISc), Indian Institute of Science Education and Research (IISER) to name a few having being carrying out research to promote science education and for developing tools to enhance learner participation in science project in schools. This includes developing teaching-learning material, teaching aids, designing curriculum, text books and effective teaching methodologies etc. The Department of Science and Technology has also given shape to the Science and Technology Policy in the year 2003 where special emphasis has been laid on research and development in the field of science education and provision of funds for producing innovative research studies has also been made. This shows the growing focus of the research community towards science education and hopefully by the time the NCERT publishes the next educational survey, a large number of studies would have been carried out in our country.

Apart from the educational and research community the Indian Government has also realised the importance of science education and it is making concentrated efforts for its promotion and amelioration. Recently the Indian Prime Minister Mr. Manmohan Singh while inaugurating the 95th Indian Science Congress (ISC) declared that the central government would work with state governments and universities to launch a new revolution in modern education, especially science education and called upon the academia and the scientific community to make 2008 the year of revitalising science education in India. Making a personal commitment towards an affirmative action for rejuvenating science education, the prime Minister said the time had come for action, as the nation could not afford to miss the bus or delay matters further. He further said that the government is committed to investing more, much more in education, especially science education. The 11th five-year plan is, in fact, a national education plan. The plan allocation for education has been stepped up to 19 percent of gross budgetary support in the 11th plan (2007-12) from 7.7 percent in the 10th plan. The Prime Minister also declared the setting up of 30 new central universities, five Indian Institutes of Science Education and Research (IISE&R), eight more Indian Institutes of Technology (IITs), seven new Indian Institutes of Management (IIMs) and 20 Indian Institutes of Information Technology (IIITs) across the country. The main objective of the government is to enlarge the pool of scientific manpower and foster research in multi-disciplinary sciences for which the science and technology ministry will also launch a special programme - 'Innovation in Science Pursuit for Inspired Research'. He further stated that science has to be made a preferred discipline of study for the students and we must attract the best and the brightest to science. There is a need of both qualitative improvement and a quantitative expansion in the pool of science students.

1.5 AIMS AND OBJECTIVES OF THE STUDY

The main focus of this study is to understand the impact of the use of technology in teaching science at the secondary level and to determine its effectiveness in terms of selected learner outcomes. This is one of the first studies in India to use the modified form of the *Technology–Rich Outcomes-Focused Learning Environment Inventory* (TROFLEI; Aldridge, Dorman, & Fraser, 2004; Aldridge & Fraser, 2003) in conjunction with attitude and efficacy scales to assess the technology-supported learning environments in a science classroom. *The Questionnaire on Teacher Interaction* (QTI; Wubbels & Levy, 1993) has also been used in this study to investigate the perceptions that students have of their teacher interpersonal behaviour in a technology-supported science classroom. Since the study is being conducted in a co-educational school, exploring the gender differences in a technology-supported learning environment would also be one of the aims of this research. The overall aim of the study is to determine the effectiveness of the technology-supported classroom in teaching of science in terms of satisfaction of students.

The specific objectives of the proposed research study are:

1. to determine the reliability and validity of the modified form of Technology–Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) for use with urban Indian secondary school students;

2. to further validate the Questionnaire on Teacher Interaction (QTI) when used in a technology-supported learning environment;

3. to investigate associations of students' perceptions of their technology-supported learning environment in a science classroom with attitude towards science, academic efficacy and academic achievement;

4. to investigate associations of students' perception of their teacher-student interactions with attitude towards science, academic efficacy and academic achievement in a technology-supported science classroom; and

5. to investigate whether gender differences occur in students' perception of their technology-supported learning environment in a science classroom and their teacher-student interaction along with differences in their attitude towards science, academic efficacy and academic achievement in a technology-supported learning environment.

1.6 SIGNIFICANCE OF THE STUDY

Globally the widespread use of technology in schools has now gone beyond the major industrialist countries as evidenced in a 1999 *International Association for the Evaluation of Educational Achievement* (IEA) study, the *Second Information Technology in Education Study: Module I* (SITES MI)- which documented the significant investments in educational Information and Communication Technologies (ICT) around the would (Pelgrum & Anderson, 1999).

The use of technology in education is driven and supported by evidence that new technologies can change schools and improve education (Bracewell, Breuleux, Laferriere, Benoit, & Abdous, 1998; Coley, 1997; Means & Olson, 1995; Wenglinski, 1998) and by major shifts in policy at both national and international levels. Technology can transform schools and classrooms by bringing in new curricula based on real world problems, providing scaffolds and tools to enhance learning, giving students and teachers more opportunities for feedback and reflection, and building local and global communities that include students, teachers, parents, practising scientists, and other interested parties (Bransford, Brown, & Cocking, 2000)

In the highly influential synthesis of research, *How People Learn*, the emphasis on 'Learning with Understanding' is the hallmark of the new science of learning (Bransford et al., 2000). They summarized research on the benefits of new technologies for enhancing students' learning, stressing that technologies do not guarantee effective learning, but that technologies can make it easier to create environments that embed research-based principles of learning.

In many fields, new technologies allow representation of data in new ways. Technologies such as three-dimensional models of planets or molecular structures help people to visualize difficult to understand concepts. This move from static to a technology-based dynamic model has profoundly changed the nature of inquiry in mathematics and science for researchers, as well as for students (Bachelard, 1984; Holland, 1995)

Review of past research gives detailed information regarding the work done by a number of researchers, educators and technologists in studying the role and impact of technology on education. Research in this area has also been done in India (Goel, 1993; Lalitha & Shailja, 1986; Padma & Chakraborti, 1990; Singh, 1991). However, few studies have been conducted in studying the learning environments of technology-supported science classrooms at the secondary level in general and almost none in India in particular.

The proposed research gives me an opportunity to contribute to the ever expanding field of learning environments, specifically the effects brought on by the introduction of multimedia technology in the classroom. The present study is significant for the following reasons.

1. It is for the first time that the TROFLEI (Technology-Rich, Outcomes-Focused Learning Environment Inventory) is used in an Indian setting to study the students' perceptions of the learning environment in technology-supported science classrooms at the secondary level.

2. This study is also significant because the TROFLEI, which has been used mainly in terms of computer-enriched classrooms, is adapted to a technology-supported classroom where the computer is one of the components to deliver the contents to the students.

3. In this study for the first time, use of a ten-item attitude scale derived from the *Test Of Science Related Attitudes* (TOSRA) (Fraser, 1981) for studying the attitudes of Indian students towards science when taught through the technology-supported classroom at the secondary level is employed.

4. Also the Questionnaire on Teacher Interaction (QTI) is used to study the teacher-student interaction in a technology-supported learning environment.

5. The TROFLEI and the QTI are also used for the first time in India to investigate gender differences and associations between technology-supported learning environments and students' attitude, achievement and academic efficacy.

The present study happens to be the first study on the learning environments of technology-supported classrooms at the secondary level in an Indian school setting wherein such classrooms are not known to exist especially in the state of Jammu and Kashmir which is a militancy infested area in which the infrastructure of the schools in general is quite poor as far as implementation of technology is concerned. In fact, the development of a low cost technology-supported classroom can be humbly claimed to be a major innovation if its success is demonstrated as it might lead to major changes for the teaching of general science.

Seen in the above perspective the research study is likely to be a significant effort to try out the efficacy of the ICT supported learning environment for the teaching of science in an Indian school at the secondary level using reliable and valid tools of measurement and assessment.

1.7 LIMITATIONS OF THE STUDY

This research was mainly concerned with studying the impact of technology on the psychosocial learning environments of the secondary science classrooms in India and the teacher-student interactions in such classrooms. Since this study required a technology based setup to observe the classroom transactions, the choice of schools was quite limited as in the city of Jammu, where this study was conducted, the schools had good situations in terms of computer labs but the use of technology for academic activities in the classroom was negligible. Hence, for this reason, the study could be undertaken in only one school where technology-supported classrooms were in place for teaching school subjects.

This also meant that the sample size was greatly reduced and fewer teachers could participate in the study. Another limitation of the study was the availability and access to technology-supported classrooms, as such a setup was not available in all the classes and thus a lot of time was consumed in arranging different classes in a limited number of rooms available for the purpose. This research study also involved training the teachers in the use of technology which was a difficult task as pre-trained teachers were not available who could be readily used for teaching through a technology based setup.

1.8 OVERVIEW OF THE THESIS

This thesis consists of seven chapters covering all aspects of this research study right from review of literature, the research design, analysis of data and findings of the study. Chapter 1 provides information regarding the background of the study, the positive impact of technology on classroom learning, a perspective from the Indian point of view on the development of science education in the country, the aims and objectives of the study and the significance of the study.

Chapter 2 throws light on the review of literature essential for the study. In this chapter, literature describing research on technology and classroom learning, research studies related to the use of technology in Indian classrooms, learning environment research, research on application of technology in the field of learning environments and research on teacher-student interaction are examined. Review of literature from studies using the What Is Happening In This Class (WIHIC), Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) and Questionnaire on Teacher Interaction (QTI) is also presented.

The research methodology used in this study is discussed in Chapter 3. This includes the research aims and objectives, the preparation for the study including the setting up of the technology-supported classrooms, training of teachers in the use of technology, sample for the study and the selection of the research instruments. The quantitative and qualitative methods of data collection and analysis have also been discussed in this chapter.

Details of validation data for the TROFLEI along with the attitude and efficacy scale and the QTI are presented in Chapter 4. The new scale developed for TROFLEI has also been validated and its intercorrelations with other scales computed. A factor analysis was also performed to ensure the factor structure of the new instrument.

Chapter 5 presents data from other measures used in the study. These include descriptive statistics using TROFLEI and QTI, associations between attitude towards science, academic efficacy and academic achievement with both TROFLEI and QTI and gender difference in a technology-supported classroom in terms of psycho-social learning environments, teacher-student interaction and learner outcomes.

Qualitative data from the interviews are presented in Chapter 6. These data report on further validation of the TROFLEI and the QTI by comparing the means scores of these instruments with the interview responses by the students.

Finally, Chapter 7 reports the major findings with reference to the research objectives of the study. This chapter also provides information on the implications, limitations and conclusions of this study. Future directions for research based upon the findings of this study are also suggested.

The thesis ends with the references used in the study after which there are several appendices consisting of a full set of questionnaires as used in this study, the interview schedule and the process diagram of the technology-supported classroom setup for the purpose of this research.

1.9 CHAPTER SUMMARY

This chapter gives an outline of the background of the study and the motivation that I had, to take up this research. The role of technology in improving the teaching learning process in the science classroom has also been projected. The field of learning environment has been introduced and how technology is being used to bring about positive changes in the classroom environment in educational institutions across the globe has also been highlighted. Science education from the Indian point of view has been discussed in terms of its development and research studies being done in this area along with the research objectives and significance of the study. Lastly, in this chapter, a brief overview of the contents of each chapter contained in this thesis is presented. The next chapter reports on the literature reviewed for the purpose of undertaking this study.

CHAPTER 2

REVIEW OF LITERATURE

2.1 INTRODUCTION

The review of literature in this chapter throws light on the contribution of technology in improving the process of education in different countries in general and India in particular. Since the main aim of this study is to assess the learning environments of the technology-supported science classrooms, hence the review of various studies on the use of technology in teaching and learning process was important. The review also deals with the ever expanding field of learning environments and briefly gives the historical perspective of the development of learning environments and its various instruments that are used to understand the students and teachers perception of their psychosocial environments. In fact, the recent studies involving the use of technology in the field of learning environments have also been summarised for the first time in this study thereby highlighting the integration of different technologies ranging from computers, Internet, Web-based technologies, multimedia rich curriculum and other ICT based tools for enriching the learning environments.

The purpose of this study is also to validate the two classroom environment research instruments, first being the Technology-Rich Outcomes–Focused Learning Environment Inventory (TROFLEI) (Fraser, 1998) which has been developed using the What Is Happening In This Class (WIHIC) (Fraser, Fisher, & McRobbie, 1996) instrument and the other being the Questionnaire on Teacher Interaction (QTI) (Wubbels & Levy, 1993). This review of literature also gives extensive information about the development of the WIHIC questionnaire and the studies in which it has been used and validated in a large number of countries with different samples of students and then discusses the development and validation of the TROFLEI as an instrument to study the perceptions of the students regarding their psychosocial environment in a technology-rich classroom learning environment.

The last part of this chapter discusses the historical development of the Questionnaire on Teacher Interaction (QTI) which has been used to study the students' perceptions of the teacher interpersonal behaviour or teacher-student interactions in a technology-supported classroom environment. A number of research studies using the QTI as an instrument have also been outlined signifying its reliability and validity and usefulness in assessing interpersonal behaviour.

2.2 TECHNOLOGY AND CLASSROOM LEARNING

Technology has played a major role in improving the modern education system at various levels of learning whether it be school, college or university education. Not only has the use of technology increased to make the process of teaching and learning in the classroom more effective, learner centred and outcome focussed but it has also given an impetus to the teachers to use it as a tool to bridge the gap between traditional learning and modern educational requirements for the overall development of the learner. A look at the use of technology at various levels and in different settings, shows how rapidly various information and communication technologies are being adopted as a catalyst to enhance learning.

Researchers (Bransford, Brown, & Cocking, 2000; Roschelle, Pea, Hoadley, Gordin, & Means, 2000) remarked that a number of features of new technologies are consistent with principles of the science of learning and hold promise for improving education. They contended that new information and communications technologies (ICT) can bring exciting curricula based on real-world problems into the classroom, and provide tools to enhance learning. The interactivity of technologies is cited as a key feature that enables students to receive feedback on their performance, test and reflect on their ideas, and revise their understanding. Networked technology can enable teachers and students to build local and global communities that connect them with interested people and expand opportunities for learning.

Rapid developments in technology have influenced the evolution of student centred learning environments (Strommen & Lincoln, 1992). Complex information systems can now be designed and accessed for individual purposes with comparative ease

(Marchionini, 1988). Emerging information systems, such as the *World Wide Web*, support varied student-centred approaches in a variety of settings (Shotsberger, 1996). Integrated multimedia platforms are now common place, providing powerful systems for developing and using highly sophisticated learning environments. Software innovations have also been prominent. Significant advances in authoring, multimedia development, production tools, simulation software, and expert system shells have been apparent (Li & Merrill, 1990). Simplified use has increased interest in classroom applications of "learning by designing" (Harel & Papert, 1991; Pea, 1991; Trollip & Lippert, 1987). Software developments have increased not only the power and versatility of emerging systems, but have made them increasingly friendly and intuitive. Individuals can uniquely define the purposes of technology's uses, and exploit its capabilities to support individual interests and needs.

Particularly in recent years, a number of studies have provided convincing evidence that technology can be effective in teaching basic skills. For example, a study on the impact of learning technologies on student achievement in Illinois reported that scores on state assessments improved in many areas, such as 11th grade science and 10th grade reading, (Silverstein, Frechtling, & Miyaoka, 2000).

While evidence indicates that computers can help students improve their performance on tests of basic skills, many researchers investigating the use of technology in education have found that technology is most powerful when used as a tool for problem solving, conceptual development, and critical thinking (Culp, Hawkins, & Honey, 1999; Means, 1994; Sandholtz, Ringstaff, & Dwyer, 1997). It involves students using technology to gather, organize, and analyse information, and using this information to solve problems. In this manner, the technology is used as a tool, and teachers and students (not the technology) control the curriculum and instruction (Means, Blando, Olson, & Middleton, 1993).

One of the most powerful uses of technology in education is to tailor instruction to students' individual learning needs. Technology can provide the means for students with special needs to communicate via email and use the Internet for research, and can also help teachers accommodate students' varying learning styles (Silverstein et al., 2000). Gifted students can work at their own pace and explore subjects in more depth than the basic curriculum. Technology can also analyse and provide immediate feedback on performance, and can suggest modifications in instruction where necessary to improve student achievement (CEO Forum on Education & Technology, 2001).

In addition to examining the effect of technology on student outcomes, researchers have investigated the impact of technology on classrooms, schools, and districts. Results of a variety of studies (Chang et al., 1998; Hawkins, Spielvogel, & Panush, 1996; Means, 1994) suggest that, over time, technology can serve as a strong catalyst for change at the classroom, school, and district level. Glennan and Melmed (1996) point out that introducing information technology into the schools may provide the catalyst that enables and forces the restructuring necessary to meet the national education goals. Conversely, evidence also exists that technology will have a stronger impact when technology integration is part of a broad based reform effort (Sandholtz et al., 1997). In other words, the relationship between technology and reform appears to be reciprocal. Each can benefit from the other.

The application of educational technologies to instruction has progressed beyond the use of basic drill and practice software, and now includes the use of complex multimedia products and advanced networking technologies. Today, students use multimedia to learn interactively and work on class projects. They use the Internet to do research, engage in projects, and to communicate. The new technologies allow students to have more control over their own learning, to think analytically and critically, and to work collaboratively. This "constructivist" approach is one effort at educational reform made easier by technology, and perhaps even driven by it. Traditional lecture methods are often left behind as students collaborate and teachers facilitate. Students, who often know more about technology than the teacher, are able to assist the teacher with the lesson. Since this type of instructional approach, and the technologies involved with it, is a recent development, it is hard to gauge its educational effects. Still, an increasing body of evidence as presented by Bialo and Sivin-Kachala (1996) suggests positive results. The Apple Classrooms of Tomorrow (Dwyer, 1994), a 10-year project where students and teachers were each given two computers, one for school and one for home, illustrates some of the gains made in students' advanced skills. ACOT reports that students explored and represented information dynamically and in many forms, became socially aware and more confident, communicated effectively about complex processes, became independent learners and self-starters, worked well collaboratively, knew their areas of expertise and shared expertise spontaneously and used technology routinely and appropriately. Another effort called the Buddy Project (Indiana's Fourth Grade, 1990) supplied students with home computers and modem access to school. Positive effects included an increase in writing skills, better understanding and broader view of math, ability to teach others, and greater problem solving and critical thinking skills.

Numerous studies over the years, summarized by Bialo and Sivin-Kachala (1996), report other benefits enjoyed by students who use technology. These benefits involve attitudes toward self and toward learning. The studies reveal that students feel more successful in school are more motivated to learn and have increased self confidence and self esteem when using CAI. This is particularly true when the technology allows the students to control their own learning. It is also true across a variety of subject areas, and is especially noteworthy when students are in risk groups (special education, students from inner-city or rural schools).

Recently there has been a shift in the way ICT is perceived in the classroom, with a shift towards the quality of learning experiences rather than just quantifiable outcomes (Godfrey, 2001). Furthermore, while the earliest approaches to integrating ICT into the school curriculum focussed on technology skills as an end in themselves, researchers now describe ICT as a powerful teaching and learning tool that has the potential to reshape the educational process (Cotton, 1997; King, 1997; Newhouse, 1998).

Many studies (e.g., Bain, McNaught, Mills & Lueckenhausen, 1998; Lajoie, 1993; Sandholtz, Ringstaff, & Dwyer, 1991) indicated that the use of computers in the classroom increases student motivation and interest. In a series of case studies at 17 English primary and secondary schools, Passey, Rogers, Machell, McHugh and Allaway (2003) examined the impact of ICT on pupil motivation, learning outcomes, behaviour and school attendance. Their study concluded that overall motivational aspect of ICT was positive. The forms of motivation which arose were concerned with commitment to learn, more so than completion of tasks and they found that ICT had a positive effect on student engagement, research, writing and presentation. There was also evidence that ICT impacted positively on students attitude and engagement towards their school work and that their behaviour in class was better when ICT was used.

2.2.1 Summary

On reviewing the literature in this chapter it is observed that the role of technology in the improvement of the teaching learning process is multifaceted. Technology has become the enabler of education in the 21st century and has opened up new vistas in the field of educational research. With the advancements in technology and development of curriculum-based rich ICT material the learners have ample opportunities to learn at their own pace and time in a highly interactive environment. The benefits of technology are clearly evident from the studies that have shown that the students level of achievement, attitude, motivation and interests have increased and improved over a period of time. New research studies are being undertaken in different countries to study the effect of technology on classroom learning as the learning needs of the learners are changing and new technological developments are taking place to help the teacher in making the teaching learning process in the classroom more effective.

2.3 RESEARCH ON USE OF TECHNOLOGY IN INDIAN CLASSROOMS

The status of research in India with respect to instructional uses of computers and technology at the school stage, in general, can, at best be described as in a "stage of development". This is primarily so because the instructional use of computers and allied technology at the school stage started late (in the year 1984 to be precise), when the government of India started the Computer Literacy and Studies in School (CLASS) project for senior secondary students. Before 1984, computers were mainly used in India for storage and processing of scientific and research data. In the view of these developments, even though the use of computers in school is gradually increasing yet its use in classroom learning situations is very limited as computers are mostly used for learning computer languages and other applications rather that as tools for learning other subjects.

Reasons for the paucity of research on usage of technology in the classroom learning process have been identified by several writers. According to Adinarayana and Anadan (1992, 93), among other factors, paucity of research on CAI in India is due to lack of computer knowledge among teachers to prepare CAI programmes on different subjects or content areas, lack of supporting infrastructural facilities such a sufficient quantity of hardware, software, trained manpower, suitable laboratories, regulated power supply, and competent teachers who are necessary for advancement in CAI.

As succinctly observed by Gupta (1992) that we still need to successfully interface computers with classroom learning due to the following reasons: a) paucity of trained teachers b) lack of student friendly software c) inadequate hardware d) lack of initiative on part of the teachers e) lack of willingness on part of the parents and learners to deviate from the conventional methods of learning f) lack of graphical and multimedia support for effective CAI and g) inadequate maintenance and upgrading of computers.

Notwithstanding the above, some experiments or studies have been conducted in India in the last two decades to explore the effectiveness of computers and other technologies as tools of classroom learning. Some representative studies are now summarized to give a perspective of studies in India.

Lalitha and Shailaja (1986) conducted a study on Computer Assisted Instruction (CAI) in relation to traditional teaching and came up with the conclusion that CAI was more effective than traditional teaching with respect to imparting knowledge but not so in regard to developing understanding.

Gupta (1985) conducted a study on the effectiveness of Computer Aided Instruction in Chemistry. The investigator reported computer aided instruction to be a more effective technique in terms of students’ gains at the ninth grade level.

Padma and Chakraborti (1991) studied the attitudes of high school students towards computer education and concluded that significant differences existed between the attitudes of boys and girls towards computer education. They further concluded that there was no difference between tribal and non-tribal students as regards their attitudes towards computer education.

Raghvan and Dharmarajan (1991) conducted field trials for the development of educational computer software packages on two hundred students of grade ten in Coimbatore District of Tamil Nadu. A unit on matrix in mathematics was presented through the computer and compared to conventional method. The results of the study showed the relative superiority of the Computer Aided Instructional Technique with the mean scores of students having being coached through software based learning modules significantly higher than their counterparts coached by conventional methods.

Shade and Mani (1991) presented a theoretical model for use of computers for effective instruction of exceptional children. Giving details of the mildly handicapped (speech or language disorder), physically handicapped, gifted and talented and sensory impaired (visually impaired and blind), they showed how computer attributes were ideally suited to enhance and improve classroom management, training opportunities and teaching techniques for these groups of students to best promote individualized instruction and facilitate optimal learning experiences for the learners.

Singh, Ahluwalia, and Verma (1991) conducted an experiment in the domain of teaching of mathematics to test the effectiveness of Computer Aided Instruction when compared with a conventional method. Taking students in groups of 20 to 30, the investigators compared the effectiveness of the two methods in three units of mathematics at ninth grade level. The result of the study showed significant differences between the mathematics achievement of the students who had used computers as compared to the students learning by the conventional method in favour of the former group. Differences in achievement scores of male and female students were not found to be significant.

Stella (1992) conducted a study to test the effectiveness of computer assisted learning with reference to under-achievers. In her experimental study, she developed a computer assisted learning package on the topic “language of sets” in mathematics with provisions for branching and remediation and tried it with 147 students studying in seventh grade (including 26 over-achiever, 73 normal achievers and 48 under-achievers). The investigator found computer assisted learning to be an effective individualized instructional technique especially for under-achievers when compared to average or over-achievers.

Goel and Dube (1993) in their studies employed a CAI technique on children in the age group of 4 to14 years and studying in primary classes in the University Innovative School Devi Ahilya University, Indore. The investigators took up the project of developing interesting programs for children in the subjects of biology, geometry and languages and reported that these programs were running well for children and the latter were found to be cooperative, constructive and appreciative in their approach.

Gupta (1996) also investigated the efficacy of the computer assisted instructional technique when compared with the conventional method of teaching chemistry at the ninth grade level and found that there were significant differences in the achievement level of the students and the students preferred to study using the computer based learning modules. Gender differences were also observed in the use of technology in teaching science in this study.

Umed Singh (1995) developed study material relating to video instructional package for teaching environmental awareness. It was field tested and used in three schools in Gujarat, Uttar Pradesh and Rajasthan and was found to be a very effective and interesting. The study also reported that students enjoyed working through video package.

Enigo (1997) undertook doctoral work on a study relating to effectiveness of instructor controlled interactive video (ICIV) and conventional non-interactive video. He found that instructor controlled interactive video was more effective than the lecture method and conventional non interactive video. Irrespective of the difficulty level of the content area contained in the ICIV, it was found to be more effective.

Purushothaman and Stella (1994) studied the effectiveness of teacher controlled interactive video for group instruction and found that it yielded better academic achievement when compared to the traditional method. The teachers presented with video lessons made the most desired impact. The research study concluded that the teacher component should not be eliminated.

Chandra and Pandya (1996) studied the effect of video films for imparting legal education and found that students from a science stream achieved higher than students from an arts stream. Similarly, those students who had studied in the English medium school did better than those who had studied in vernacular schools.

Surwase and Chincholkar (1997) studied the use of educational technology in teaching of geography to class five students. They found that geography teachers were not trained in using various technologies. During the study, researchers found that teachers agreed that difficult concepts can be taught easily by using educational technology.

Neera (1996) compared the effectiveness of video teaching learning material (VTLM), video aided instruction (VAI) and conventional teaching (CT). He found students most favourably disposed towards VTLM. Students retained more of what they learned when exposed to VTLM compared with students who were exposed to VAI. It was clear that students exposed to VTLM and VAI were significantly different in their achievements.

Rangaraj (1997) for his doctoral study investigated the effectiveness of computer assisted instruction in teaching physics. He found that CAI as Support System (CAISS) was much better than CAI as individualized instruction. Retention also was higher when taught through CAISS.

2.3.1 Summary

In the previous section, various research studies on the use of technology in India have been illustrated. The research studies have been done utilizing various technologies available in Indian schools and colleges such as computers, video based instruction, computer assisted instruction, programmed learning modules, etc. These studies have shown that use of technology in teaching and learning has brought about improvement in student achievement, helped in creating interest in various school subjects and enhanced their learning ability. Relative superiority of technology-aided classroom teaching over the conventional classroom teaching has also been established in these research studies. However, there have been very few research studies on understanding the learning environments of classes where technology has been introduced. In fact studies concerning attitude towards school subjects when taught through technology-supported classrooms are very few. Hence an in depth analysis of the overall impact of technology-supported classrooms is somewhat lacking because of paucity of research studies in this area. This study aims to contribute to the field of learning environments and also make a value addition to Indian research studies specially those related to study the impact of technology in teaching-learning process.

2.4 RESEARCH ON LEARNING ENVIRONMENTS

An examination of past reviews of research (Aldridge, Fraser, & Huang, 1999; Anderson, 1982; Fraser, 1991; Fraser & Walberg, 1981a; Templeton & Johnston, 1998; Wubbels, Creton, & Hooymayers, 1992) shows that international research efforts over the last three decades involving the conceptualisation, assessment and investigation of perceptions of various aspects of the classroom learning environment has been a thriving field of study. Furthermore, science education researchers have led the world in the field of classroom environment research, and this field has contributed much to understanding and improvement of science education (Aldridge, Fraser, & Haung, 1999; Anderson, 1982; Fraser, 1991; Fraser 1998b; Fraser & Walberg, 1981a; Rickards & Fisher, 1999; Wubbels, Creton, & Hooymayers, 1992).

Classroom environment assessment provides a means of monitoring, evaluating and improving science curriculum planning and teaching.

Considerable progress has been made over the last four decades in the conceptualisation, assessment and investigation of the important but subtle concept of learning environments (Fraser, 1986, 1994, 1988a, 1998b; Fraser & Walberg, 1991; McRobbie & Ellett, 1997; Wubbels & Levy, 1993). Research in the past two decades has also employed the use of qualitative methods in learning environment research (Anstine Templeton & Nyberg, 1997; Tobin, Kahle & Fraser, 1990), and also the combination of both qualitative and quantitative methods (Aldridge, Fraser, & Huang, 1999; Anstine Templeton & Johnson, 1998; Fraser & Tobin, 1991; Johnson & Anstine Templeton, 1999; Tobin & Fraser, 1998). There have been investigations into associations between students' perceptions of the classroom environments and student cognitive and affective outcomes (Fraser, 1986, 1991, 1994). Such studies have reported that students' perceptions of the classroom environment consistently account for considerable variance in student outcomes (Fraser & Fisher, 1982a, 1982b; Wong & Fraser, 1994). The idea of 'grain sizes' (the use of different-sized samples to answer different questions within a study) in learning environment research has been used effectively in studies that combine qualitative and quantitative methods of data collection (Fraser & Tobin, 1991; Tobin & Fraser, 1998).

A key advance in the thinking that contributed greatly to the study of learning environments was the Lewinian formula proposed by Kurt Lewin (1936). According to Lewin, the dynamics of an event can always be traced back to the relationship between the individual and the environment. He believed that all behaviour and experience are a function of the person and his/her environment and every kind of behaviour is totally dependent on the psychological field. His mathematical formula $B= f\,(P, E)$ indicates that behaviour (B) reflects the environment (E) and the person within the environment (P). This formula stressed the need for new research strategies in which behaviour was considered to be a function of the person and the environment.

Murray (1938) developed a theory to describe an individual’s personal needs and environmental press. He defined needs as those specific, innate and personal requirements of an individual such as personal goals. An individual’s need to achieve these goals or their drive to attain them is also a factor in an individual’s personality. The environmental factors that were beyond an individual’s control that either enhanced or retarded the individual’s achievement of their personal goals and needs were defined as press. Murray used the term *alpha press* to refer to an external observer’s perceptions of the learning environment and *beta press* to refer to observations by the constituent members of the environment under observation (Murray, 1938).

Stern, Stein, and Bloom, (1956) built on Murray’s discrimination between *alpha press* and *beta press.* They suggested that *beta press* could further be discriminated by the individual view and experience of the environment that each student, for example, has of the learning environment versus the shared view that the students have as a group of participants in the learning environment. They used *private beta press* to represent the idiosyncratic view a student may have of the classroom environment and *consensual beta press* for the shared view of the students’ perceptions. This study utilises the student *consensual beta press* perspective for the data collected through survey and observation methods and *private beta press* perspective for the interviews conducted with the students.

Classroom research methods about three decades ago were centred on observation techniques where trained observers would categorise classroom activities and interactions between members of the class. Along with an improvement in observation procedures and techniques (Brophy & Good, 1986), came a categorisation of observations as either high or low inference measures which were defined as the specific items that were recorded during classroom observations sessions. High-inference measures recorded during classroom observations required the observer to make an inference about the teacher’s behaviour in terms of such aspects as warmth, clarity or overall effectiveness. Either a member of the classroom environment or an outside observer could make high-inference observations.

Murray's needs-press model was utilised and extended (Pace & Stern, 1958) to report on high inference measures in educational learning environments. A problem with outside observers is that they must make judgements on the observations that are based on experiences external to the learning environment. Further to this, Pace and Stern (1958) suggested that an assessment of the relationships between the environmental press and a student's needs might be useful in predicting personal achievement.

Over 30 years ago, Walberg developed the *Learning Environment Inventory* which was used as part of the research and evaluation activities on Harvard Project Physics (Walberg & Anderson, 1968). About the same time, Moos began developing social climate scales for a wide range of human environments, including those for use in psychiatric hospitals. Moos (1974) developed a scheme of classification of human environments. Moos' three dimensions are Relationship, Personal Development and system Maintenance and System Change. The Relationship dimension refers to the type and strength of the personal relationships in the environment, the degree to which people are involved in the environment and assist each other. The Personal Development dimension assesses basic directions of personal growth and self-enhancement. The System Maintenance and System Change dimension measures the extent to which the environment is orderly, maintains control and is responsive to change. Moos used these dimensions in development of the *Classroom Environment Scale* for use in school settings (Moos, 1974).

The pioneering work of Walberg and Moos on perceptions of classroom environment developed into a major field of research in education. This research is well documented in handbooks (Fraser, 1994; Fraser & Tobin, 1998), books (Fraser, 1986; Fraser & Walberg, 1991; Freiberg, 1998), special journal editions to record the advances in research in the field (McRobbie & Ellett, 1997) and numerous research documents and publications in the professional journals. The study of classroom environment research has developed tremendously over the past three decades and there is now an international journal dedicated to the field (Fraser, 1998a).

The study of educational environments and their effects has been a major concern of educational researchers, policy makers and practitioners. Many questions have been asked about the relationship between the classroom environment and educational outcomes. Some of these have included, does a classrooms environment affect student learning and attitudes? What types of questionnaires and instruments should a teacher use to measure the climate of a classroom? What are the psychosocial factors which influence the students learning? Are there any associations between the classroom environment and affective and cognitive outcomes of students? The development of various learning environment instruments enabled researchers to explore these problems. As a result learning environments have become a firmly established field of study in educational research. An overview of a number of different classroom environment instruments and their scales is given in Table 2.1.

Table 2.1

Overview of Scales in 13 Classroom Environment Instruments

Instrument	Level	Items Per Scale	Scales Classified According to Moos' Scheme		
			Relationship Dimensions	Personal Development Dimensions	System Maintenance & Change Dimensions
Learning Environment Inventory (LEI)	Secondary	7	Cohesiveness, Apathy Friction, Favouritism, Cliqueness, Satisfaction	Speed, Difficulty, Competitiveness.	Diversity, Formality, Goal Direction, Disorganization, Material Environment, Democracy
My Class Inventory (MCI)	Elementary	6-9	Cohesiveness, Friction, Satisfaction	Difficulty, Competitiveness	
College and University Classroom Environment Inventory (CUCEI)	Higher Education	7	Personalization Involvement Cohesiveness Satisfaction	Task Orientation	Innovation Individualization
Classroom Environment Scale (CES)	Secondary	10	Involvement, Affiliation, Teacher Support	Task Orientation, Competition	Order & Organization, Rule Clarity, Teacher Control, Innovation.

Table 2.1 (Continued)

Instrument	Level	Items Per Scale	Scales Classified According to Moos' Scheme Relationship Dimensions	Personal Development Dimensions	System Maintenance & Change Dimensions
Individual Classroom Environment Questionnaire (ICEQ)	Secondary	10	Personalization Participation	Independence Investigation	Differentiation
Science Laboratory Environment Inventory (SLEI)	Upper Secondary	7	Cohesiveness	Open Endedness Integration	Rule Clarity Material Environment
Constructivist Learning Environment Survey (CLES)	Secondary	4	Gender Equity	Investigation Resource Adequacy	Innovation
Computer Classroom Environment Inventory (CCEI)	Secondary	5	Satisfaction	Investigation Open Endedness	Material Environment Organization
Cultural Learning Environment Questionnaire (CLEQ)	Secondary	8-10	Gender Equity Collaboration Risk Involvement	Competition Congruence	Teacher Authority Modelling Communication
What is happening in this classroom (WIHIC)	Secondary	8	Student Cohesiveness Teacher Support Involvement	Investigation Task Orientation Cooperation	Equity
Distance and Open Learning Environment Scale (DOLES)	Tertiary	4-12	Student Cohesiveness Teacher Support Personal Involvement & Flexibility	Task Orientation & Material Environment, Technology Resources	Student Centre Environment, Home Environment
Socio-Cultural Environment Scale (SCES)	Secondary Elementary	6	African World View	Societal Expectation	Authoritarianism, Goal Structure Sacredness of Science

(Developed from Fraser, 1998)

2.5 DIFFERENT VERSIONS AND FORMS OF LEARNING ENVIRONMENT RESEARCH INSTRUMENTS

Learning environment research instruments are designed for teachers to assess their classroom environment with minimum effort and maximum ease of use. The instruments have been refined to make the administration of the questionnaire an easy task for the teacher and also less time consuming without compromising on the reliability and validity of the instrument. The learning environment instruments have been designed to measure the students' perceptions of the present classroom environment and also the preferences of the students in terms of desirable changes in the classroom environment. The different versions/forms of the learning environment research instrument are discussed below.

2.5.1 Actual and Preferred Forms

A distinctive feature of most of the learning environment instruments is that they have, not only a form to measure perceptions of actual or experienced classroom environment, but also a form to measure perceptions of ideal or preferred classroom environments. The preferred forms are concerned with goal and value orientations and they measure perceptions of the classroom environment which are preferred by the students (Fraser & Walberg, 1991). Although the item wording is almost the same for both Actual and Preferred Forms, there are slightly different instructions given for answering the forms. Students are made to understand that for the Actual Form they have to rate their classes as what they are actually like and for the Preferred Form what they would prefer or like it to be.

2.5.2 Short and Long Forms of Learning Environment Instruments

Some teachers over a period of time have reported that they would like to have classroom environment instruments available which would take less time to administer and score. Keeping these demands in view short forms of the CES, the ICEQ, and the MCI were developed (Fraser, 1982; Fraser 1994; Fraser & Fisher 1983). The main three criteria while developing the short forms were; total number of items in each forms was reduced to about 25 items to provide greater economy in time while administering and scoring the instrument, these short forms were developed to be amenable to easy hand scoring and lastly to provide adequate reliability for the assessment of the perceptions of applications which involve averaging the perceptions of students within a class to obtain class means.

2.5.3 School-Level and Classroom-Level Environments

Studies have reported that it is useful to distinguish between measuring the school-level and classroom-level environments. Fraser (1994) noted that the focus of past research in science education has been primarily on classroom-level environment. School-level environment considers psychosocial aspects of climate of the whole school (Anderson, 1982). At the school level, factors such as relationship between teachers and their teaching colleagues, heads of department and school principals, play a major role in making up the school-level environment.

2.5.4 Summary

In this section, the development of the field of learning environments was reviewed dating back to Lewin’s formula (1936) of the relationship between the individual and his environment and Murray’s need press model (1938). From the seminal work of Walberg and Anderson (1968) and Moos (1974) more three decades ago the area of learning environments has developed in a field of study in its own right. This chapter also gives and overview of the various instruments that have been used in the learning environments research, their level, items and the three dimensions according to which they have been classified. As a part of this study two important learning environment instruments have been used, one in a modified form, the TROFLEI which has been modified from the What Is Happening In This Class (WIHIC) questionnaire and the other in its actual form, the Questionnaire on Teacher Interaction (QTI).

2.6 THE STUDY OF PERCEPTIONS OF CLASSROOM LEARNING ENVIRONMENTS

2.6.1 Development of 'What Is Happening In This Class' (WIHIC) Questionnaire

The What Is Happening In This Class (WIHIC) questionnaire was developed by Fraser, Fisher and McRobbie (1996) to study the perceptions of the students for interpreting the classroom learning environments. The original 90-item nine-scale version was refined by both statistical analysis of data from 355 junior high school science students, and extensive interviewing of students about their views of their classroom environments in general, the wording and salience of individual items and their questionnaire responses (Fraser et al., 1996). In the final version only 56 items remained in seven scales with eight items in each scale.

The WIHIC has a separate Class Form (which assesses a student's perception of the class as a whole) and a Personal Form (which assesses a student's personal perception of his or her role in a classroom). The WIHIC has been successfully used in its original form or in modified form in studies involving 250 adult learners in Singapore (Khoo & Fraser 1997) and 2,310 high school students in Singapore (Chionh & Fraser 1998). The WIHIC has also been used in a number of cross-national studies in Australia and Taiwan in 50 junior high school classes in each country (Aldridge, Fraser & Huang, 1998). The Australian sample consisted of 1,081 students and the Taiwanese sample had 1,879 students. Among the conclusions from this study was the need for caution to be exercised when interpreting data from questionnaires from cross-national studies where there are cultural differences even if questionnaires have been back translated.

The seven scales of WIHIC and their descriptions are given in Table 2.2.

Table 2.2

Description of Each Scale in the What Is Happening In This Class? (WIHIC) Questionnaire

No.	Scale Name	Scale Description
1.	Student Cohesiveness (SC)	The extent to which student know, help and are supportive of one another.
2.	Teacher Support (TS)	The extent to which the teacher helps, befriends, trusts and is interested in students.
3.	Involvement (IV)	The extent to which students have attentive interest, participate in discussions, do additional work and enjoy the class.
4.	Task Orientation (TO)	The extent to which it is important to complete activities planned and stay on the subject matter.
5.	Investigation (IN)	The extent to which skills and processes of enquiry and their use in problem solving and investigation are emphasised.
6.	Cooperation (CO)	The extent to which students cooperate rather than compete with one another on learning tasks.
7.	Equity (EQ)	The extent to which students are treated equally by the teacher.

Responses of the items are scored 1,2,3,4,5 respectively, for the responses Almost Never, Seldom, Sometimes, Often, Very Often. Missing or invalid responses are scored 3, the mid-range value.

2.6.2 Research on Classroom Environment using WIHIC

The What Is Happening In this Class (WIHIC) questionnaire has been widely used to assess the psychosocial aspects of classroom learning environments in various countries. This instrument has also been the basis of conducting research in different classroom environments in terms of building a new instrument by modifying the existing scales to suite specific research needs. The questionnaire has also been translated to different languages like Chinese and Korean. Some of the earlier studies using WIHIC are reported in this section.

The WIHIC questionnaire was used to study the associations between learning environments in mathematics classrooms and students' attitude towards the subject in Australia by Rawnsley and Fisher (1998). The result of the study focussed on the findings that in the classes in which the teachers were perceived to be highly supportive, equitable and investigative, the attitudes of the students towards mathematics were positive. The study was carried out on 490 grade 9 students in 23 mathematics classes in Australia and found that the reliability and validity of the WIHIC was high and was thus the right instrument to study the perceptions of the students.

The WIHIC was also validated in Singapore (Chionh & Fraser, 1998; Fraser & Chionh, 2000). The Singaporean sample consisted of 2,310 geography and mathematics students from 75 randomly selected intact grade 10 classes in 38 schools. Each student responded to the Actual and Preferred Class Form of the WIHIC separately for his/her geography and mathematics classroom. When principal component factor analysis with varimax rotation was conducted, it was found that the seven-factor *a priori* structure of the WIHIC was supported. The internal consistency reliability (Cronbach alpha coefficient) for the Actual Form of the WIHIC scales ranged from 0.88 to 0.92 for geography and from 0.87 to 0.93 for the mathematics using the individual student as the unit of analysis, and ranged from 0.94 to 0.97 for geography and from 0.92 to 0.98 for mathematics using the class mean as the level of analysis. Analysis of variance (ANOVA) with class membership as the independent variable and the WIHIC scales as the dependent variable revealed that the eta^2

statistic varied between 0.14 and 0.21 for geography and between 0.11 and 0.29 for mathematics.

The WIHIC questionnaire used by McRobbie and Thomas (2000) who attempted to change the learning environment in a classroom and document these changes in students' perceptions of their learning environments. They also studied the corresponding changes in the teachers' and their students' perceptions of such changes. From the study it was evident that the learning environments had become more characterised by a perspective on science learning and teaching as a form of individual and shared inquiry and knowledge building. This study also stressed that further research was needed involving collaboration with teachers in finding successful strategies to change the learning environment and enhance levels of reasoning and understanding in science classrooms. The reliability coefficients of the WIHIC as reported by the study ranged from 0.84 to 0.88 which makes it a reliable instrument to be used in research studies.

Khine and Fisher (2001) used the WIHIC to study the associations between students' perceptions of the science classroom learning environments, their attitudinal outcomes and cultural background of their teachers. The study was conducted on a sample of 1,188 students from 54 science classes in 10 secondary schools in Brunei.. The study showed that the Western teachers had a favourable influence on the students which was clearly evident from the perceptions of the students. The learning environments were positive in classes where teachers were more supportive, involved, cooperative task oriented and maintained equity. The WIHIC was found to be a highly reliable and valid instrument with its reliability ranging from 0.78 to 0.87 and the discriminant validity measure ranged from 0.37 to 0.45.

Upper primary and middle school (Grades 6–8) students' perceived and preferred classroom environment was assessed by Sinclair and Fraser (2002) using the Elementary and Middle School Inventory of Classroom Environments (ICE) which itself is based on the WIHIC questionnaire. This is another example where the WIHIC was able to be modified into another form. In this study the WIHIC Scales were selected and the wording of items was modified to maximise suitability for the primary and middle school levels. This study showed that teachers perceived and preferred scores were more positive than their students and the females typically perceived and preferred a more positive classroom environment than did males. The new instrument based on WIHIC was also shown to be reliable and valid with the alpha reliability values ranging from 0.54 to 0.80 and the significant ANOVA eta^2 values ranged from 0.11 to 0.18.

Wallace, Venville, and Chou (2002) carried out an interpretive study of a Grade 8 science classroom in Western Australia and investigated students' understandings of the nature of their classroom learning environment. The study was done using some selected items from the WIHIC and both quantitative and qualitative methods were used to assess the data. The study concluded that the learning environments were not the same for the individuals who attended the same classroom and they had different perceptions on cooperation, involvement, teacher support and equity. However regardless of the technique, learning environment research is likely to be of most value when it is closely connected to the rhythms of the classroom and the processes of teaching and learning.

Dorman (2003) validated the WIHIC questionnaire cross-nationally using a sample of 3,980 high school students in Australia, the UK and Canada. Confirmatory factor analysis supported the seven-scale *a priori* structure of the instrument and thus proved that the instrument is a valid measure of classroom environment. The factorial invariance of model parameters across three countries, three grade levels and gender attests to the wide applicability of the WIHIC. The study showed that the WIHIC can be used with confidence in a wide range of Western countries. However, it would be desirable that a wider sample of countries with quite different educational cultures (e.g., Middle Eastern, South and Central American) be involved in further validation work with the WIHIC. The data analysis exhibited high reliability and validity of the WIHIC with the reliability values ranging from 0.76 to 0.85 and the mean correlation (discriminant validity) ranging from 0.32 to 0.45.

One of the first studies in India using the WIHIC questionnaire was undertaken by Koul and Fisher (2003) wherein they assessed the science students' perceptions of their science teachers' interactions, classroom learning environments and its associations with students' cultural background and cognitive achievement scores.

The study was conducted with a sample of 1,021 students from 31 year nine and ten science classes in seven schools of Jammu. This study was unique as it was the first study to determine the reliability and validity of the WIHIC and the QTI questionnaires in India. The Student Cohesiveness, Involvement, Task Orientation and Equity scales of the WIHIC demonstrated positive associations with the cognitive achievement of the students. The study also showed that for the cultural background indicator variables, students from Kashmiri backgrounds perceived their teachers in a significantly more positive way than did those from the other cultural groups. The associations for cognitive achievements displayed significantly positive associations for the scale of Understanding and negative associations for the scales of Uncertain, Dissatisfied and Admonishing in the QTI. This study also helped in establishing the reliability and validity of the WIHIC in Indian settings with the reliability coefficient ranging from 0.58 to 0.83 and the discriminant validity ranging from 0.38 to 0.47.

Huang (2003) investigated gender differences in students' perceptions of their psychosocial environment and related variables. The WIHIC questionnaire was also used to assess only the psychosocial environment. Analysis of data collected from 644 middle school students in Taiwan after analysis revealed that there were significant gender differences in perceptions towards their classroom environments in favour of girls. The study showed that a positive learning environment helps the students to enjoy school, to spend more time in homework, hold higher academic expectations, improve their course grades, etc.

In another attempt to validate the WIHIC in schools in the USA, the questionnaire was administered to a sample of 1,720 students from eight-grade science classes from 11 Californian schools (Rickards, et.al, 2003). Results indicated that some scales of the WIHIC were more inclined to measure personal, idiosyncratic features of the student's perceptions of their learning environments, whereas other scales contain more variance at the class level. On average, girls perceived their learning environments more positively than boys. Considering that it was one of the first studies in USA using the WIHIC, the reliability of the instrument was well established with the reliability ranging from 0.77 (Student Cohesiveness) to 0.89

(Teacher Support; Cooperation) at the student level, and from 0.78 (Student Cohesiveness) to 0.96 (Teacher Support) at the class level.

Wahyudi and Treagust (2004) cross-validated results for an Indonesian language version of the modified form of the WIHIC questionnaire and investigated the nature of science classroom learning environments in Indonesian lower secondary schools. The WIHIC was administered to approximately 1,400 students and their teachers in 16 schools. The modified form of the questionnaire was found to be reliable and valid and was also capable of differentiating between the perceptions of students in different groups with the reliability values for the Actual Form ranging from 0.68 to 0.88 and for the Preferred Form 0.70 to 0.88. Also the values of eta^2 statistics ranged from 0.15 to 0.23 which established the validity of the WIHIC. The study also found that the female students held somewhat better perceptions of actual and preferred classroom learning environment than did male students on all scales except Teacher Support in the actual version.

A unique study using the WIHIC to evaluate the physical and psychosocial classroom environments in computerised settings was conducted by Zandvliet and Fraser (2005). This research is distinctive because it jointly considered the physical and psychosocial learning environments in a single study, thus furnishing a holistic and ecological approach to the investigation of an important learning environment in networked classrooms. The study was conducted with a sample of 1,400 students in 81 classes in Australia and Canada. The study showed that when student satisfaction was used as a dependent variable, direct and statistically significant associations with satisfaction were found for psychosocial environment variables, but not for physical environment variables. Moreover, direct associations were found between psychosocial environment dimensions and physical environment variables. The results also highlighted the reliability and discriminant validity of the WIHIC as ranging from 0.77 to 0.95 and 0.16 to 0.52.

The WIHIC was used by Martin-Dunlop and Fraser (2005) along with other learning environment scales to study the impact of an innovative science course for prospective elementary teachers on their perceptions of the learning environment and compared these perceptions with those of their previous laboratory science courses.

This research has made a distinctive contribution to the learning environments field because it was the first study to investigate laboratory classroom environments at the university level with prospective elementary teachers. The study showed that for students' previous science course, two scales that received an average item mean over 4 (meaning that the practice occurred 'often') were Student Cohesiveness and Cooperation. Thus, their previous science course was a relatively supportive environment where students knew and helped each other, and cooperated rather than competed with one another on learning tasks. Also the difference in the two scales was statistically significant and the prospective elementary teachers had a positive attitude towards science.

A study was conducted among middle school students in California, focussing on the effectiveness of using innovative strategies for enhancing the classroom environment and students' attitudes and conceptual development. Ogbuehi and Fraser (2007) used the WIHIC questionnaire along with other learning environment instruments to collect data from 661 students in 22 classrooms involving four inner city schools. The effectiveness of the innovative strategy was evaluated in terms of classroom environment and attitudes, along with an achievement test administered to a subgroup of 101 students. The study showed that in comparison of with the experimental group, which experienced the innovative strategy, with a control group supported the efficacy of the innovative teaching methods in terms of learning environment perceptions, attitudes to mathematics, and mathematics concept development. Also associations were found between perceptions of classroom learning environment and students' attitudes to mathematics and conceptual development when simple correlations and multiple regression analyses were used.

Saunders and Fisher (2006) used the WIHIC questionnaire along with the CUCEI to study the learning environments of the university science education classes to provide an opportunity for the student teachers to improve the learning environments of their primary school classrooms during their practicum teaching. The study involved 26 pre-service teachers who were graduates from different disciplines and had undertaken a one year programme in primary education. The study highlighted the reliability and validity of WIHIC which ranged from 0.80 to 0.89 and the mean correlation with other scales from 0.09 to 0.48. This study was significant as it combined both quantitative and qualitative methods to show that the intervention strategies for improving aspects of the learning environments were successful in bringing about some positive changes in the university teaching environment.

The domain of learning environments research has produced many promising findings, leading to an enhancement of the teaching and learning process in many countries. For example, a study was conducted in Turkey by Telli, Cakiroglu and den Brok (2006) to study Turkish high school students' perception of their classroom environment in biology and to investigate relationships between these perceptions and students attitude towards biology. The data for the study were gathered from 1,983 ninth and tenth grade students from 57 biology classes using the WIHIC questionnaire. The results of the study indicated that the students had moderately favourable attitudes of their learning environment in biology, with higher ratings for inquiry and enjoyment than for career. It was also observed that some elements of the learning environment, like student cohesiveness, task orientation and equity, were perceived more positively than others. The alpha reliability values for the WIHIC ranged from 0.75 to 0.88 thereby establishing its use for further research to study the learning environments in various settings.

2.6.3 Summary

The review of literature of the studies using the WIHIC shows that it is one of the most sound instruments for assessing the student's perceptions of their learning environments. The perceptions can also be measured both from the personal as well as classroom point of view. In fact a number of instruments have been developed using the WIHIC which shows that it is a highly reliable and valid instrument and can be used in various educational settings and environments. Since the present study also used an instrument based on the WIHIC, it was important to understand the instrument in detail and appreciate its usability.

2.7 STUDIES INVOLVING TECHNOLOGY AND LEARNING ENVIRONMENTS

A number of research studies have been done to study the impact of technology-based education on the learning environments of classrooms at various levels. Studies in the area of e-Learning, Web based e-Learning, Computer Classrooms, Computer Laboratories and Internet learning environments have been prominent amongst a few.

Rapid advances in technology, particularly with the Internet, have led to the availability of numerous tools to support teaching and learning. A study by Goh and Tobin (1999) involved the use of an Internet application, Connecting Communities of Learners (CCL), in courses for prospective teachers. This study was undertaken to ascertain student and teacher perceptions of the learning environments associated with the use of the CCL. The study revealed that CCL was a high-quality learning tool and a method of lesson delivery which made both teacher and students connect better and made them work closer with one another. When used with the teacher education program, the CCL made available better-quality student interaction, collaboration, reflection and feedback in an electronic learning environment that integrated convenience, efficiency and autonomy of learning. As in all learning environments, the CCL could not meet the needs of all learners. However, it satisfied and generated a sense of confidence among those who adapted well to its use.

Harwell, Gunter, Montgomery, Shelton, and West (2001) carried out collaborative action research between a regional university and a local school (Grade 6 level) using learning environments research and monitored alignment of classroom learning activities from a constructivist viewpoint while integrating technology into the curriculum. Student perceptions in the study were measured by the Constructivist Learning Environment Survey (CLES). The study showed that as teachers became more competent and confident in technology use and more knowledgeable about the constructivist viewpoint of teaching and learning, they became more committed to modification of their instructional practices.

Newhouse (2001) developed and used the New Classroom Environment Instrument (NCEI) to advocate the use of portable computers in a school. This study particularly focussed on the impact of the computers on classroom learning environments. This study showed that when computers were consistently used to support a student-centred approach to learning which particularly involved group work, analysis indicated a good person-environment fit. It further portrayed that environments in which computers were used frequently happen to be more innovative and involvement among students was high.

Fisher and Chang (2003) conducted research to study the perceptions of students in a Web based learning environment. This study shows that teachers can have their course material delivered as a web based learning application and will help the researchers and developers to evaluate their own web based learning environments in accordance with the four core aspects of Access (accessing the online material), Interaction (the interaction and participation of all parties involved in the online learning), Response (the responses and perceptions of students learning in this environment) and Results (the students learning outcomes and achievement in this learning environment). This concept was well received by the students.

Technology has provided innovative ways to deliver the course material to students in the classroom. One such study was conducted by Khine (2003) wherein a CD-Rom based comprehensive resource to facilitate learning the concepts and skills associated with classroom management were developed. The CD-ROM was designed in a web enabled format so that it could interface with video clips and multimedia materials that are relevant to classroom management issues. This module provided opportunities for students to have face-to -face interaction with their peers as well as their tutors. The students were also able to have on-line discussions to exchange their experiences and encourage thinking and reflection.

A study to investigate the relationship between attitudes and achievement of university students in computer classrooms was conducted in Indonesia by Margianti (2003). The main contribution of this study was the development of a widely applicable, economical and valid learning environment instrument which has the potential to become a powerful tool that the teachers can use to monitor and guide the improvement in the learning environment in their classes. This study also highlighted the gender differences in perception of the classroom learning environment with females preferring a more favourable environment than males in terms of student cohesiveness, teacher support, task orientation and cooperation in a computer classroom.

Technology-rich learning environments offer the potential to take teaching and learning beyond the four walls of the classroom where learning can be based on real-world problems and learners become active participants in constructing their own learning. Trinidad (2003) in Hong Kong conducted a study by building Technology-rich learning environments using the Mediated Learner Approach (MLA) in the form of an e-learning module for students. This enabled the educators and learners to interact and manage the learning experiences and work with peers to support each other through a social-constructivist approach. This was achieved by building a supportive, collaborative e-learning environment that focussed working within a community of learners. The study shows that technology-rich learning environments using e-learning can engage the learner giving them a sense of empowerment, where they are no longer dependent on the specific and often limited knowledge of their educators.

A study to examine how the technology-rich classroom learning environments of today can better prepare students to make an effective contribution to their technology-based futures was conducted by Rickards (2003) in Australia. This study focused on issues related to the use of various technologies in schools today, the role of computers and other computing devices, new technologies available in the schools including both hardware and software. Issues related to budgetary considerations for schools in adopting technology, the methods of teaching and the role of the teacher in using technology in the classroom have been discussed in detail. Another issue taken up in this study is the professional development of teachers in using ICT tools for its better integration into the day to day classroom teaching and learning process. Thus effective teaching and effective teacher utilisation of technology-rich learning environments serve as a role model for the young, as well as a breeding ground for the development of creative, capable and empowered problem solvers for the future.

Zandvliet (2003) conducted a study of classroom environments in emerging Internet (web capable) classrooms in Canada. The study involved an evaluation of the physical and psychosocial learning environments of Internet enabled classrooms. This research showed that the introduction of Internet resources in classrooms enables progressive approaches to teaching and learning and described the learning environment in computerised classrooms as being a complex system in which many competing and interrelated physical, psychosocial and contextual factors were at work which need to be fully considered in shaping good instruction.

Educational activity is no longer confined by text, print based materials, time or space. Online educators are challenged to develop appropriate strategies to deal with new information and communication technology-rich ways of teaching and learning. It appears that the same features that are important in classroom environments, the perceptions of students and teachers of the psychosocial environment, are equally important in the digital world. Such is the research done by Clayton (2003) in New Zealand to assess the online learning environments using the *Online Learning Environment Survey* (OLLES). This study shows that the demand for more flexibility in education, the improvement in the ICT technologies and the constantly reducing cost of such technologies is making electronically mediated education increasingly more viable, attractive, cost effective and valued.

Newby (2003) investigated differences between students' perceptions of learning environments of computer laboratories. The study throws light on how the use of ICT in education has increased dramatically at the university level where computers are used in most disciplines. Hence students are required to master computer skills before they can master the subject being taught. This study involved the use of an instrument called the *Computer Laboratory Environment Inventory* (CLEI) for measuring aspects of a computer laboratory environment and the other, the *Attitude to Computers and Computing Courses* (ACCC) questionnaire used to measure students' attitudes (Newby & Fisher, 1997). This study has demonstrated that there are significant differences in the environmental and attitudinal variables of the students in the computer laboratory environment.

The use of Information Technology in teaching and learning has become a reality in modern day science classrooms and in fact across all subject areas. Due to the recent increase in the application of E-learning to the traditional mode of instruction, it is now time for those studying the classroom learning environments to begin focussing their research on the evaluation of E-learning as a viable approach to teaching and learning. A study to evaluate the E-Learning environments of lower secondary science classrooms was undertaken by Lang and Wong (2003) in Singapore. This study made use of the *E-Learning Classroom Environment Questionnaire* (ELCEQ) to assess the learning environments of the science classroom by understanding the perceptions of the students. This study provides the basic understanding of how e-learning is incorporated into the existing mode of teaching science in Singapore secondary schools and also that the students perceive the learning environments with e-learning incorporated into face-to-face interaction to be positive.

She and Fisher (2003) studied how science learning among students was facilitated by the use of a web-based, multimedia, science learning program delivered through an online e-learning environment. This study examined the learning environment created during teacher and student use of this program in their science class and also investigated its impact on students' cognitive and affective learning outcomes among different learning styles and different grade levels. The WIHIC, the *Web-Based Computer Assisted Learning* (WBCAL) questionnaire and the *Satisfaction of Web-Based Learning* (SWBL) questionnaire were used in the research to study the perceptions of students of their online e-learning environments. It was found that the students perceived their learning environment as having high levels of student cohesiveness, task orientation, cooperation, equity and differentiation. In addition, the students' attitudes towards using computer and web usage were positive.

In some classrooms, teaching methods have evolved little over the years. Enrolments in subjects like science have progressively declined and one possible reason for this outcome has been the persistent use of traditional teaching methods which disengage many students. In less than a decade, the Internet has emerged as a potential tool to vary classroom routines. However, its use in high school science classrooms is still stated to be in a state of infancy. Chandra and Fisher (2005) conducted a study to understand the challenges and rewards of a web-based learning environment in physics. The study used the Web-Based Learning Environment Instrument (WEBLI) for collection of data. The study showed that the 3D Virtual Learning Environment had the potential to provide a rich learning experience for participants and that students perceived the enhanced online environment more favourably than the typical online learning environment. The environment had been enthusiastically received by the students.

2.7.1 Summary

In the review of literature in this section, it is evident that technology-based education has played a major role in the study of learning environments in several countries. Not only have various learning environment instruments been developed to study the impact of technology but they have also been validated and found to be reliable for use in further research in different settings and other countries. The general trend that can be observed from these studies is that there has been a positive impact on the learning environments due to the use of technology-based education. The review of past studies also highlights the importance of the various forms of technology-based learning environment instruments that have been developed and used by researchers to study the perceptions of the students’ actual and preferred learning environments.

2.8 THE STUDY OF PERCEPTIONS OF TECHNOLOGY-SUPPORTED CLASSROOM LEARNING ENVIRONMENTS

2.8.1 Development of 'Technology-Rich Outcomes–Focused Learning Environment Inventory (TROFLEI)'

The TROFLEI was developed using an intuitive-rational approach complemented by exploratory and confirmatory factor analyses. The first stage of the development of the TROFLEI was made much simpler by using an existing classroom environment instrument, the WIHIC questionnaire as a starting point. The WIHIC was originally developed by Fraser, McRobbie and Fisher (1996) and attempted to incorporate those scales that previous studies had shown to be predictors of student outcomes. Both personal forms and class forms of the WIHIC have been developed. The Personal Form uses the same scales and comparable items as the Class Form, but is worded to elicit the student's perception of his/her individual role within the classroom, as opposed to the students' perceptions of the class as a whole (Fraser, 1994, 1998a, 1998b; Fraser, Giddings & McRobbie, 1995; Fraser & McRobbie, 1995; Fraser, McRobbie & Fisher, 1996). The Personal Form is concordant with the constructivist theory of learning (Bruner, 1986; Tobin, 1993; von Glasersfeld, 1989). Based on the assumption that individuals construct their own meaning and knowledge of the world, rather than attaining it from external sources, the Personal Form enables students to provide individual interpretations of their environment. The Personal Form was used in the present study.

The strong nature of the What Is Happening In This Class (WIHIC) questionnaire, in terms of reliability and validity, has been widely reported in studies that have used the instrument in different subject areas, at different age levels and in nine different countries as reported in previous section. Since the initial development of the WIHIC, the questionnaire has been used successfully in studies to assess the learning environment in Singapore (Fraser & Chionh, 2000), Australia and Taiwan (Aldridge & Fraser, 2000), Brunei (Khine & Fisher, 2001), Canada (Zandvliet & Fraser, in press), Australia (Dorman, 2001), Indonesia (Adolphe, Fraser & Aldridge, 2003), Korea (Kim, Fisher & Fraser, 2000), USA (Allen & Fraser, 2002) and Canada, Britain and the US (Dorman, 2003). Within these countries, the WIHIC has been used to assess students' perceptions of the learning environment in a range of subjects including high school science (Aldridge & Fraser, 2000), mathematics (Margianti, Fraser & Aldridge, 2001), mathematics and science (Raaflaub & Fraser, 2002) and mathematics and geography (Fraser & Chionh, 2000). Using a sample of 3,980 high school students from Australia, Britain and Canada, confirmatory factor analysis was used to support the seven-scale a priori structure of the WIHIC (Dorman, 2003). In this study, Dorman found that all items loaded strongly on their *a priori* scale, although model fit indices revealed a degree of scale overlap. Overall, the study strongly supported the international applicability of the WIHIC as a valid measure of the classroom psychosocial environment.

The robust nature of the WIHIC made it a sensible choice as a starting point for the present study. All seven of the original WIHIC scales were included in the new instrument, namely, Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation and Equity. Three new scales of educational importance were developed for the purpose of this study. To capture the individualised nature of an outcomes-based program, a Differentiation scale was adapted from the Individualised Classroom Environment Questionnaire (ICEQ; Fraser, 1990). This scale assesses the extent to which the teacher provides opportunities for students to choose the topics on which they would like to work and to work at their own pace. Because technology-rich learning environments require students to use computers in a range of ways, the Computer Usage scale was developed to provide information about the extent to which students used a computer in various ways (e.g., email, accessing the Internet, discussion forums). Finally, a Young Adult Ethos scale was developed to assess the extent to which teachers give their students responsibility for their own learning.

2.8.2 Description of Actual and Preferred Forms of the TROFLEI

The TROFLEI consists of 80 items assigned to 10 underlying scales (8 items per scale). Table 2.3 shows scale names and descriptions. Students respond to items using a five-point frequency response format (viz. Almost Never, Seldom, Sometimes, Often, Almost Always). To provide contextual cues and to minimise confusion to students, it was considered appropriate to group together in blocks items that belong to the same scale instead of arranging them randomly or cyclically (Aldridge, Fraser, Taylor, & Chen, 2000). Scale scores for each respondent are obtained by aggregating scores for the eight items for that scale. Of particular relevance to the present study is the distinction between Actual and Preferred Forms of the TROFLEI. While the Actual Form elicits information on what students perceive to be the current classroom environment, the Preferred Form assesses students' perceptions of what environment they would like in the classroom. For example, in the Actual Form TROFLEI an item, I explain my ideas to other students, has a corresponding Preferred Form item, I like explaining my ideas to other students. For each item of the TROFLEI, students record their perceptions of actual and preferred environments on adjacent response scales.

Table 2.3

Names and Descriptions of the TROFLEI Scales

Scale Name	Scale Description
Student Cohesiveness (SC)	The extent to which student know, help and are supportive of one another.
Teacher Support (TS)	The extent to which the teacher helps, befriends, trusts and is interested in students.
Involvement (IV)	The extent to which students have attentive interest, participate in discussions, do additional work and enjoy the class.
Task Orientation (TO)	The extent to which it is important to complete activities planned and stay on the subject matter.
Investigation (IN)	The extent to which skills and processes of enquiry and their use in problem solving and investigation are emphasised.
Cooperation (CO)	The extent to which students cooperate rather than compete with one another on learning tasks.
Equity (EQ)	The extent to which students are treated equally by the teacher.
Differentiation (DI)	The extent to which teachers cater for students differently on the basis of ability, rate of learning and interests.
Computer Usage (CU)	The extent to which students use their computers as a tool to communicate with others and to access information.
Young Adult Ethos (YAE)	The extent to which teachers give students responsibility and treat them as young adults.

Responses of the items are scored 1, 2,3,4,5 respectively, for the responses Almost Never, Seldom, Sometimes, Often, Almost Always.

2.8.3 Research on Classroom Learning Environment using TROFLEI

Since the Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) is a relatively new instrument as compared with the other learning environment instruments, its awareness and use has been quite limited. Very few studies have incorporated the use of the TROFLEI and have tried to validate the instrument in different settings with different sample of students and with different subjects. Studies, even though limited in number show that this instrument is a highly reliable, valid and informative tool in the hands of the researcher, that policy planners and teachers associated with the development of ICT for use in school education can benefit from its use and effectively implement strategies for improving technology-supported learning environments in schools across various countries.

Aldridge and Fraser (2003) carried out a study that involved the validation of the TROFLEI for assessing students' perceptions of their actual and preferred classroom learning environments in technology-rich, outcomes-focused learning settings. They analyzed data from 1,035 students in 80 classes for substantiating the validity and reliability of the questionnaire for use at the senior high school level across a number of different subjects. The study also highlighted: (a) associations between students' perceptions of the learning environment and their academic achievement, attitude towards the subject, attitudes toward computer use and academic efficacy; and (b) the success of an innovative new school in promoting ICT-rich and outcomes-focused classroom learning environments. The TROFLEI was found to be valid and reliable at the senior high school level across a number of different subjects and learning areas. A series of item and factor analyses led to a refined version of the TROFLEI that displays satisfactory factorial validity for both the actual and preferred versions of the questionnaire. Further analyses supported the ability of the actual responses to differentiate between classrooms on all scales and, therefore, teachers and researchers could use it with confidence in the future. As part of the TROFLEI instrument development an attitude scale was also developed. The three scales assessed important affective outcomes of technology-rich, outcomes-focused learning environments, namely, Attitude to Subject, Attitude to Computer Use and Academic Efficacy. Satisfactory factorial validity, internal consistency reliability and discriminant validity were found for the new attitude scales for both the individual and class mean as the units of analysis.

Aldridge, Dorman, and Fraser (2004) conducted further research using the TROFLEI and multitrait-multimethod modelling. The study was conducted with a sample of 1,249 high school students from Western Australia and Tasmania who responded to the Actual and Preferred Forms of the TROFLEI. Separate exploratory factor analyses for the two forms supported the 10 scale *a priori* structure of the instrument. The use of multitrait-multimethod modelling with the 10 scales as traits and the two forms of the instrument as methods supported the TROFLEI's construct validity. The results of this research provided strong evidence that this instrument had sound psychometric properties and is a valid measure of classroom environment. The study also suggested that further validation work with the TROFLEI in other countries was needed. The present study attempts to further validate the TROFLEI in technology-supported science classrooms in Indian settings.

Another study using the TROFLEI was conducted by Kerr, Fisher, Yaxley, and Fraser (2006) in which they assessed students' perceptions of their actual and preferred psychosocial classroom learning environment in outcomes-focused, technology-rich, learning settings, and related psychosocial factors to students' satisfaction with learning and to physical aspects of learning environment. The TROFLEI was administered to 816 science students in year 11 from 35 classrooms in each of Tasmania's eight public senior secondary colleges. Results showed strong associations between students' psychosocial learning environment and satisfaction, as measured by attitudes towards their subject and computer usage, and academic efficacy. However, weak associations were found between student satisfaction and the physical environment. Gender analysis showed that female students generally perceived actual and preferred environments more positively than male students, and pre-tertiary students generally indicated more positive actual and preferred environments than non-pre-tertiary students. Commenting on the workspace environment they showed that ICT-rich facilities varied in number and quality between colleges, and the workspace environment, lighting levels, and air quality, was often found to be deficient. Teacher and student interviews revealed the reluctance of many science teachers to adopt new pedagogies and their reluctance to accept change. The results of the study also revealed that the TROFLEI is a reliable and a valid instrument for assessing the psychosocial learning environments of technology-rich classrooms with its reliability ranging from 0.81 to 0.93 for the Actual Form of the questionnaire and 0.83 to 0.94 for the Preferred Form. Also, the mean correlation which describes the discriminant validity ranged from 0.23 to 0.42 for the Actual Form and 0.25 to 0.50 for the Preferred Form adding further confirmation of the validity of the TROFLEI for future research.

2.8.4 Summary

The TROFLEI instrument was primarily designed to study the psychosocial learning environments of technology-rich-outcomes-focused-environments. Although this instrument has not been used often, being of recent origin, it has been shown to be a highly reliable and valid instrument that can be used in assessing the students' actual and preferred perceptions of their technology-rich learning environments. The review of literature also suggests that this instrument has not been used in India. Since technology is now being used in the Indian classrooms, the use of TROFLEI in Indian classroom conditions is timely.

2.9 STUDY OF TEACHER-STUDENT INTERACTIONS

2.9.1 Introduction

Today teachers and students spend a substantial amount of time interacting with one another in the classroom. Educators are of the opinion that the classroom learning environment becomes more progressive if the teachers and students share a healthy relationship. There are a numbers of variables that influence the learning environments in the classroom with the key variable being the student-teacher interaction. Getzels and Thelen (1960) suggested that teacher-student interaction is a powerful force that can play a major role in influencing the cognitive and affective development of students. The importance and significance of the teachers' behaviour in the classroom in terms of its effect on student achievement and motivation was also studied in detail by Wubbels and Levy (1993)

According to Walberg (1976) and Winne and Marx (1977), students' perceptions of their teachers behaviour should not be underestimated but it should be considered an important mediator between the instructional characteristics and academic achievement.

2.9.2 Leary's Model for Interpersonal Behaviour

The ultimate goal of teaching is to assist students to become independent and self-regulated learners. During this process the teacher has to undertake many different jobs with main focus being on communication with students. Thus teaching and learning can be considered as a communication process. The interpersonal behaviour of the students and teachers depend on the effectiveness of this communication process.

By interpreting the class as a communication system, a number of characteristics of the teacher-student communication can be considered. Arends (1998) believes that an open and honest communication process is the single most important variable for promoting positive classroom environment.

In clinical and psychological research settings, Leary (1957) and his co-workers analysed hundreds of dialogues between patients and their therapists in order to classify the different types of behaviour exhibited. These dialogues and discussions were divided into short statements representing different kinds of interpersonal behaviour. The statements were coded and arranged into 16 dimensions with two levels of behaviour. The Level one behaviours were classified in terms of interpersonal mechanisms, gestures or reflexes and involved two-way interpersonal codes. The Level two behaviours are classified in terms of interpersonal attributes.

Leary (1957) believed that the way humans communicate is indicative of their personality. Along with other psychologists, he felt that the most important forces driving human behaviour are the reduction of fear and the corresponding maintenance of self-esteem. Therefore, when people communicate, they consciously or unconsciously choose behaviours which avoid anxiety and allow them to feel good about themselves. These may differ from each person and depend upon the personality of the communicating partner. One individual might choose an authoritarian style, whereas another prefers dependency to achieve the same end (Wubbels, Creton, Levy, & Hooymayers, 1993).

Leary then developed a model which describes and measures specific interpersonal behaviour. The model places personality at the heart of the interpersonal behaviour. The model allows for a graphic representation of all human interaction. Using the model it is possible to record the behaviour and interaction during a dialogue between one person and another. Both normal and abnormal behaviour can be represented on the same scale which can not only be used as a diagnostic tool in psychotherapy but also in management settings.

The 16 dimensions suggested by Leary and his colleagues were later reduced to eight categories of interpersonal behaviour (Wubbels, Creton, Levy, & Hooymayers, 1993). This two-dimensional coordinate system of representing interpersonal behaviour mapped the degree of cooperation between the individual's communication on the horizontal axis and the degree of control or influence over the communication process of the communicator being observed on the vertical axis as depicted in Figure 2.1. Leary originally labelled the Cooperation-Opposition Axis the "Affection-Hostility" continuum (Wubbels, Creton, Levy, & Hooymayers, 1993).

Although Leary's model was an adequate model to represent interaction behaviour and withstood testing in psychological research settings, the 128-item Interpersonal Adjective Checklist (IAC) that Leary used to gather his data about four levels of behaviour intensity was cumbersome in an education setting, (Wubbels, Creton, Levy & Hooymayers, 1993) and contained many items which were not pertinent to teachers.

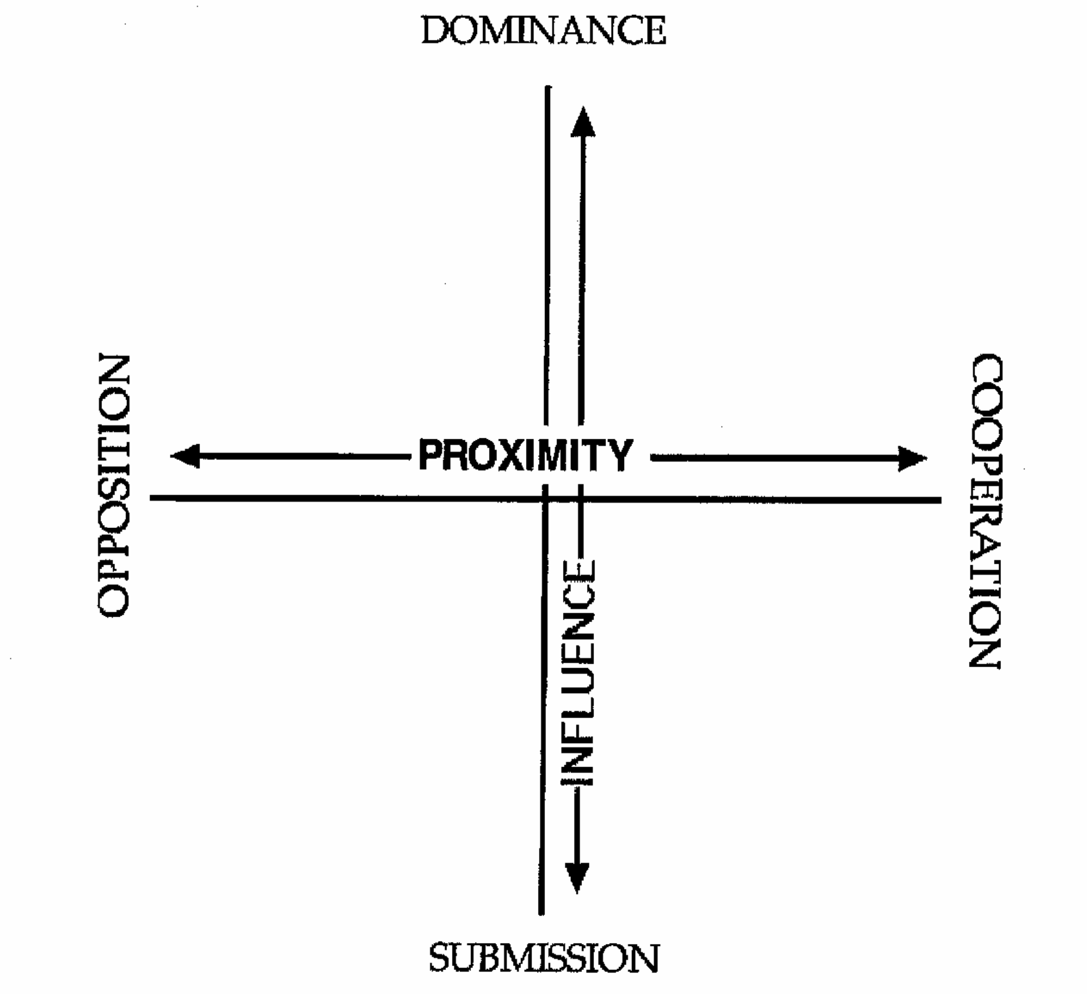


Figure 2.1. The two-dimensional coordinate system of the Leary Model.
(Source: Wubbels, Creton, Levy & Hooymayers, 1993, p.15).

This two-dimensional model based on the work of Leary (Wubbels, Creton, Levy, & Hooymayers, 1985) has been used widely in educational settings (Wubbels, Creton, Levy, & Hooymayers, 1993). Also the cross-national validation of the Leary model has shown it to be culturally universal (Lonner, 1980; Wubbels & Levy, 1991).

2.9.3 The Development of the Model for Interpersonal Teacher Behaviour

The two dimensional coordinate system of Leary's model has two consecutive behaviours prevailing upon each other in the same quadrant. For example, dominance and cooperation DC as well as cooperation and dominance CD can be seen in the same quadrant (Figure 2.2). This represents the prevalence of the first behavioural attribute over the latter one as exhibited by the teacher in the classroom. The difficulty with this two-dimensional model was of exhibiting two conflicting behaviours in the same quadrant, such as when opposition and submission are plotted in the same quadrant. This limitation might have led to the modification of the two-dimensional model given by Leary into a more comprehensive one.

The model for interpersonal teacher behaviour (Wubbels & Levy, 1993) has been adapted from Leary's model. In this model teacher behaviour is mapped with the Proximity dimension (Cooperation, C - Opposition, O) and the Influence dimension (Dominance, D – Submission, S) to form eight sectors, each describing different behaviour aspects (Figure 2.3). The sections in the model for interpersonal teacher behaviour are labelled DC, CD, CS, SC, SO, OS, OD, DO according to their position in the coordinate system. For example the two sectors DC and CD are both characterised by Dominance and Cooperation. In the DC sector, the Dominance aspect predominates over the Cooperation aspect, whereas in the adjacent sector CD, Cooperation predominates over the Dominance aspect.

These modified behavioural aspects were labelled Leadership, Helping/Friendly, Understanding, Student Responsibility/Freedom, Uncertain, Dissatisfied, Admonishing and Strict Behaviour.

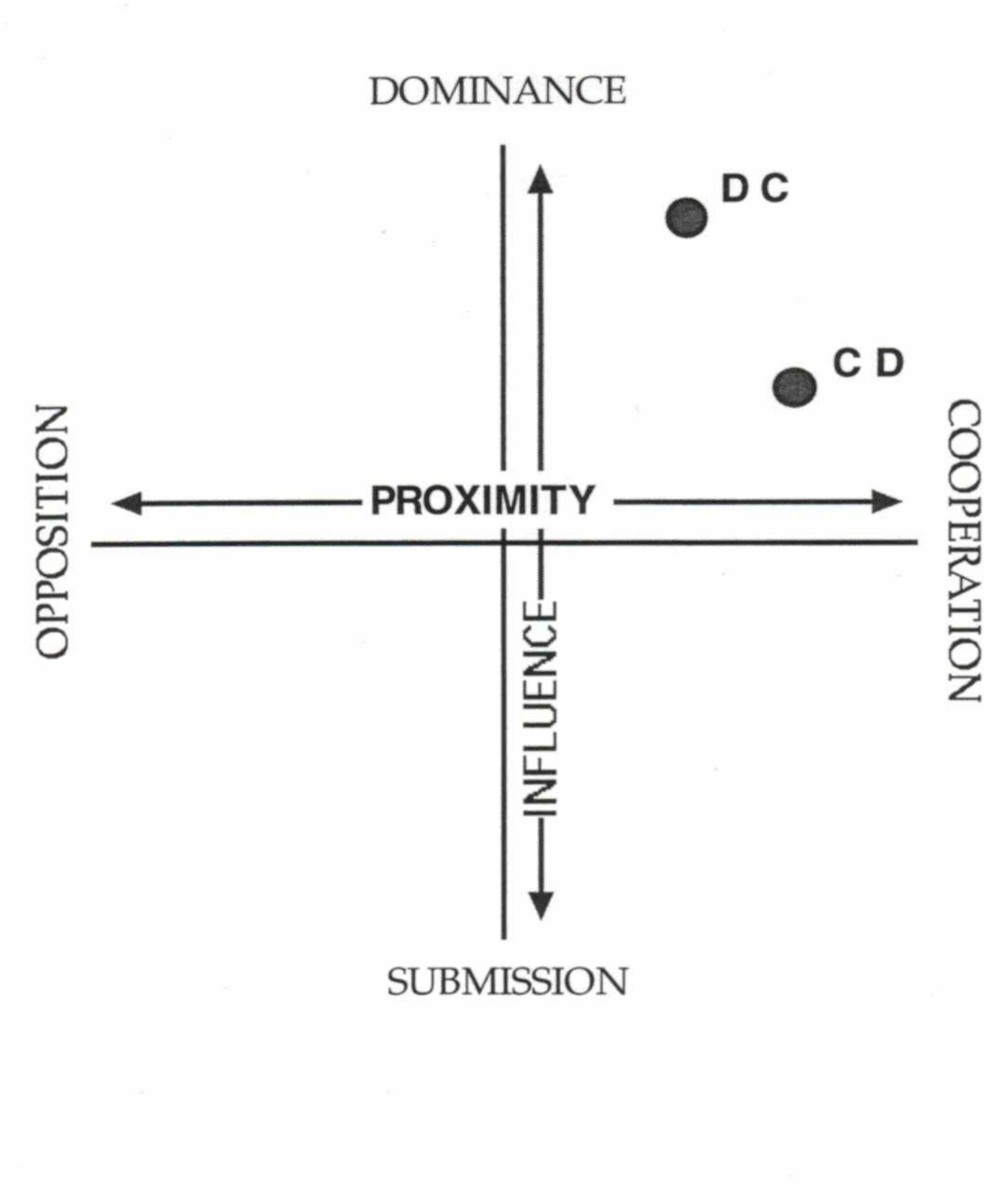


Figure 2.2. DC and CD placements in Leary Model.
(Source: Wubbels, Creton, Levy & Hooymayers, 1993, p.15)

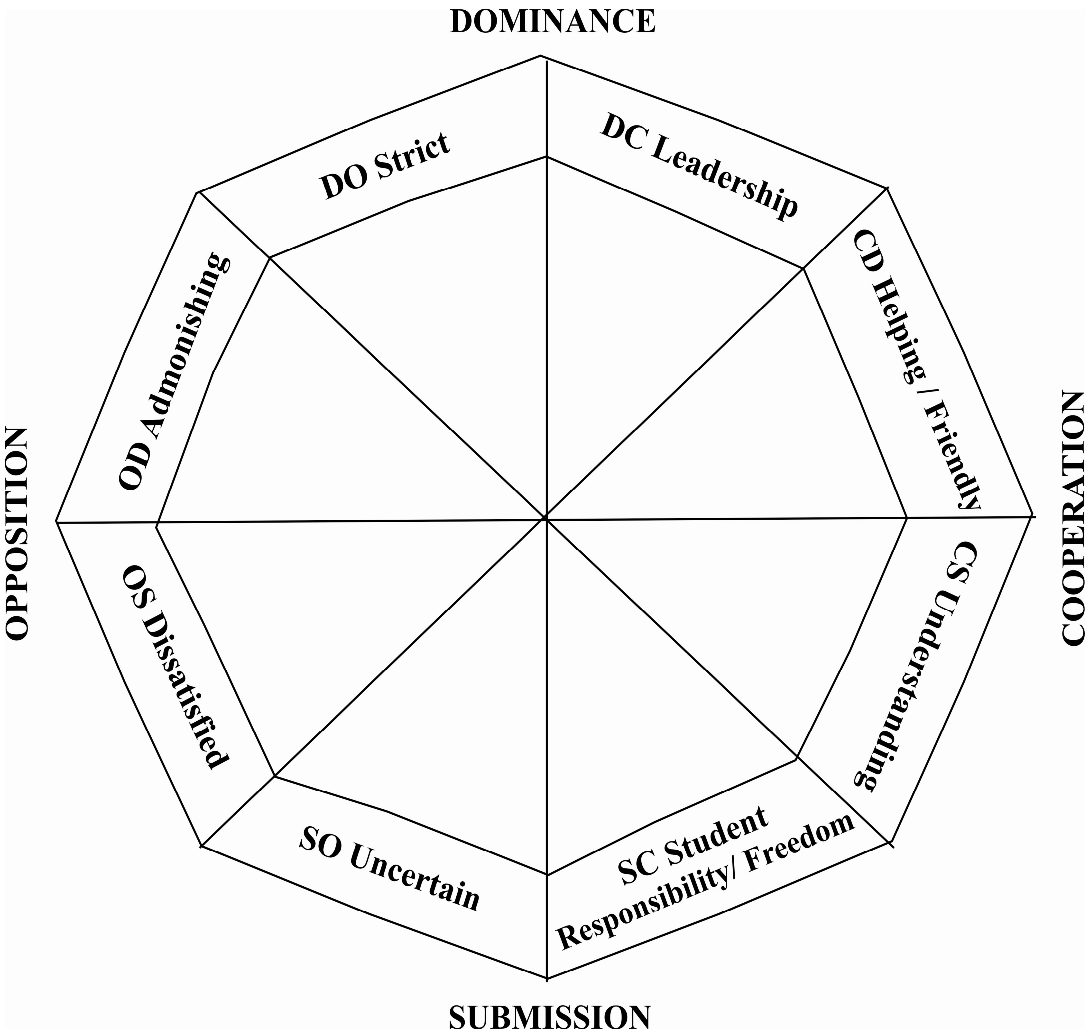


Figure 2.3. The Model for Interpersonal Teacher Behaviour.
(Source: Fisher, Fraser, & Wubbels, 1993)

2.9.4 The Development of the Questionnaire on Teacher Interaction (QTI)

The Questionnaire on Teacher Interaction has been extensively used in educational research at the international level and its utility has been well established in the literature (Brekelmans, Wubbels, & Creton, 1990; den Brok, Levy, Rodriguez, & Wubbels. 2002; Fisher, Fraser, & Rickards, 1997; Fisher, Henderson, & Fraser, 1995; Gorham & Zakahi, 1990; Hecht, Andersen, & Ribeau, 1989; Levy, Rodriguez, & Wubbels, 1992; Rickards & Fisher, 1998; Scott & Fisher, 2000; Wubbels, Brekelmans, & Hermans, 1987; Wubbels, Brekelmans,& Hooymayers, 1991; Wubbels, Creton, & Hooymayers, 1985; Wubbels & Levy, 1991; Wubbels & Levy, 1993). The QTI has been the focus of well over 120 (learning environment) studies in many countries (den Brok, Brekelmans, Levy, & Wubbels, 2002) and has been translated into more than 15 languages (Wubbels, Brekelmans, van Tartwijk, & Admiraal, 1997).

An instrument was required at lower secondary school science classes, to measure teacher-student interpersonal behaviour. This gave rise to a multi-scale instrument having good internal consistency within scales and is able to differentiate between student perceptions in different classrooms. In this section the history and development of the teacher-student interpersonal behaviour questionnaire, the QTI is discussed. The various forms of the QTI and its use in past research have also been discussed in brief.

The studies using the QTI as an instrument have demonstrated that the nature of relationship between the teacher and his/her students is an important aspect of the learning environment (Fraser & Walberg, 1991) and the behaviour patterns that are established in a classroom learning environment are relatively stable over time (Brekelmans, Holvast, & van Tartwijk, 1990; Fraser & Walberg, 1991). Creton, Wubbels, and Hooymayers (1993), Wubbels, Creton, and Holvast, (1988) and Fraser (1991) suggested that the circular communication processes that consist of behaviour as well as determine behaviour develop early in the year in a classroom. Once these behaviours have been developed and stability has been achieved in the classroom both students as well as teachers resist change.

It has been suggested that students and their teacher should have interacted at least for a period of two to three months prior to the administration of the QTI to a target group as the items ask for responses to statements about the teacher's behaviour over a long period of time, not just during the current lesson (Brekelmans, 1989; van Tartwijk, Brekelmans, & Wubbels, 1993). It is also assumed that the nature and patterns of the teacher-student interpersonal behaviour that are established during this time are very likely to remain relatively stable for the remainder of the year (Fraser & Walberg, 1991). This conveys that the student teacher interaction nature and patterns will remain the same if the questionnaire is administered after the initial two to three months settling-in period (Brekelmans, 1989). However, for the study described in this thesis the survey data were collected towards the end of the academic session when students and teacher interaction patterns were well established.

The QTI (Wubbels & Levy, 1991, 1993) was designed to assess teacher-student interpersonal behaviour in lower secondary classroom and developed out of a need to measure secondary students' and teachers' perceptions of teacher behaviour. In early 1980s, the original version of the QTI in Dutch language was developed in four trials in The Netherlands and had 77 items, which were arranged in the eight scales corresponding to the eight sections of the model for interpersonal teacher behaviour (Wubbels, Creton, Levy, & Hooymayers, 1993). Nine to eleven items were included in each of the eight scales. These 77 items were derived from the 128 items of the ICL (Wubbel, Creton, & Hooymayers, 1992) and later these 128 items were modified, reworded and finally reduced to 77 items. The other change made from the ICL was change of response from 'yes' or 'no' to a five point Likert type response. Later, an American version of the QTI was developed in the English language, and had 64 items (Wubbels & Levy, 1991). The items deleted from the Dutch version were on the basis of correlation analysis of the 77-item version to 64 items in the American version.

An Australian version of 48 items followed these two pioneering versions of the QTI (Fisher, Fraser, & Wubbels (1993). This shorter version has six items in each of the eight scales. Table 2.4 represents the nature of the QTI by providing a scale description and a sample item for each of the eight scales. The 48-item Australian version of the QTI was used for this study.

Table 2.4

Description of Items for Each Scale in the QTI

Scale	Description
Leadership [DC]	Extent to which teacher provides leadership to class and holds student attention.
Helping/ Friendly [CD]	Extent to which the teacher is friendly and helpful towards students.
Understanding [CS]	Extent to which teacher shows understanding and care to students.
Student Responsibility/Freedom [SC]	Extent to which the students are given opportunities to assume responsibilities for their own activities.
Uncertain [SO]	Extent to which teacher exhibits her/his uncertainty.
Dissatisfied [OS]	Extent to which teacher shows unhappiness/dissatisfaction with the students.
Admonishing [OD]	Extent to which the teacher shows anger/temper and is impatient in class
Strict [DO]	Extent to which the teacher is strict with demands of the students.

Responses to all the versions of the QTI items are recorded on a five point Likert scale scoring from 1 (Never) to 5 (Always) on the questionnaire only. The use of a separate response sheet is not practised with this instrument and thus reducing the time in responding and facilitating the quick administration of the QTI.

From the administration of the QTI to students, we obtain information about the students' perceptions of the interpersonal behaviour of their teacher. In the same manner, when administered to teachers we get information about teachers' perceptions of their own behaviour or the behaviour they consider ideal. In this study only the student version of the QTI was used.

All the 48-items of the Australian version of the QTI are arranged in cyclic order and in blocks of four This (see Appendix A). Items 1-24 assess the four scales called Leadership, Understanding, Uncertain, and Admonishing, whereas items 25-48 assess the scales of Helping/Friendly, Students Responsibility and Freedom, Dissatisfied, and Strict.

In addition to the three forms of the QTI already discussed, a primary level version of the QTI has been developed, trialed and validated in Singapore (Goh & Fraser, 1995; Goh & Fraser, 1996; Goh, Young, & Fraser, 1995). This version has been adapted from the 48-item QTI in order to be more readable for the younger students and has a revised three-point response format. Further to this another modification of the QTI has resulted in the *Principal Interaction Questionnaire* (PIQ) (Cresswell & Fisher, 1997). This questionnaire assesses the teachers' or school principals' perceptions of principal interpersonal behaviour using the same eight scales of the QTI.

2.9.5 Review of Literature on Teacher-Student Interactions

The QTI was used on a sample of 792 students and 46 teachers in the states of Western Australia and Tasmania (Fisher, Fraser, & Wubbels, 1993; Fisher, Fraser, Wubbels, & Brekelmans, 1993). The results of the study revealed that, generally, teachers did not reach their ideal and differed from the best teachers as perceived by students. Students perceived that the best teachers are strong leaders, more friendly and understanding, and less uncertain, dissatisfied and admonishing than are teachers on average. This pilot study strongly supported the validity and the potential usefulness of the QTI in Australia.

One of the earliest studies of interpersonal behaviour from a cross-national perspective (Wubbels & Levy, 1991) was carried out in The Netherlands and the USA. In this study, an attempt was made to validate the English version of the QTI, and investigate if the Dutch and the English versions of the questionnaire were equivalent, and examine any differences in the students' or teachers' perceptions of interpersonal teacher behaviour in these two countries. The study found that teacher behaviours were similar in many ways but that American teachers saw strictness as being more important whereas Dutch teachers emphasised student responsibility and freedom. According to Wubbels and Levy, this study was a first step towards cross-national research with the QTI and the comparisons with other variables such as student cultural background are enhanced by the availability of this new instrument. Although the primary aim of this study was to develop an English version of the Dutch QTI for use in an American setting, it did serve as an excellent ground for the future development of the Australian 48-item version of the QTI (Wubbels, 1993)

Wubbels and Levy (1993) reported the validity and reliability of the QTI when used in The Netherlands. The 64-item American version of the QTI was also used with 1,606 students and 66 teachers in the USA, and the cross-cultural validity and usefulness of the QTI were confirmed (Wubbels & Levy, 1991).

The data collected from the studies in The Netherlands, the USA and Australia were analysed (Levy, Creton, & Wubbels, 1993), where students had been asked to rate their best and the worst teacher while using the QTI. The best teachers rated by the students were strong leaders, friendly and understanding. The outstanding feature of worst teachers, as rated by the students, was their increased admonishing and dissatisfied character. Although there were not many differences in the characteristics of Dutch and American teachers, when compared in this study (Wubbels & Levy, 1991), American teachers were still perceived as stricter and Dutch teachers as giving their students more responsibility and freedom.

Keeping the past tradition of learning environment research in mind (Fraser, 1992; Fraser & Fisher, 1982) it was important to establish how teacher-student interpersonal behaviour affects student outcomes. The first use of the 48-item QTI was carried out by a team of researchers who studied 489 students in 28 biology classes in senior high school (Fisher, Henderson, & Fraser, 1995). The three distinct student outcomes included in this study were student attitude, achievement in a written examination and performance on practical tests. Few studies before this had investigated the associations between students' perception of teacher-student interactions in science classes and student outcomes. The validity and reliability of the QTI when used with senior secondary students was confirmed in this study. The alpha reliability scores for the different QTI scales ranged from 0.63 to o.83 when the individual student was used as the unit of analysis (Fisher, Henderson, & Fraser, 1995). The reliability scores were higher when the class mean was used as the unit of analysis ranging from 0.74 to 0.95. Generally, the dimensions of the QTI were found to be associated significantly with student attitude scores. In particular, students' attitude scores were higher in classrooms in which students perceived greater leadership, helping/friendly, and understanding in their teachers' interpersonal behaviours. On the contrary, students' attitude scores were lower in classrooms in which students perceived greater uncertainty, dissatisfaction, admonishing, and strictness in their teachers' interpersonal behaviours. This study reported that a biology teacher ought to ensure the presence of these interpersonal behaviours to promote favourable student attitudes to their class and laboratory work.

The validity and reliability of the QTI when used with senior secondary students was confirmed in this study. The alpha reliability scores for the different QTI scales ranged from 0.63 to 0.83 when the individual student was used as the unit of analysis (Fisher, Henderson, & Fraser, 1995). The reliability scores were higher when the class mean was used as the unit of analysis ranging from 0.74 to 0.95.

The QTI was also employed in a cross-national study in Singapore and Australia in 1997 (Fisher, Rickards, Goh & Wong, 1997). The study involved 720 students in 20 grade 8 and 9 science classes Singapore and 705 students in 29 grade 8 and 9 science classes in Australia. In Singapore, the alpha reliability figures for different QTI scales ranged from 0.50 to 0.88 when the individual student was used as the unit of analysis, and from 0.60 to 0.98 when the class mean was used as the unit of analysis. For the Australian sample, the corresponding values were 0.60 to 0.88 and 0.64 to 0.96, respectively (Fisher, Rickards, Goh, & Wong, 1997). The results for this sample generally provided further cross-validation information supporting the internal consistency of the QTI with either the individual student or the class mean as the unit of analysis. The Student Responsibility/Freedom scale had reliability figures less than the other scales, particularly in Singapore, and it was suggested that this scale requires examination and revision before being used in that country.

Another cross-national study was conducted in Brunei and Australia (Rickards, Riah, & Fisher, 1997). In this study the QTI was found to be a valid and reliable instrument. Reliabilities for the scales of the QTI when used in Brunei were found to be acceptable and ranged from 0.58 to 0.80 when the individual student was used as the unit of analysis. These data were then applied to a cross-national study, which provided an Australian sample of secondary science classrooms. Reliabilities for the QTI scales ranged from 0.60 to 0.88 for the student as the unit of analysis and 0.64 to 0.96 for the class mean as the unit of analysis.

A study using the QTI in Australia examined students' attitudes to mathematics and teacher-student interpersonal behaviour in mathematics classrooms (Fisher & Rickards, 1998). This confirmed the reliability of the QTI when used with a sample of 405 students in nine schools together with their 21 grade 8, 9, and 10 Mathematics teachers. Student attitude scores were consistent with those found in science classrooms and were higher in classrooms in which students perceived greater leadership and, helping/friendly behaviours in their teachers' interpersonal behaviours and lower in classrooms in which students perceived greater dissatisfaction, admonishing, and strictness in their teachers' interpersonal behaviours.

Kim, Fisher and Fraser (2000) translated the QTI into Korean and administered it to 543 eighth grade students in 12 secondary schools. It was reported that the questionnaire yielded Cronbach alpha reliability figures ranging from 0.61 to 0.83.

An attempt to validate the QTI in a specific cultural context was made in Brunei. Out of 48 statements contained in the Australian version of QTI, 20 statements were reworked and re-phrased in order to suit the local context (Khine, Larwood, & Fisher, 2000). The revised questionnaire was administered to 276 students in 14 classrooms and it was found that the reliabilities ranged from 0.60 to 0.76 with the individual students as the unit of analysis.

The Netherlands Organisation for Scientific Research funded study (den Brok et.al, 2003) reported on the reliability and validity of QTI when used with secondary science students from six different countries: USA, Australia, Slovakia, Singapore and Brunei. In this study, multilevel structural equation modelling, correlation analyses and other techniques were used to determine the construct validity of the QTI. The results showed that there were slight differences in scale positions between the countries when plotting on the circle and that further research is necessary to determine whether the instrument has cross-cultural validity.

Rickards, den Brok and Fisher (2003) constructed a large data set out of several prior studies using the QTI in four different states of Australia in the past decade. The main aim of this study was to develop a typology of interpersonal behaviour of an Australian teacher. More than 85% of the teachers were classified as either being directive, authoritative or tolerant-authoritative. Uncertain-tolerant, uncertain-aggressive and repressive teachers were hardly found in the Australian sample.

Koul and Fisher (2003) in one of the first studies in India used the Questionnaire on Teacher Interaction (QTI) to investigate associations between Indian students' perceptions of teacher-student interactions and attitudes towards science. The total sample comprised of 1,021 students from 31 science classes from years 9 and 10 in seven different co-educational schools. The study reported that the QTI had an alpha reliability index ranging from 0.53 to 0.72 and the ANOVA eta^2 statistics ranging from 0.13 to 0.25. This study also shows that the students perceived their teachers as demonstrating leadership and understanding behaviours quite often and the teachers seldom were uncertain, dissatisfied or admonishing.

A study to examine associations between Turkish high school student's perceptions of their science teacher's interpersonal behaviour and their attitude towards science was carried out by Telli, den Brok and Cakiroglu (2006) using the adapted and translated version of the QTI. The data for the study was collected from 2,342 students in grade 9^{th} to 11^{th} from 81 science classroom sin 14 public schools. The alpha reliability scores to establish the reliability of the QTI ranged from 0.44 to 0.84 considering the individual as the unit of analysis and from 0.65 to 0.95 with the class as a unit of analysis, also the eta^2 statistics ranged from 0.18 to 0.29. This study showed that generally the students perceived their teachers as dominant and highly cooperative. Results from this study also indicated differences in perception according to subject taught.

Nijveldt, Beijaard, Brekelmans, Verloop, and Wubbels (2006) developed and validated a procedure to assess the interpersonal competencies of teachers. This procedure includes the use of the QTI, an observation instrument and a self-reflection instrument. The concepts of construct-irrelevant variance and construct under-representation were used to explore the validity of the assessment procedure with regards to the noting of evidence and combining of evidence to attain an overall judgement by four separate assessors for the same beginning teacher. The validity of the assessment procedure was found to be satisfactory and the use of multiple assessment instruments clearly added value to it.

2.9.6 Summary

The review of literature on the QTI reveals that it is an instrument of historical importance and from its inception it has been used successfully in assessing the students' perception of the teacher's interpersonal behaviour and may also be used to examine associations between perceptions of teacher's interpersonal behaviour and students' attitude towards science and cognitive outcomes. This questionnaire has been used in a number of countries and has proven to be highly reliable and valid for use in future research. Since the present study is being conducted in India and the QTI has been used only once to study the students' perceptions of their teachers' interpersonal behaviour in science classrooms, this will further validate the use of the QTI in India in studying students' perception of student-teacher interactions in a technology-supported science classroom.

2.10 CHAPTER SUMMARY

This chapter highlights the research studies done in various countries regarding the use of technology in the teaching learning process. The research done in India with regards to educational technology has also been discussed although such studies have been quite limited in number. This chapter also introduced the field of learning environments and the huge amount of research completed in this area with detailed information on the various tools used in the study of learning environments such as the WIHIC, LEI and CLES. Studies on the learning environments of technology-supported classrooms using the TROFLEI questionnaire have also been discussed in this chapter. The historical development of the teacher interpersonal behaviour model and development of the teacher-student interaction questionnaire, QTI, has also been discussed along with previous research studies conducted using the QTI in various countries. This chapter provides the theoretical basis for this study. The next chapter describes the research methodology used in the present study with detailed information on the research objectives, design of the study, the sample, the instruments used in the study and the methods of data collection and analysis.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

Research methods are indicate the various steps in the plan of attack to be adopted for solving a research problem. It is, therefore, very important that researchers have a thorough understanding of diverse research methods – their strengths, limitations, applications and appropriateness.

Best (1982) has observed, that since no two research undertakings are exactly alike, it is impossible to set forth any rigid formulation of methods or procedure. There is a wide variation in the conditions and circumstances which determine the objective nature of research problems in different fields. The purpose of a study may vary from problems in different fields. The purpose of a study may also vary from researcher to researcher in terms of where it is to be conducted and the applications that are to be made of it. In addition, great differences in the capacities and characteristics among the individuals who do research work are a proved fact. Thus all methods defy portrayal in term of formula or standardization.

Mouly (1970) described that there are many ways and means of gathering, analyzing and reporting research data. Educators are not in thorough agreement as to the so-called methods of collecting and handling the data. In research literature many variations of different terms are used to designate shades of meaning. Research workers use terms which suit their own needs and express their own purposes. As an illustration, Mouley gave an alphabetic list of as many as 131 terms used in literature dealing with educational research to denote the procedure and methods used in studying research problems. This implies that no study can be carried out through the use of only one method.

The decision about the method or methods to be employed always depends upon the nature of the problem selected and the kind of data necessary for its solution. Whatever the method to be employed, it is essential that it should be describable otherwise it will lose its significance and effectiveness. Thus if the research methodology cannot be clearly described, chances are that the results of the study will be too vague and general (Mouly 1970).

In the previous chapter, a number of research studies were reviewed in order to understand the impact of technology on education and the various tools for assessing the learning environments of technology-supported classrooms and the teacher–student interactions in such classrooms. In keeping with most of this research, the questionnaire survey method has been used as part of the research methodology in this study. The present chapter outlines the specific research objectives, the various phases of the study, which includes setting up of a technology-supported classroom, training of teachers, sampling of students, selection of instruments for assessing the psychosocial learning environment of technology-supported classrooms and teacher-student interactions, to the quantitative and qualitative methods of analysis used in this study.

3.2 RESEARCH AIM AND OBJECTIVES

The specific objectives of the proposed research study are:

1. to determine the reliability and validity of the modified form of Technology–Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) for use with urban Indian secondary school students;

2. to further validate the Questionnaire on Teacher Interaction (QTI) when used in a technology - supported learning environment;

3. to investigate associations of students' perceptions of their technology-supported learning environment in a science classroom with attitude towards science, academic efficacy and academic achievement;

4. to investigate associations of students' perception of their teacher-student interactions with attitude towards science, academic efficacy and academic achievement in a technology-supported science classroom; and

5. to investigate whether gender differences occur in students' perception of their technology-supported learning environment in a science classroom and their teacher-student interactions along with differences in their attitude towards science, academic efficacy and academic achievement in a technology-supported learning environment.

Apart from the specific objectives of the study the overall aim of the proposed research is to determine the effectiveness of the technology-supported classroom setup in teaching of science at the secondary level in Indian schools specifically in Jammu where this study is being conducted.

3.3 DESIGN OF THE STUDY

The whole study was carried out in three stages. In the first stage, low cost technology-supported classrooms were setup. In the second stage, the science teachers were trained in the use of technology and in the third phase the TROFLEI and the QTI were administered for the purpose of data collection and further analysis.

3.3.1 Technology-Supported Classroom

Worldwide there has been a strong push to get educational technology into the hands of teachers and students. A lot of experimentation has been going on to harness the immense potential of technology and internet for education in schools. Some initiatives have met with partial success but most have failed to bring about any significant change in the life of a teacher or the student. The technology-supported classroom project was developed with this reality in mind. The main purpose is to empower teachers with technology right inside their classrooms. The technology-supported classroom enables teachers to use digital resources such as graphics, animations, 3D Images and Video clips in addition to the chalk and talk methods of teaching in their day to day teaching life. This results in a completely new multi-sensory learning experience for students and helps them to improve their academic performance.

Schools across India have set up modern computer laboratories and audio visual laboratories equipped with an LCD projector and a PC. The computer labs are used to deliver IT education to students as per the prescribed curriculum of the school and randomly selected educational software is used to help students learn other subject curriculum concepts in the audio visual labs. Schools also use educational software in computer labs to help students learn other subjects.

It has been observed that students visit the computer labs or AV rooms once or twice a week. This allows each student to get an exposure of just about 40-50 periods, with each period being of 40 minutes duration, during the entire academic session with technology. Students spend nearly half or more of these 40-50 periods in learning IT concepts. Of the over 1,200 odd periods in any given academic year, only 15-20 periods are being used for computer aided education covering non IT subjects. In this way, technology does not affect the subject teachers and a student’s life in schools. The technology-supported classroom as conceptualized by the investigator for the present study, on the other hand would help to integrate technology in the day-to-day life of teachers and students inside their classrooms and affects a significant part of teaching and learning in any given academic session (see Figure 3.1). Ideally, the classrooms would be lively learning platforms for students and the teachers can choose from a mix of teaching tools such as the traditional chalk and blackboard coupled with graphics, sound, animations, and videos.

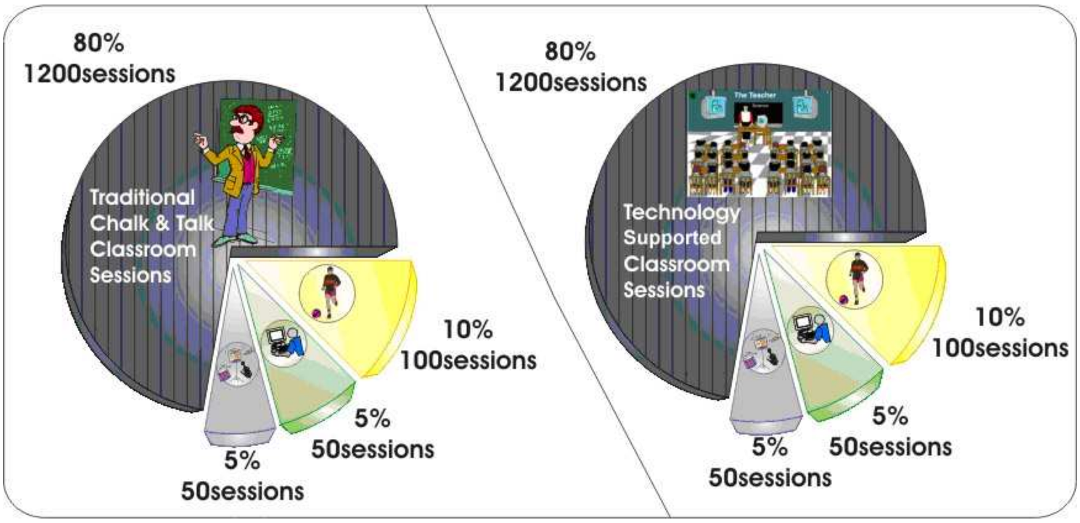


Figure 3.1. Comparison of integration of technology in conventional classes versus technology-supported classrooms.

The technology-supported classrooms set up for the purpose of this study, first involved creating a local area network connecting classrooms of different grades where learning environments were to be assessed. This network of classrooms was connected to a central knowledge centre which housed the server on which more than 7,000 digital learning packages in terms of animated lessons, video lessons, presentations. covering various topics pertaining to general science for secondary level were installed. The knowledge centre was also equipped with a few computers for use by teachers. Each class in the study was provided a large screen television connected with a computer to connect to the server in the knowledge centre to access the digital resources. The classes where such kind of setup was made operational were referred to as ‘Technology-supported Classrooms’ (Appendix C). A schematic diagram of the technology-supported classroom setup has been given in Figure 3.2.

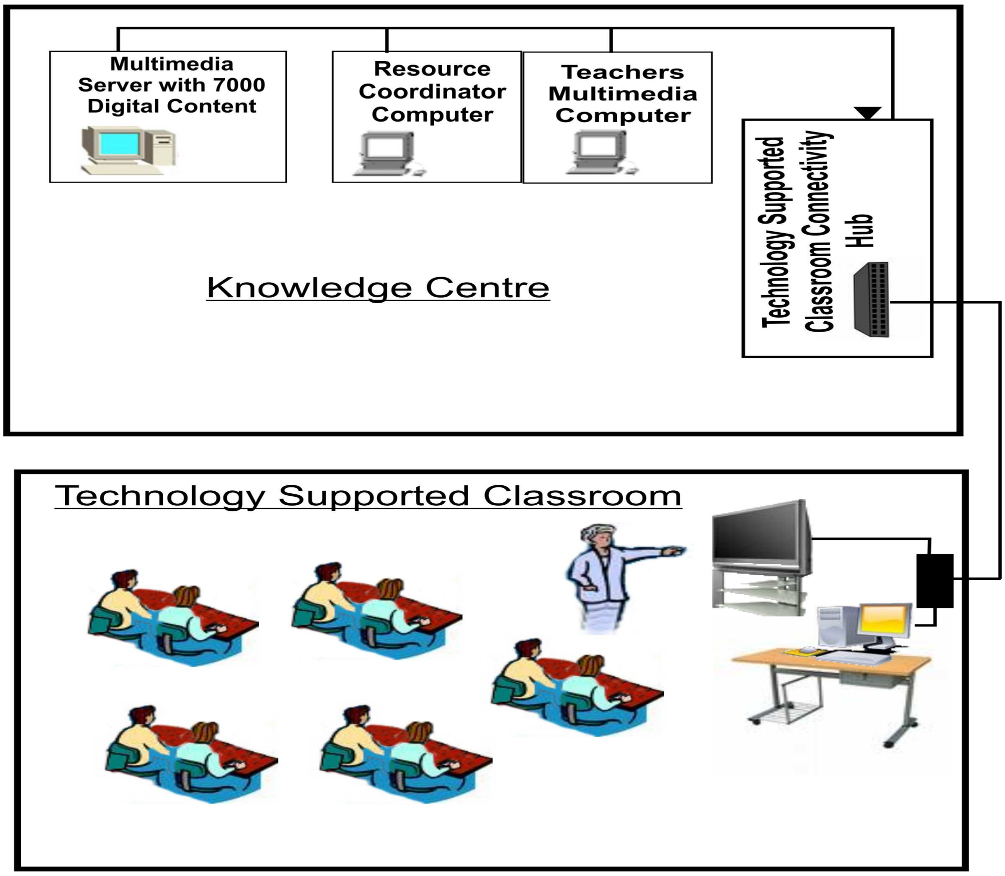
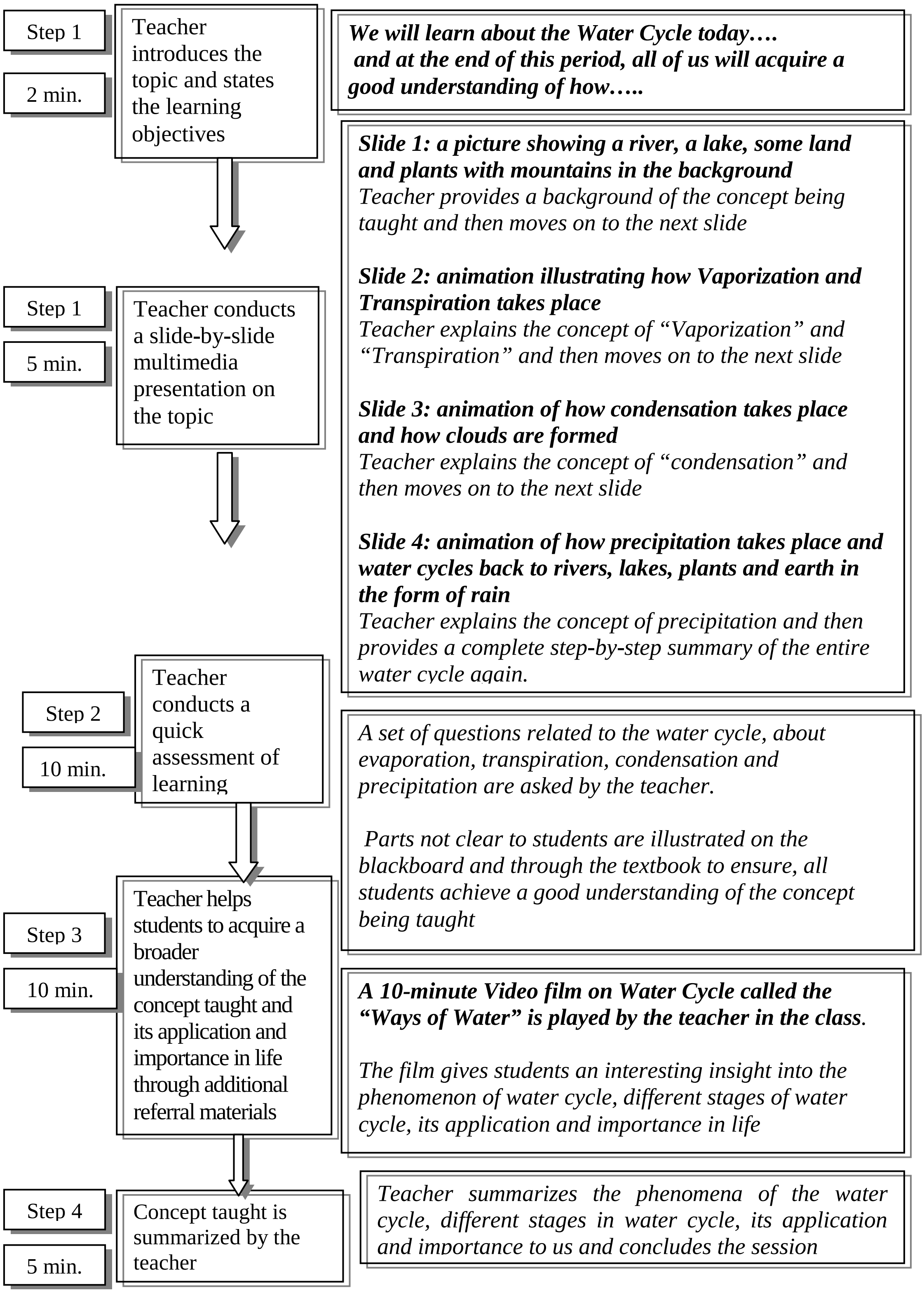


Figure 3.2. Schematic diagram of technology-supported classroom.

3.3.2 Teacher Training and Classroom Teaching

After setting up the technology-supported classrooms, the next stage involved training of science teachers in the use of technology to make the classroom teaching more lively, interactive and effective. The teachers were first made familiar with the digital resources in the knowledge centre where they selected the topic they had to teach in the classroom and then practised the lesson in accordance with the prescribed syllabus. On the basis of the topic to be taught using the technology-supported classroom each teacher prepared a teaching plan for use in his/her respective science class. The teaching plan was developed in such a way that the teacher was able to use a mix of traditional and modern teaching tools while teaching science, without having to change the way they are used to teaching in classrooms (Figure 3.3).

Figure 3.3. Sample teaching plan in a technology-supported science classroom.



Teaching activities based on these plans were conducted for a period of about eight months so that the students were well exposed to the use of technology in day-to-day learning activities. As a part of this study, ten science teachers were trained to use this technology-supported classroom and they were required to teach each class on their timetable for a duration of 40 minutes per session daily. It was planned to conduct 1200 sessions for the 15 classes chosen for the study, which meant that there would be 150 sessions in a month for all the classes. Hence there would be 10 sessions per class in each month which would account for 400 minutes of intervention in terms of teaching science through a technology-supported classroom per class per month. This exposure was designed to help in assessing the psychosocial learning environments and teacher-student interactions in a technology-supported science classroom in an effective manner. The achievement level of the students will also be determined through an end of the year exam based on the lessons studied through the technology-supported classrooms.

3.3.3 Sample for the Study

The school chosen for this study was a 70-year old higher secondary school (10+2) in Jammu (J & K State, India), which has used various innovative methods in teaching different subjects. In recent times this school has taken a lead in the introduction of technology in the classroom to make the teaching learning process more meaningful and effective. Therefore, this school was chosen as it provided the right atmosphere to study the psychosocial learning environments and perceptions that students have of their teachers' interpersonal behaviour in a technology-supported science classroom. The sample for the study was chosen carefully so as to be representative of the school and was comprised of coeducational classes in order to permit an unbiased test of gender differences. The sample involved 705 students in 15 science classes from grades 6 to 11, spread in the age group of 11 to 17 years. Out of 705 students, 379 were male students which accounted for 53.8% of the sample and the female students were 326 in number which accounted for 46.2% of the sample.

3.3.4 Research Instruments Selection

The field of learning environments has expanded at a phenomenal pace in the last three decades and a wide variety of instruments have been developed for assessing the psychosocial learning environments in a classroom situation. Some of these instruments have been highlighted in Chapter 2 of this study. While selecting the instruments for this study a number of factors were considered. Firstly, it was made sure that the instrument was statistically reliable, valid and widely applicable, and secondly, caution was taken with regard to the language and wording as most of the instruments had been developed in Western countries and had to be used for the first time in Indian school setting.

After reviewing a number of instruments, the Technology–Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) (Aldridge & Fraser, 2003) and the Questionnaire on Teacher Interaction (QTI) (Wubbels & Levy, 1993) were selected to assess the learning environments of technology-supported classroom and teacher interpersonal behaviour. Both these instruments have been widely used in a number of research studies and have been found to be reliable and valid as indicated in Chapter 2.

3.4 DATA COLLECTION

After making requisite preparations for the study and selection of the instruments for the purpose of assessment, the process of data collection was initiated. The data collected for the study were both quantitative and qualitative in nature. The quantitative data were collected by administering the TROFLEI and the QTI to the sample selected for the study and the qualitative data were gathered by conducting student interviews related to the questionnaires and their general perception of the psychosocial learning environment in a technology-supported science classroom and their teacher interpersonal relationships. Qualitative data were collected by interviewing 45 students in all, three students from each class.

3.4.1 Quantitative Data Collection

The QTI enables information concerning student's perceptions of teacher interpersonal behaviour to be gathered and had been used once before in Indian school settings (Koul & Fisher, 2003). It has been found to be a reliable and valid tool of assessment and hence was administered to the sample without making any changes. The version of the QTI used in this study consisted of 48 items, six for every sector of the model for teacher interpersonal behaviour as discussed in Chapter 2. Responses to the items are scored 1, 2, 3, 4, 5, respectively, for the responses, Never, Seldom, Sometimes, Often and Always. A copy of the QTI has been included in Appendix A.

On the other hand, the TROFLEI which was based on the What Is Happening In This Class (WIHIC) (Fraser, Fisher, & McRobbie, 1996) was being used for the first time in an Indian school setting. The original version of the TROFLEI consisted of 80 items assigned to 10 scales (eight items per scale) as illustrated in Table 2.3 in Chapter 2. The questionnaire was available in two forms, the Actual and the Preferred. The Actual Form measured the classroom environment in its current form while the Preference Form measured perceptions of students' ideal or preferred classroom environments. The students respond to items using a five-point frequency response format (viz. Almost Never, Seldom, Sometimes, Often, Almost Always).

The TROFLEI was modified for use with Indian school students who were studying science through a technology-supported classroom. First, the Computer Usage scale was removed from the questionnaire as the computer was used only as a component in the study and represented only a part of the technology used in the classroom; hence it was felt that there was no need to retain the scale for assessing computer usage. Secondly, a decision was taken not to include the Young Adult Ethos scale for the simple reason that in the conventional Indian classroom situation students are hardly given any responsibility and it is more teachers driven. The data thus collected would not have provided a true assessment of the learning environment as measured by this scale. Thirdly, the Attitude towards Computers scale was also removed as it was not in the scope of the study. However the two scales of Attitude towards

Science (AS) and Academic Efficacy (SSE) were retained as they formed an important part of this study. The Attitude towards Science scale measures the extent to which students are interested in, enjoy and look forward to lessons in science and the Academic Efficacy scale assesses students' judgments of their capabilities to organize and execute courses of action to attain designated types of educational performances. Finally, a new scale, namely, 'Technology Teaching' was added to assess the extent to which the use of technology helped the students in understanding science by making it more lively and interesting. The Technology Teaching scale also consisted of eight items to which students responded using a five point scale, i.e. the items were scored 1, 2, 3, 4, 5, respectively, for the Almost Never, Seldom, Sometimes, Often and Almost Always responses. The different scales of the modified version of the TROFLEI are shown in Table 3.1.

The modified TROFLEI was then field tested with a sample of 50 students from grades 7 to 11 to ensure that the changes made to the questionnaire were comprehended by the students. An examination of the responses given by the students revealed that some of the items had not been properly understood. These items were modified so that the students could understand them and respond in the right manner, for example, item number 16 in the Teacher Support scale read, 'The teacher's questions help me to understand' to which the students did not respond. This was changed to, 'The teacher's questions help me to understand the topic' which was well responded to by the students. Similarly item number 27 in the Task Orientation scale read, 'I know the goals for this class' and this was changed to, 'I know the purpose of studying in this class' and was well accepted by the students. The items in different scales which were changed have been presented in Table 3.2. The final version of the modified form of the TROFLEI consisted of nine learning environment scales having 72 items (eight in each scale) and two additional scales of Attitude towards Science and Academic Efficacy having eight items each. For ease of administration the actual and preferred forms of the TROFLEI were merged to form a single instrument. A copy of the modified version of the TROFLEI has been included in Appendix B. Thus after making the required changes, the questionnaire was ready for final administration and was used for collection of data to asses the technology-supported learning environments in a science classroom.

Table 3.1

Names and Descriptions of Modified TROFLEI Scales

Scale Name	Scale Description
Student Cohesiveness (SC)	The extent to which student know, help and are supportive of one another.
Teacher Support (TS)	The extent to which the teacher helps, befriends, trusts and is interested in students.
Involvement (IV)	The extent to which students are attentive interest, participate in discussions, do additional work and enjoy the class.
Task Orientation (TO)	The extent to which it is important to complete the activities planned and stay on the subject matter.
Investigation (IN)	The extent to which skills and processes of enquiry and their use in problem solving and investigation are emphasised.
Cooperation (CO)	The extent to which students cooperate rather than compete with one another on learning tasks.
Equity (EQ)	The extent to which students are treated equally by the teacher.
Differentiation (DI)	The extent to which teachers cater for students differently on the basis of ability, rate of learning and interests.
Technology Teaching (TT)	The extent to which students find learning science through the use of technology interesting, lively and informative.

Responses of the items are scored 1, 2, 3, 4, 5 respectively, from Almost Never, Seldom, Sometimes, Often to Almost Always.

Table 3.2

TROFLEI Items Modified for Use in Indian School Settings

Scale	Item No.	Original	Modified
Teacher Support	16	The teacher's questions help me to understand.	The teacher's questions help me to understand the topic.
Task Orientation	27	I know the goals for this class.	I know the purpose of studying in this class.
Task Orientation	28	I am ready to start this class on time.	I am always ready to study in this class.
Task Orientation	29	I know what I am trying to accomplish in this class.	I know what I am trying to achieve in this class.
Differentiation	60	I am set tasks that are different from other students' tasks.	I am given tasks that are different from other students' tasks.
Differentiation	63	I use different assessment methods from other students.	I am assessed in a different manner from other students.

3.4.2 Qualitative Data Collection

To further validate the quantitative data obtained through the administration of the learning environment questionnaire and the teacher interpersonal behaviour questionnaire, interviews were conducted with the students in order to have a better understanding of the learning environments in a technology-supported science classroom.

Interview in simple words means 'Conversation with a Purpose'. It is in a sense an oral questionnaire and is a generic concept which includes a variety of procedures used in collecting data through a person-to-person contact between an interviewer and a respondent (Gheselli & Brown, 1955). Rosnow and Rosenthal (1989) addressed the advantages of face-to-face interviews and suggested that they provide for trust and cooperation of the participants and help the researcher to interpret the questionnaire and maintain flexibility in terms of sequence and wordings of the questions.

For the purpose of this study, three students were selected from each of the 15 classes and were interviewed in order to validate the data collected from the questionnaires. The interviews were also conducted to assess whether the students perceived their technology-supported classroom learning environment to be more effective for studying science than their regular classroom. The students were interviewed one at a time and the conversation was audio taped and later transcribed for analysis. Questions of the interview were based on the items in the different scales of TROFLEI, QTI and the attitude scale to which the students had earlier responded and were organized in a semi-structured manner. However, such an interaction may lead to interviewees saying things to please, rather that speaking truthfully. Care was taken to make sure that the information given was true. Overall, this procedure is inexpensive, data rich, flexible, stimulating and elaborative of individual responses. The semi-structured interview schedule which was used as guideline is depicted in Table 3.3 for the TROFLEI questionnaire, Table 3.4 for the QTI questionnaire and Table 3.5 for the attitude scale.

Table 3.3

Interview Schedule for the TROFLEI

Scale	Question
Student Cohesiveness	1. Do you make friends with students in this class? 2. Do students in this class like you? 3. Do you get help from other students in this class?
Teacher Support	1. Does the teacher go out of his/her way to help you? 2. Is the teacher interested in your problems? 3. Do the teacher's questions help to understand the topic?
Involvement	1. Do you give your opinion during class discussions? 2. Are your ideas and suggestions used during class discussions? 3. Do the students discuss with you how to go about solving problems?
Task Orientation	1. Do you know the purpose of studying in this class? 2. Are you always ready to study in this class? 3. Do you know how much work you have to do?
Investigation	1. Do you carry out investigations to answer questions and test your ideas? 2. Do you find out answers to questions by investigating? 3. Do you solve problems by using information obtained from your own investigation?
Cooperation	1. Do you cooperate with other students when doing assignment work? 2. Do you share your books and resources? 3. Do you cooperate with other students on class activities?
Equity	1. Does the teacher give you as much attention as to other student?. 2. Are you given the same opportunity in the class? 3. Do you receive the same encouragement from the teacher?
Differentiation	1. Are you given tasks that are different from other students? 2. Are you assessed in a different manner? 3. Do the Students who work faster than you move to the next topic?
Technology Teaching	1. Do you find learning science in the technology classroom Interesting? 2. Do you find the audio-visual effects in the content matter to be appealing? 3. Do you look forward to learning science in the technology classroom?

Table 3.4

Interview Schedule for the QTI

Scale	Question
Leadership	1. Does the teacher know everything that is going on in the class? 2. Is your teacher a good leader? 3. Does your teacher act confidently?
Helping/Friendly	1. Does the teacher help you in your work? 2. Do you depend upon your teacher? 3. Does the teacher allow you to take jokes in the class?
Understanding	1. Does the teacher trust you? 2. Is the teacher willing to explain things again? 3. Does the teacher listen to you when you have something to say?
Student Responsibility/ Freedom	1. Can you influence your teacher? 2. Does the teacher give lot of free time in the class? 3. Is the teacher lenient?
Uncertain	1. Does the teacher acts as if he/she does not know what to do? 2. Is it easy to make a fool out of your teacher? 3. Is the teacher uncertain?
Dissatisfied	1. Does the teacher think that students' don't know anything? 2. Does the teacher think that students' cheat? 3. Does the teacher think that students' can't do things well?
Admonishing	1. Does the teacher get angry quickly? 2. Is the teacher too quick to correct students' when they break a rule? 3. Is the teacher sarcastic?
Strict	1. Is the teacher strict? 2. Does the teacher give difficult tests? 3. Are you afraid of your teacher?

Table 3.5

Interview Schedule for the Attitude Scale

Scale	Question
Attitude Scale	1. Do you look forward to lessons in this class? 2. Is this subject one of the most interesting school subjects? 3. Do these lessons make you interested in this subject?

3.5 QUANTITATIVE DATA ANALYSIS

The data collected after administering the TROFLEI and QTI questionnaires was first tabulated and coded in an Excel file. The data were then statistically analysed using SPSS version 14. The statistical tools were selected from the point of view of achieving the research objectives proposed for the study.

The first research question aimed at establishing the reliability and validity of the TROFLEI questionnaire as it was being used for the first time in an Indian school situation. Three indices for scale reliability and validity were generated for both the Actual and Preferred Forms separately. The Cronbach alpha reliability coefficient was used as an index of scale internal consistency which indicates the reliability of the test items relative to other test items which are designed to measure the same construct of interest. Analysis of variance (ANOVA) results were used as evidence of the ability of each scale in the Actual Form to differentiate between the perceptions of students in different classrooms. A discriminant validity index (namely, the mean correlation of a scale with other scales) was used as evidence that each TROFLEI scale measures a separate dimension that is distinct from the other scales in this questionnaire. The TROFLEI was further validated by factor analysing the data collected. Principal components factor analysis followed by varimax rotation was carried out to confirm a refined structure of the TROFLEI comprising of 72 items in nine scales. The intercorrelations of the nine scales of TROFLEI were also computed to ensure the belongingness and association of the new scale of 'Technology Teaching' with the other scales of the instrument.

In order to fulfil the second research objective, the reliability and validity of the QTI were established by computing the Cronbach alpha reliability coefficient for the data collected and analysis of variance (ANOVA) as an evidence of the ability of each scale to differentiate between the perceptions of students in different classrooms along with eta^2 statistics, which provides an estimate of the strength of the association between class membership and the dependent variable. The circumplex nature of the QTI was also investigated to further validate its use.

Research objectives three and four seek to investigate the students' perception of a technology-supported learning environment in the science classroom and their teacher-student interactions with attitude towards science, academic efficacy and academic achievement. To carry out these investigations simple and multiple correlation analyses along with the calculation of a regression coefficient between the nine classroom environment scales of TROFLEI, the eight inter personal behaviour scales of the QTI and three student outcomes i.e. attitude towards science, academic efficacy and academic achievement (the score obtained by the student in the annual examination at the end of the academic year based on lessons in science taught to the students through technology-supported classroom) were employed. The simple correlation provides information about the bivariate association between each learning environment scale and each student outcome. A multiple correlation analysis of relationships between each outcome and the TROFLEI and QTI scales provides a more complete picture of the joint influence of correlated environment dimensions on outcomes. To understand which individual scale makes the largest contribution to explain the variance in student attitudes, the regression coefficients for both TROFLEI and QTI were examined. The regression coefficient values describe the influence of a particular environment variable on an outcome when all other environment variables in the regression analysis are mutually controlled.

The fifth research objective aimed at investigating whether gender differences occur in students' perception of their technology-supported learning environment in a science classroom and their teacher-student interactions along with differences in their attitude towards science, academic efficacy and academic achievement in a technology-supported learning environment. A test of significance of the difference between means (t-test) was used for investigating whether such differences were statistically significant for male and female students.

A descriptive statistical analysis on all the scales of the TROFLEI and QTI along with the Attitude Towards Science and Academic Efficacy scale was done to compute scale means and standard deviations in order to understand the nature of technology-supported learning environments and the relationship between teachers and students.

Apart from analyzing the data from the TROFLEI and the QTI, a survey was used to assess the reactions of students towards learning science through a technology-supported classroom. This survey included 20 items which were administered to a small sample of students who have studied science in a technology-supported learning environment. This enabled the researcher to understand and assess the effectiveness of the technology-supported learning environments in teaching of science (see Appendix D). The frequencies of the responses on the evaluation survey were converted to percentages for the purpose of interpretation.

3.6 QUALITATIVE DATA ANALYSIS

The qualitative data in this study were collected in the form of interviews with the students that were recorded and later transcribed. The information was then carefully examined to determine whether or not it supported assertions based on the quantitative analysis of the questionnaires. The student interview data were also used to establish the construct validity of the TROFLEI and the QTI questionnaires. The responses received from the students helped in developing a picture of the nature of learning environments in their respective classrooms especially in relation to the use of technology in their classes for teaching science and their perceptions of the teacher's interpersonal behaviour in the classroom. The responses on the attitude scale helped in understanding students' attitude towards their subject, which was science in this case, and also whether the technology-supported learning environments help promote a positive attitude towards science. These data were also used in establishing the construct validity of the TROFLEI and the QTI instruments used in this study.

3.7 CHAPTER SUMMARY

This chapter gives detailed information on the research methodology used in the study which was both quantitative and qualitative in nature. A questionnaire survey method was used to collect information using two tools of measurement, a modified form of the Technology–Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) and the Questionnaire on Teacher Interaction (QTI). This chapter also discussed the development and setup of the technology-supported classroom which was the nerve centre of the teaching and learning activity in this study. The training of teachers and the use of technology was also described in this chapter. The process of data collection which included the sampling for the study, the choice of the school, choice of instruments, and modification of instruments to suite Indian school settings and administration of the questionnaires along with student interviews were also detailed in this chapter. Finally, the process of data analysis was described which included the statistical tools for determining the reliability and validity of the TROFLEI and the QTI to be used with Indian school students, i.e. Cronbach's alpha reliability, mean correlation, ANOVA, eta^2 and factor analysis. Determining the association of student outcomes, attitude towards subject, academic efficacy and academic achievement, with the scales of the TROFLEI and QTI using simple, multiple correlation and regression coefficients were also discussed in this chapter. Finally, the analysis of gender differences on the nine scales of the TROFLEI and eight scales of the QTI along with differences on the Attitude Towards Science and Academic Efficacy scales and achievement was done using the t-Test. Chapter Four reports on the reliability and validity of the TROFLEI, QTI and the attitude and efficacy scales.

CHAPTER 4

VALIDATION OF INSTRUMENTS

4.1 INTRODUCTION

The previous chapter reported on the research methodology of the present study along with the research aims and objectives and the techniques of data analysis to be employed. The present chapter reports on the reliability and validity of the two questionnaires, i.e., the TROFLEI and the QTI when used in a technology-supported learning environment in a science classroom with students in Jammu, India. The quantitative analysis in this chapter will seek to achieve the research objectives one and two as reported in section 1.5 of Chapter 1. It would be pertinent to mention that the modified TROFLEI is being used for the first time in Indian school settings. This chapter also reports on the validation of the Attitude Towards Science scale and the Academic Efficacy scale which are also being used for the first time to assess students' attitude towards science and their self efficacy while studying science in a technology-supported learning environment.

4.2 VALIDATION OF THE TROFLEI

The data for the modified TROFLEI were collected from a sample of 705 students in 15 classes who studied science in a technology-supported classroom setting and were analysed for determining the reliability and validity of the TROFLEI questionnaire for use in Indian settings. Three indices for scale reliability and validity were generated for both the Actual and Preferred Forms separately. The Cronbach alpha reliability coefficient was used as an index of scale internal consistency indicating the consistency of the test items relative to other test items which are designed to measure the same construct of interest. A coefficient of 0.00 indicates a complete absence of a relationship, whereas 1.00 is the maximum possible coefficient that can be obtained (Fraenkel & Wallen, 2000). Analysis of variance (ANOVA) results were used as evidence of the ability of each scale in the Actual Form to differentiate between the perceptions of students in different classrooms. A discriminant validity index (namely, the mean correlation of a scale with other scales) was used as evidence that each TROFLEI scale measures a separate dimension that is distinct from the other scales in this questionnaire.

Before determining the reliability and validity of the instrument it would be worthwhile to mention that the modified form of the TROFLEI used in this study involved the development of a new scale, i.e. Technology Teaching and since this scale is being used for the first time, its inter-correlations with other TROFLEI scales will give an impression of its strong association and 'belongingness' in the instrument. Table 4.1 illustrates the inter-correlations between the nine scales of TROFLEI. It is evident that all the scales are positively correlated with each other and that the inter-correlations are significant ($p<0.001$).This shows that the new scale of Technology Teaching is in harmony with other scales and will contribute to the study of technology-supported learning environments in science classrooms. The new scale has correlation values ranging from 0.32 with the Student Cohesiveness and the Differentiation scales to 0.46 for the Task Orientation scale.

Table 4.1

Inter Scale Correlations for the Modified Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI).

	SC	TS	IN	TO	IV	CO	EQ	DI	TT
Student Cohesiveness (SC)		0.46*	0.51*	0.50*	0.44*	0.52*	0.49*	0.22*	0.32*
Teacher Support (TS)			0.62*	0.45*	0.46*	0.49*	0.51*	0.34*	0.42*
Involvement (IN)				0.49*	0.56*	0.57*	0.49*	0.37*	0.34*
Task Orientation (TO)					0.56*	0.55*	0.56*	0.31*	0.46*
Investigation (IV)						0.58*	0.52*	0.43*	0.45*
Cooperation (CO)							0.59*	0.39*	0.39*
Equity (EQ)								0.32*	0.41*
Differentiation (DI)									0.32*
Technology Teaching (TT)									

* Significant at $p < 0.01$ n = 705

The results of the three statistical indices are reported in Table 4.2. The scale reliability estimates for the different scales of the TROFLEI using the individual student as the unit of analysis ranged from 0.67 for the Student Cohesiveness scale to 0.85 for the Equity scale in the Actual Form and from 0.70 for the Differentiation scale to 0.86 for the Technology Teaching scale in the Preferred Form. These indices of reliability are comparable to those in past studies that have used the WIHIC (Aldridge & Fraser, 2000; Fraser & Chionh, 2000) and the TROFLEI (Aldridge, Dorman & Fraser, 2004; Aldridge & Fraser, 2003; Kerr, 2006). The reliability results of the TROFLEI were consistently above 0.50 suggesting that the TROFLEI can be considered a reliable tool (De Vellis, 1991) with this sample of Indian school students.

Table 4.2

Internal Consistency Reliability (Cronbach Alpha Coefficient), Discriminant Validity (Mean Correlation with Other Scales) and Ability to Differentiate between Classrooms (ANOVA Results) for the Modified TROFLEI

Scale Name	No. of Items	Alpha Reliability		Mean Correlation with other scales		ANOVA eta^2
		Act.	Pref.	Act.	Pref.	
Student Cohesiveness (SC)	8	0.67	0.76	0.43	0.44	0.14*
Teacher Support (TS)	8	0.79	0.75	0.47	0.47	0.23*
Involvement (IN)	8	0.80	0.82	0.49	0.51	0.11*
Task Orientation (TO)	8	0.78	0.83	0.48	0.54	0.14*
Investigation (IV)	8	0.82	0.84	0.50	0.54	0.16*
Cooperation (CO)	8	0.82	0.82	0.51	0.55	0.09*
Equity (EQ)	8	0.85	0.84	0.49	0.52	0.14*
Differentiation (DI)	8	0.68	0.70	0.34	0.34	0.13*
Technology Teaching (TT)	8	0.84	0.86	0.39	0.47	0.21*

* Significant at $p<0.001$ n = 705
Act. Means Actual and Pref. means Preferred
The eta^2 statistics (which is the ratio of 'between' to 'total' sum of squares) represents the proportion of variance explained by class membership.

Using the individual as the unit of analysis, the discriminant validity results (mean correlation of a scale with other scales) for the nine scales of the TROFLEI ranged from 0.34 for the Differentiation scale to 0.51 for the Cooperation scale in the Actual

Form and between 0.34 for the Differentiation scale to 0.55 for the Cooperation scale in the Preferred Form (Table 4.2). The analysis of variance (ANOVA) was used to determine the ability of the actual version of each TROFLEI scale to differentiate between the perceptions of students in different classes. The one-way ANOVA for each scale involved class membership as the independent variable and the individual student as the unit of analysis. Table 4.2 reports the ANOVA results showing that all nine of the TROFLEI scales differentiate significantly between classes ($p<0.001$). Thus, students within the same class perceive the environment in a relatively similar manner, while the within-class mean perceptions of the students vary between classes. The eta^2 statistic (an estimate of the strength of association between class membership and the dependent variable) ranges from 0.09 for the Cooperation scale to 0.23 for the Teacher Support scale. Figure 4.1 represents the Cronbach alpha reliability scores of the Actual and Preferred Forms of the TROFLEI in a graphical form.

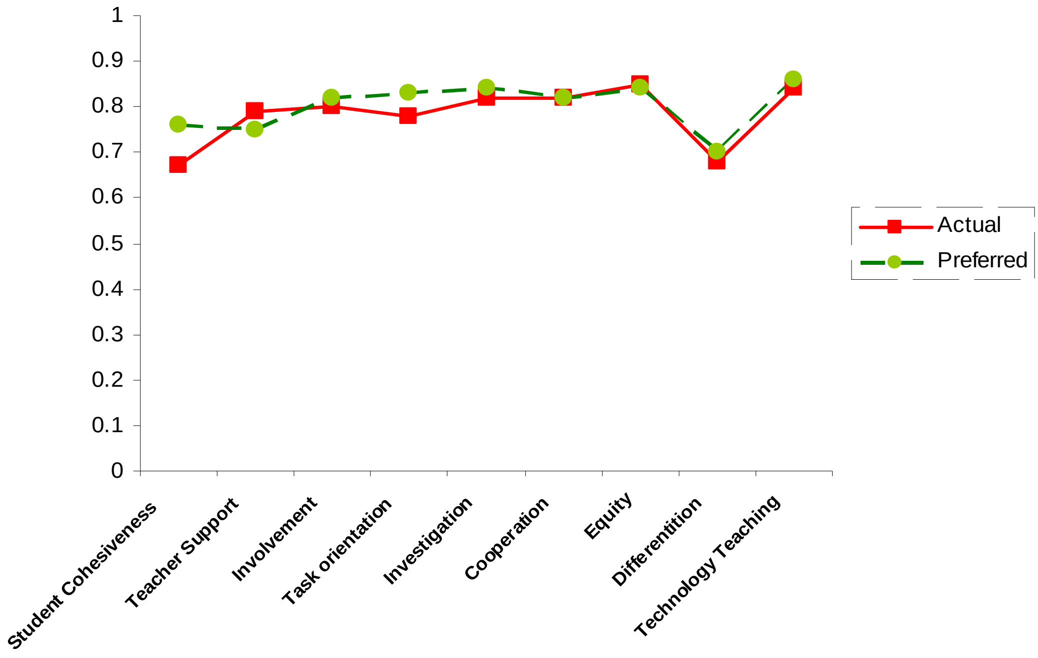


Figure 4.1. Cronbach alpha reliability of the Actual and Preferred Forms of the TROFLEI.

In order to further validate the modified TROFLEI questionnaire in the Indian setting, factor analysis was carried out on the data collected. Principal components factor analysis followed by varimax rotation confirmed a refined structure of the Actual and Preferred Forms of the TROFLEI comprising of 72 items in nine scales.

Nearly all of the 72 items have a loading of at least 0.35 on their *a priori* scale for the actual version (see Table 4.3). From the data in Table 4.3 it can be seen that item two and eight from The Student Cohesiveness scale, item 13 from the Teacher Support scale and item 23 from the Involvement scale did not load at 0.35 or above on their own or any other scale. The cumulative percentage variance extracted with each factor is also illustrated at the bottom of Table 4.3 and was found to be 44.18%.

The overall loadings confirmed the factor structure of the TROFLEI. In general, the results are similar to the previous cross-validations of the TROFLEI instrument in Australia (Aldridge, Dorman & Fraser, 2004; Aldridge & Fraser 2003). The results confirmed that the modified version of the TROFLEI could be used with confidence in technology-supported science classrooms in Indian settings.

Table 4.3

Factor Loadings for the Modified Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI)

Item No.	SC	TS	IN	TO	IV	CO	EQ	DI	TT
1	0.55								
2	-								
3	0.59								
4	0.50								
5	0.56								
6	0.52								
7	0.50								
8	-								
9		0.64							
10		0.66							
11		0.60							
12		0.42							
13		-							
14		0.67							
15		0.56							
16		0.40							
17			0.41						
18			0.56						
19			0.39						
20			0.49						
21			0.56						
22			-						
23			0.39						
24			0.35						
25				0.45					
26				0.42					
27				0.48					

28				0.53					
29				0.57					
30				0.63					
31				0.51					
32				0.51					
33					0.54				
34					0.54				
35					0.54				
36					0.51				
37					0.54				
38		0.36			0.50				
39					0.62				
40					0.46				
41						0.56			
42						0.51			
43						0.58			
44						0.51			
45						0.56			
46						0.59			
47						0.51			
48						0.47			
49				0.37			0.41		
50							0.57		
51							0.56		
52							0.63		
53							0.69		
54							0.63		
55							0.64		
56							0.63		
57								0.53	
58								0.35	
59								0.44	
60								0.66	
61								0.36	
62								0.64	
63								0.69	
64								0.67	
65									0.58
66									0.58
67									0.62
68									0.68
69									0.67
70									0.64
71									0.63
72									0.67
Cumulative % Variance	3.69	8.63	12.34	18.34	23.58	28.69	34.70	38.58	44.18

Factor Loadings smaller than 0.35 have been omitted. n = 705

4.2.1 Summary

The statistics obtained for the internal consistency (alpha reliability), the discriminant validity (mean correlation with other scales) and the ability of each scale to differentiate between the perceptions of the students in different classrooms (eta^2 statistic from ANOVA) can be considered acceptable. The data presented in Table 4.2, along with the factor analysis results in Table 4.3, indicate that the TROFLEI is a valid and reliable classroom environment instrument for the assessment of students' perceptions of their psychosocial environments in a technology-supported science classroom in Indian settings. Another important inference that can be drawn from the various statistical treatments is that the new scale of Technology Teaching that has been developed in the modified TROFLEI has shown significant associations with other scales of the instrument. Also the scales were able to distinguish between the classrooms as the eta^2 were statistically significant. The items of the scale also loaded well in the factor analysis and contributed towards the refined structure of the modified TROFLEI instrument.

4.3 VALIDATION OF THE QTI

The students' form of the Questionnaire on Teacher Interaction (QTI) was administered to 705 students, in 15 classes in a school in Jammu, who had studied science in a technology-supported learning environment to assess the student's perceptions of their interpersonal relationship with their teachers and also to understand teacher's behaviour in a technology-supported environment. In order to determine the reliability and validity of the QTI, three statistical computations were done. The first being the Cronbach alpha coefficient (Cronbach, 1951) which is a measure of internal consistency and analysis of variance (ANOVA) as an evidence of the ability of each scale to differentiate between the perceptions of students in different classrooms along with eta^2 statistics, which provides an estimate of the strength of the association between class membership and the dependent variable. The third involved checking the circumplex nature of the QTI.

The statistical data for the QTI are presented in Table 4.4. The alpha reliability coefficients for the different scales of QTI using the individual as a unit of analysis ranged from 0.51 for the Strict scale to 0.79 for the Leadership scale. However, for the scale of Admonishing the alpha reliability coefficient reported a score of 0.53 which when recomputed after deleting of an item changed to 0.66. The item deleted for computation purposes was number 12, i.e., ‘This teacher is too quick to correct us when we break a rule’. This item was then deleted in the application of the QTI in the research described in the thesis. The reliability results of the QTI were consistently above 0.50. This suggested that the QTI could be used as a reliable tool (De Vellis, 1991) in Indian classroom settings.

Table 4.4 reports the ANOVA results showing all the eight QTI scales differentiate significantly between classes ($p<0.001$, $p<0.01$). The eta^2 statistic for the QTI indicates the amount of variance in scores accounted for by class membership has also been indicated in Table 4.4. The scores ranged from 0.05 for the Dissatisfied scale to 0.23 for the Student Responsibility/ Freedom scale which shows that the QTI instrument is able to differentiate between students’ perceptions in different classrooms. Figure 4.2 represents the alpha reliability scores on the QTI in a graphical manner.

Table 4.4

Internal Consistency Reliability (Cronbach Alpha Coefficient) and Ability to Differentiate between Classrooms (ANOVA Results) for the QTI.

Scale Name	No. of Items	Alpha Reliability		ANOVA eta^2
		Before	After	
Leadership (DC)	6		0.79	0.19^{**}
Helping / Friendly (CD)	6		0.73	0.11^{**}
Understanding (CS)	6		0.68	0.14^{**}
Student Responsibility / Freedom (SC)	6		0.57	0.23^{**}
Uncertain (SO)	6		0.68	0.17^{**}
Dissatisfied (OS)	6		0.68	0.05^{*}
Admonishing (OD)	6	0.53	0.66	0.09^{**}
Strict (DO)	6		0.51	0.11^{**}

** Significant at $p<0.001$ * Significant at $p<0.01$
Bef. : Before Deleted Item Aft.: After Deleted Item n = 705
Admonishing scale: deleted item 3

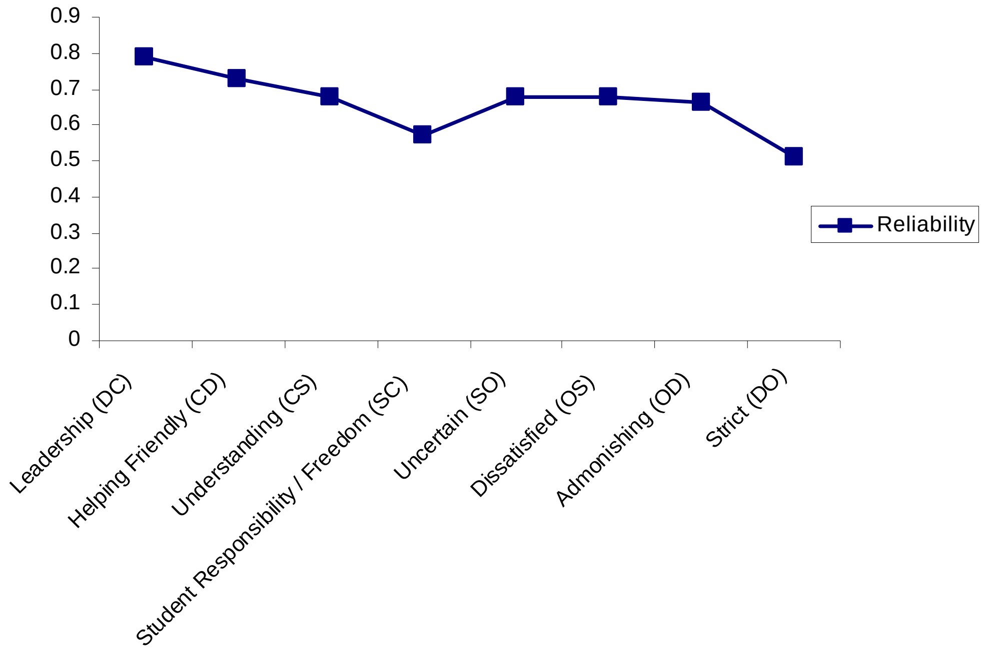


Figure 4.2. Cronbach alpha reliability scores on the QTI.

A further analysis was also carried out to explore the inter-scale correlations between the different scales of the QTI. The QTI is based on a circumplex model in which the scales are arranged to form a circular pattern of the eight dimensions of interpersonal behaviour and they are expected to be correlated.

The Model of Interpersonal Behaviour (Wubbels & Levy, 1993) as explained in Chapter 2, predicts that the correlations between two adjacent scales are highest, but correlations gradually decrease as the scales move further apart until opposite scales are negatively correlated. This pattern is reflected in Table 4.5 where the results of the inter-scale correlations from the study generally reflect the circumplex nature of the QTI and thus further confirms the validity of QTI to be used in Indian classroom settings.

Table 4.5

Inter Scale Correlations for the Questionnaire on Teacher Interaction (QTI)

	Lea DC	HFr CD	Und CS	SRf SC	Unc SO	Dis OS	Adm OD	Str DO
Leadership (DC)		0.61**	0.70**	0.32**	-0.10*	-0.17**	-0.27**	0.34**
Helping / Friendly (CD)			0.59**	0.41**	-0.12**	-0.17**	-0.24**	0.30**
Understanding (CS)				0.24**	-0.16**	-0.21**	-0.31**	0.22**
Student Responsibility / Freedom (SC)					0.30**	0.22**	0.16**	0.26**
Uncertain (SO)						0.54**	0.58**	0.19**
Dissatisfied (OS)							0.58**	0.19**
Admonishing (OD)								0.16**
Strict (DO)								

** Significant at $p<0.001$ * Significant at $p<0.01$

n = 705.

Based on the above data, Figure 4.3 illustrates the circumplex model, as it relates to the Understanding scale.

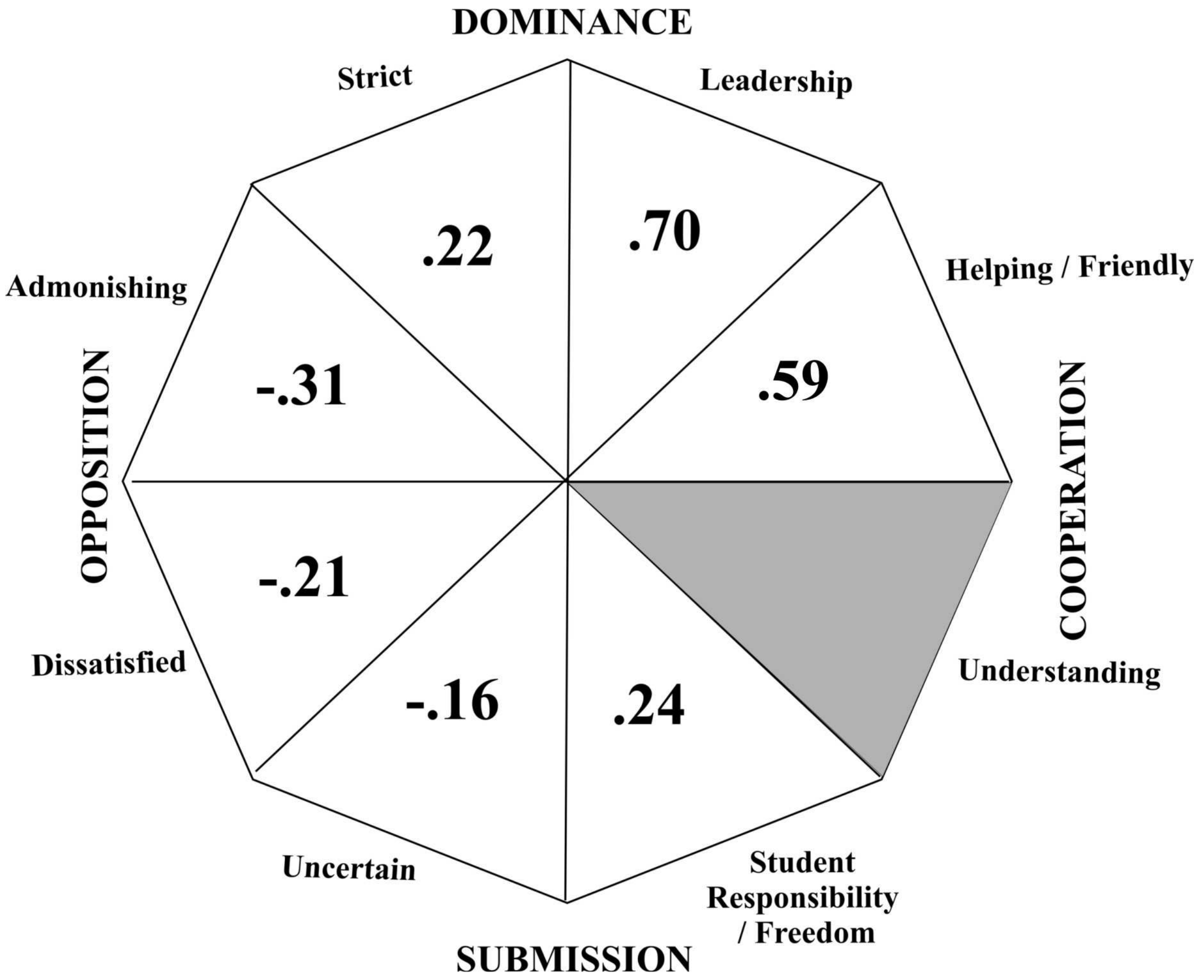


Figure 4.3. Correlation of Understanding Scale with other QTI scales showing the circumplex model

The Understanding scale is highly correlated to its neighbouring scales, Student Responsibility/Freedom which has a correlation of 0.24 and 0.59 with the Helping/ Friendly scale. The correlation becomes lower with the next scale Uncertain which is negatively correlated with a score of -0.16. As the scales move further apart correlations with Dissatisfied and Admonishing also become negative with scores of -0.21 and -0.31. The maximum negative correlation is with the opposite scale of Admonishing. Generally, the findings in this study support the circumplex model of QTI and hence validate it for use in Indian schools teaching science through the technology-supported classroom.

4.4 VALIDATION OF ATTITUDE AND EFFICACY SCALE

To measure students' attitude towards the subject and their academic efficacy data were collected on two scales, namely, the Attitude Towards Science and Academic Efficacy scales. There were in all 16 items with eight items in each scale. The data on these two scales were collected from a sample of 705 students in 15 classes. The internal consistency reliability (Cronbach alpha coefficient) for the two scales was computed with the individual as the unit of analysis. The results are shown in Table 4.6.

Table 4.6

Internal Consistency Reliability (Cronbach Alpha Coefficient) for the Attitude Towards Science and Academic Efficacy Scales.

Scale Name	No. of Items	Alpha Reliability
Attitude Towards Science	8	0.64
Academic Efficacy	8	0.66

n=705

The scale reliability for the Attitude Towards Science scale is 0.64 and for the Academic Efficacy scale is 0.66. The reliability results of the two scales were both above 0.50. This suggested that these scales could be used as reliable tools (De Vellis, 1991) in Indian classroom settings to study the attitude of students and their academic efficacy.

4.5 CHAPTER SUMMARY

This chapter has presented the scores from the quantitative data analysis of the TROFLEI and the QTI questionnaires. The reliability and validity of the two questionnaires has been established and they have been found to be reliable and valid tools for assessing the learning environments of the technology-supported science classrooms and teacher interpersonal behaviour. The principal component factor analysis confirms the factor structure of the TROFLEI and the circumplex model of the QTI was also established which was consistent with other similar studies using the TROFLEI and the QTI, as reported in Chapter 2 of this thesis. The new scale of Technology Teaching has also been found to be in harmony with other scales of the modified TROFLEI. The reliabilities of the Attitude Towards Science and the Academic Efficacy scale were also established and were reported to be high. The next chapter examines the quantitative results related to other variables in response to the research objectives of the present study.

CHAPTER 5

ANALYSIS OF RESULTS

5.1 INTRODUCTION

This chapter describes the results from the quantitative analysis of data obtained through the administration of the learning environments questionnaire TROFLEI which measures the perceptions of students' towards their technology-supported learning environments and the teacher-student interaction questionnaire QTI, which measures students' perceptions of their interaction with their science teachers in a technology-supported environment. Data analysis of the Attitude Towards Science scale and the Academic Efficacy scale is discussed. Results of the associations of the TROFLEI and the QTI with the three student outcomes, i.e. attitude towards science, academic efficacy and academic achievement are also reported in this chapter. Gender differences in relation to the technology-supported learning environments, perception of teacher-student interactions and attitude, efficacy and achievement scores are also presented. Lastly, the reactions of the students towards the technology-supported classrooms have been assessed and results reported in terms of percentage of responses.

5.2 MEANS AND STANDARD DEVIATIONS ON THE TROFLEI

The data on the nine scales of the TROFLEI were collected from 705 students in 15 classrooms who have been studying science through a technology-supported classroom setting. Item means and standard deviations were computed to determine the nature of a technology-supported science classroom learning environment using the TROFLEI. The statistical significance of the difference between means (t-test) was also calculated to study whether the differences in the means of the Actual and Preferred Forms of the TROFLEI when used in a technology-supported classroom setting were significant. The data obtained are presented in Table 5.1.

In Table 5.1 it can be seen that the mean scores of the different scales of the TROFLEI ranged from 3.33 for the Involvement scale to 4.14 for the Technology Teaching scale in the Actual Form which shows that students were generally able to perceive technology-supported science teaching as beneficial for them and technology was being used quite often in the day-to-day teaching of science in the school. An examination of the mean scores in the Preferred Form of the TROFLEI shows that the mean score ranged from 3.73 for the Differentiation scale to 4.49 for the Technology Teaching scale. This indicates that students usually want more of technology-supported science teaching in their classroom. The values of the standard deviations in both the Actual and Preferred Form of the TROFLEI are less than 1, which suggests that there are no major deviations in students' perceptions of the technology-supported learning environment in their science classrooms.

The results for the paired t-tests indicated that there is a significant difference ($p<0.001$) between the actual and preferred means for all the scales which shows that students' preferred learning environments that have more student cohesiveness, more support from the teacher than what is being provided at present, more involvement in classroom activities, more task orientation, develop more investigative ability than what students perceive they have at present, more of cooperation in learning with other students in the class, more equity and more technology-based teaching of science in the classroom. Although, all the scales of the TROFLEI show a good response from the students, the main objective is to improve the existing learning environments in the technology-supported science classroom and the information from the students' perceptions of their preferred learning environments gives us vital clues towards the areas that require our immediate focus for further improvement.

Table 5.1

Means, Standard Deviations (SD) and Significance of Difference between Means (t) for the Modified TROFLEI.

Scale Name	No. of Items	Mean		Standard Deviation(SD)		t
		Act.	Pref.	Act.	Pref.	
Student Cohesiveness	8	3.91	4.26	0.55	0.61	17.22*
Teacher Support	8	3.38	4.00	0.74	0.67	24.84*
Involvement	8	3.33	3.90	0.69	0.69	23.22*
Task Orientation	8	4.08	4.41	0.58	0.60	17.43*
Investigation	8	3.56	4.11	0.71	0.70	21.59*
Cooperation	8	3.75	4.18	0.70	0.67	20.31*
Equity	8	3.78	4.30	0.76	0.66	19.44*
Differentiation	8	3.35	3.73	0.66	0.70	17.54*
Technology Teaching	8	4.14	4.49	0.64	0.59	19.13*

* Significant at $p<0.001$
n = 705

Figure 5.1 represents the mean scores on the Actual and Preferred Forms of TROFLEI in a graphical form.

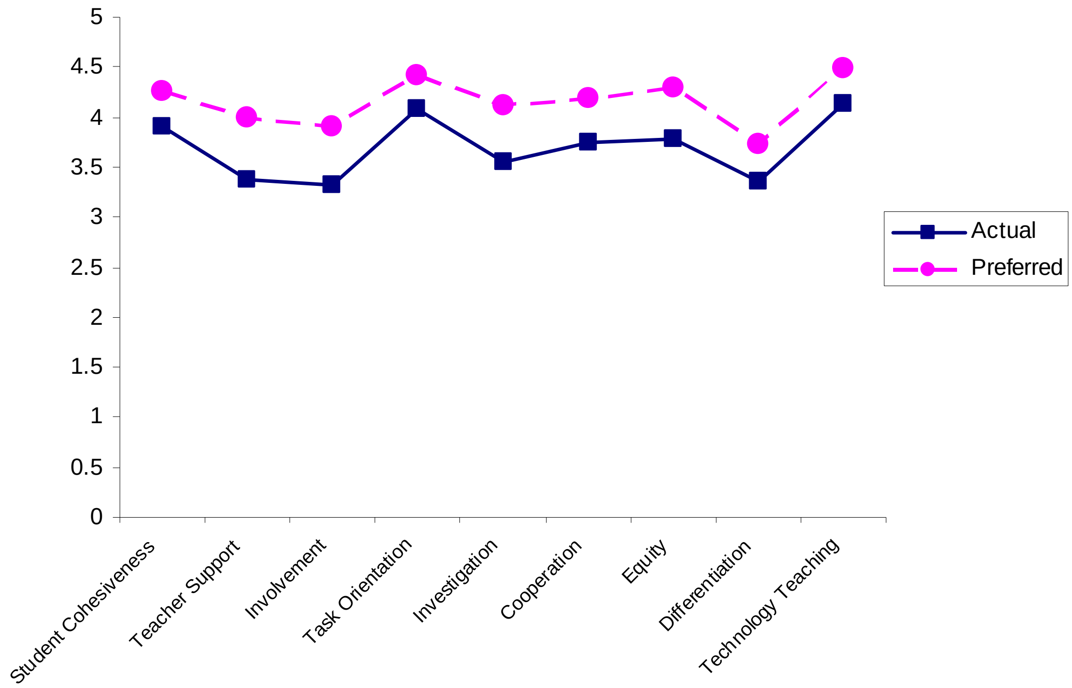


Figure 5.1. Mean scores of the Actual and Preferred Forms of the TROFLEI.

5.3 MEANS AND STANDARD DEVIATIONS ON THE QTI

The data for the descriptive statistics concerning QTI were collected from 705 students in 15 classrooms and the values of means and standard deviations are given in Table 5.2. The highest mean value is 4.05 for the Leadership scale and the least value is 2.47 for the Admonishing scale. Figure 5.2 represents the means scores of the eight scales of the QTI in a graphical manner.

Table 5.2

Means and Standard Deviations for the QTI.

Scale Name	No. of Items	Mean	S.D
Leadership (DC)	6	4.05	0.72
Helping / Friendly (CD)	6	3.63	0.80
Understanding (CS)	6	3.87	0.71
Student Responsibility / Freedom (SC)	6	3.10	0.68
Uncertain (SO)	6	2.53	0.79
Dissatisfied (OS)	6	2.72	0.81
Admonishing (OD)	6	2.47	0.84
Strict (DO)	6	3.46	0.66

n = 705

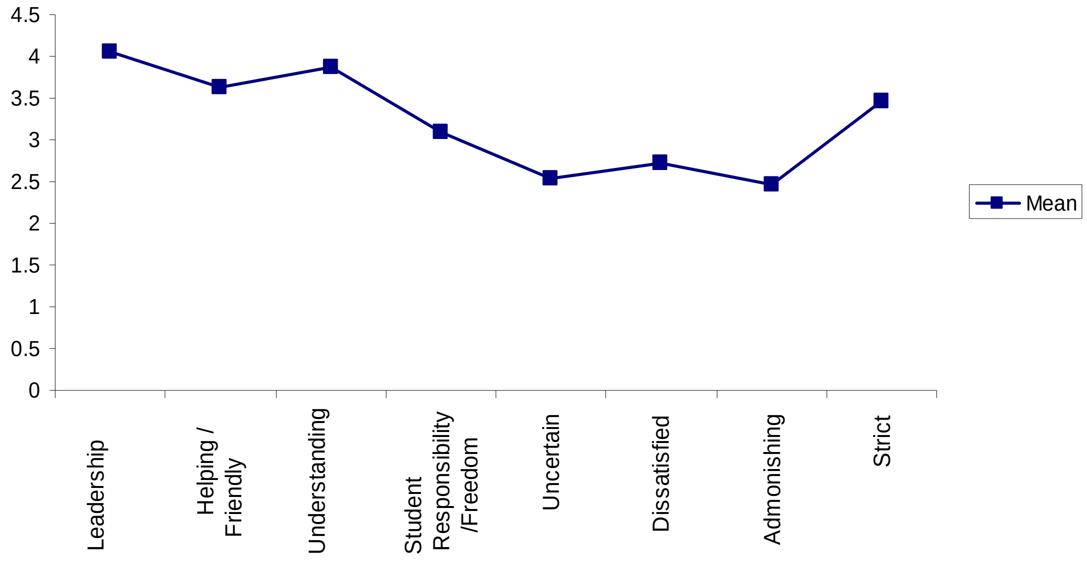


Figure 5.2. Mean scores on the eight scales of the QTI.

The overall analysis of the above results shows that the students see their teachers as good leaders most of the time and have also rated their teachers in terms of exhibiting helpful and friendly nature, understanding and giving students freedom and responsibility in the classroom. In fact, the positive factors have been exhibited by the teachers quite often in the classroom. One interesting feature of the analysis is that students perceive their teachers to be strict which is acceptable in India as a teacher is in charge of a class and gives direction to the students in various academic matters. Also, the negative aspects of the teacher-student interaction have been rated quite low by the students as teachers seldom exhibit admonishing behaviour, are less dissatisfied and less uncertain. This shows that the technology-supported classroom environment may help in creating a healthy teacher-student interpersonal relationship and promote positive behaviour. Figure 5.3 represents a sector profile depicting student's perception of the teacher-student interpersonal behaviour in the technology-supported science classroom in an Indian school which was developed by plotting the mean scores of the eight scales of the QTI (student questionnaire) in an excel worksheet. The sector profile reveals diagrammatically the degree to which students perceive each behavioural aspect exhibited by the teacher as measured through the QTI.

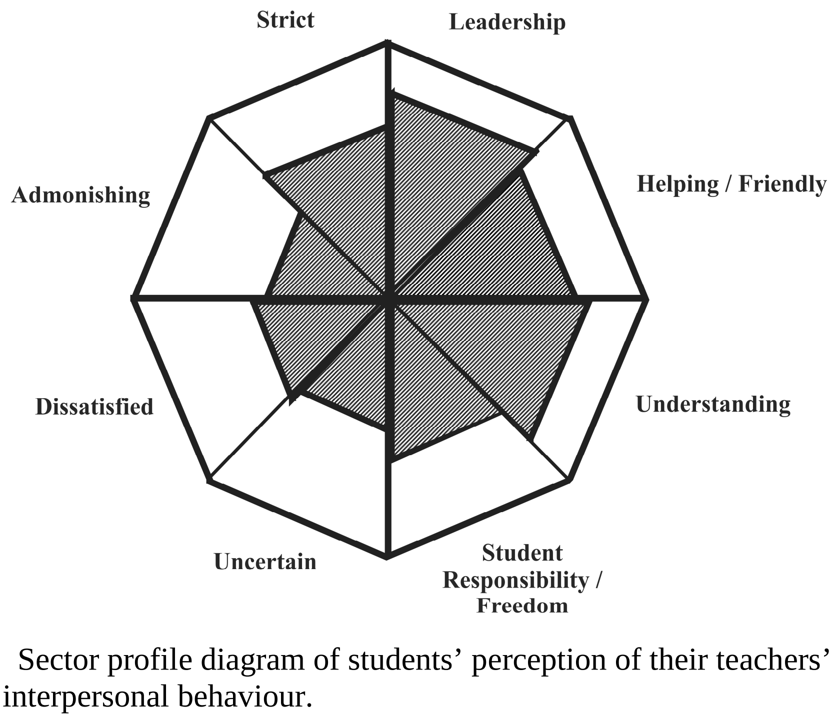


Figure 5.3. Sector profile diagram of students' perception of their teachers' interpersonal behaviour.

From Table 5.2 we can see that the standard deviation ranges from 0.66 for the Strict scale to 0.84 for the Admonishing scale. Since the values of the standard deviation are less than 1.00, it suggests that there is no major diversity in students' perceptions.

5.4 MEANS AND STANDARD DEVIATIONS ON ATTITUDE AND EFFICACY SCALE

From the data collected for the attitude and efficacy scales, the value of the mean for the Attitude Towards Science is 4.0 and that for Academic Efficacy is 3.48 (see Table 5.3). The high mean scores point toward the fact that generally students exhibited a positive attitude towards science when taught in a technology-supported learning environment and that the mean score on the efficacy scale shows that the students feel that they are successful when studying science in a technology-supported classroom.

Table 5.3

Means and Standard Deviations for the Attitude towards Science and Academic Efficacy Scale.

Scale Name	Mean	Standard Deviation
Attitude towards Science	4.0	0.64
Academic Efficacy	3.48	0.57

n = 705

5.5 INVESTIGATION OF THE TROFLEI AND QTI ASSOCIATIONS WITH STUDENT OUTCOMES

5.5.1 Introduction

As outlined in Research Questions three and four of the present study, it was to be investigated whether there are any associations between students' perceptions of their technology-supported learning environment and their perceptions of the teacher-student interactions with their attitude towards science, academic efficacy and academic achievement. In order to carry out these investigations, simple and multiple correlation analyses along with the calculation of regression coefficients were conducted between the nine classroom environment scales of TROFLEI, the eight interpersonal behaviour scales of the QTI and three student outcomes of attitude towards science, academic efficacy and academic achievement (the score obtained by the student in the annual examination at the end of the academic year). The simple correlation was conducted to provide information about the bivariate association between each learning environment scale and each student outcome. A multiple correlation analysis of relationships between each outcome and the TROFLEI and QTI scales was conducted to provide a more complete picture of the joint influence of correlated environment dimensions on outcomes and to reduce the Type I error rate associated with the simple correlation analysis. To understand which individual scale makes the largest contribution to explaining variance in student attitudes, the regression coefficients were examined to see which ones were statistically significant ($p<0.05$). The regression coefficient values describe the influence of a particular environment variable on an outcome when all other environment variables in the regression analysis are mutually controlled. These associations are discussed in this chapter, first for the TROFLEI and then for the QTI.

5.6 ASSOCIATIONS WITH THE TROFLEI

5.6.1 Association of Students' Perception of the Technology-Supported Learning Environment with Attitude Towards Science

Students' perception of their technology-supported learning environment and its association with their attitude towards science was explored using simple and multiple correlation analysis, followed by computation of the regression coefficient. The results of these analyses are shown in Table 5.4, which gives a clear picture indicating significant associations between technology-supported learning environments and student outcomes.

Table 5.4

Associations between the TROFLEI Scales and Attitude Towards Science in terms of Simple Correlation (r), Multiple Correlation (R) and Standardised Regression Coefficient (β).

Scale Name	Attitude Towards Science	
	r	*β*
Student Cohesiveness	0.24**	0.00
Teacher Support	0.26**	0.05
Involvement	0.20**	-0.07
Task Orientation	0.42**	0.30***
Investigation	0.31**	0.10*
Cooperation	0.23**	-0.10
Equity	0.34**	0.15**
Differentiation	0.09*	-0.11**
Technology Teaching	0.40**	0.20***
Multiple Correlation	R = 0.50***	
	R^2 = 0.23	

*** Significant at p<0.001, ** Significant at p<0.01, * Significant at p<0.05
n = 705 students

The results from Table 5.4 indicate that for simple correlation (r) all the nine scales of TROFLEI are statistically significantly and positively associated with student attitudes towards their class ($p<0.01$, $p<0.05$) at the individual level of analysis. The values of correlation range from 0.09 for the Differentiation scale to 0.42 for the Task Orientation scale. Another important inference that can be drawn is that students' attitudes towards science is significantly correlated in a positive direction with the Technology Teaching scale with a value of 0.40, which tells us that the use of technology in teaching science has a positive effect on student attitudes.

The multiple correlation (R) between students' perceptions as measured by the different scales of the TROFLEI and the Attitude Toward Science scale (see Table 5.4) is 0.50 at the individual level of analysis, which is statistically significant ($p<0.001$). The R^2 value indicates that 23 percent of the variance in the students' attitude towards science can be attributed to the technology-supported learning environment and thus the better the learning environment the more positive are the students' attitudes towards science. Standardized regression values were calculated to provide information about the unique contribution of each learning environment scale to the Attitude Towards Science scale. Regression coefficient values (β) indicate (see Table 5.4) that five of the nine TROFLEI scales uniquely account for a significant ($p<0.001$, $p<0.01$, $p<0.05$) amount of variance in student attitudes towards science; these are Task Orientation, Investigation, Equity, Differentiation and Technology Teaching. The β values for the significantly associated scales ranged from -0.11 for the Differentiation scale to 0.30 for the Task Orientation scale. Although the Differentiation scale has a significant association with the attitude scale, it is negatively associated. This means that the influence of the differentiation environment variable is opposite to student's attitude towards science, i.e. the greater the differentiation perceived by the students in the classroom, the poorer their attitude towards the subject. From the point of view of this study, it is pertinent to note that the Technology Teaching scale is positively associated with the attitude scale and has a value of 0.20 which is significant ($p<0.001$). This again shows that the technology-supported learning environment has a healthy relationship with development of a positive attitude towards science, which in fact is the aim of this study.

5.6.2 Association of Students' Perception of the Technology-Supported Learning Environment with Academic Efficacy

Simple (*r*) and multiple correlation (*R*) along with computation of the regression coefficient (*β*) were used to study the associations between the students' perception of their technology-supported learning environments as measured by the TROFLEI and their academic efficacy. Table 5.5 illustrates the results of the statistical analysis.

Table 5.5

Associations between the TROFLEI Scales and Academic Efficacy in terms of Simple Correlation (r), Multiple Correlation (R) and Standardised Regression Coefficient (β).

Scale Name	Academic Efficacy	
	r	*β*
Student Cohesiveness	0.32**	0.02
Teacher Support	0.40**	0.06
Involvement	0.42**	0.14**
Task Orientation	0.44**	0.20***
Investigation	0.44**	0.11*
Cooperation	0.40**	-0.03
Equity	0.35**	-0.01
Differentiation	0.36**	0.14***
Technology Teaching	0.43**	0.21***
Multiple Correlation	*R* = 0.60***	
	R^2 = 0.33	

*** Significant at $p<0.001$, ** Significant at $p<0.01$, * Significant at $p<0.05$
n = 705.

The results from Table 5.5 indicate that for simple correlation (*r*) all the nine scales of TROFLEI are statistically significantly and positively associated with students' academic efficacy ($p<0.01$) at the individual level of analysis. The values of correlation range from 0.32 for the Student Cohesiveness scale to 0.44 for the Task Orientation and Investigation scales. Another important inference that can be drawn is that Academic Efficacy is significantly correlated in a positive direction with the Technology Teaching scale with a value of 0.43 which is highly significant ($p<0.01$). This tells us that the use of technology in teaching science could improve the students' beliefs in their own efficiency and effectiveness in science.

The multiple correlation (*R*) between students' perceptions as measured by the different scales of the TROFLEI and the Academic Efficacy Scale (see Table 5.5) is 0.60 at the individual level of analysis, which is statistically significant ($p<0.001$). The R^2 value indicates that 33 percent of the variance in the students' academic efficacy can be attributed to the technology-supported learning environment. Standardized regression values were calculated to provide information about the unique contribution of each learning environment scale to the Academic Efficacy scale. Regression coefficient values (β) indicate (see Table 5.5) that five of the nine TROFLEI scales uniquely account for a significant ($p<0.001$, $p<0.01$, $p<0.05$) amount of variance in academic efficacy; these are Involvement, Task Orientation, Investigation, Differentiation and Technology Teaching. The β values for the significantly associated scales ranged from 0.11 for the Investigation scale to 0.21 for the Technology Teaching scale, which is the highest value and is significant at $p<0.001$. All the β values are positive. Again from the data it is clear that the technology-supported learning environment in a science classroom has a positive effect on the academic efficacy of the students.

5.6.3 Association of Students' Perception of the Technology-Supported Learning Environment with Academic Achievement

The association between the academic achievement of the students and their perception of technology-supported learning environments as measured using TROFLEI was also studied using simple and multiple correlations. The statistical results are presented in Table 5.6.

Table 5.6

Associations between the TROFLEI Scales and Academic Achievement in terms of Simple Correlation (r), Multiple Correlation (R) and Standardised Regression Coefficient (β).

Scale Name	Academic Achievement	
	r	*β*
Student Cohesiveness	0.20**	0.10
Teacher Support	0.14**	0.00
Involvement	0.11**	-0.04
Task Orientation	0.23**	0.12*
Investigation	0.20**	0.10*
Cooperation	0.11**	-0.11*
Equity	0.20**	0.10
Differentiation	-0.01	-0.15***
Technology Teaching	0.30**	0.20***
Multiple Correlation	$R = 0.34$***	
	$R^2 = 0.12$	

*** Significant at $p<0.001$, ** Significant at $p<0.01$, * Significant at $p<0.05$
n = 705

The data illustrated in Table 5.6 indicate that for simple correlation (*r*) eight out of the nine scales of the TROFLEI are statistically significantly and positively associated with students' academic achievement ($p<0.01$) at the individual level of analysis. The values of correlation ranged from 0.11 for the Involvement and Cooperation scales to 0.30 for the Technology Teaching scale. Thus academic achievement is significantly correlated in a positive direction with the Technology Teaching scale with a value of 0.30, which implies that a technology-supported science classroom may help improve the academic achievement of the students in terms of their performance in the examination and attainment of knowledge.

The multiple correlation (*R*) between students' perceptions as measured by the different scales of TROFLEI and the Academic Achievement Scale (as seen in Table 5.6) is 0.34 at the individual level of analysis, which is statistically significant ($p<0.001$). The R^2 value indicates that 12 percent of the variance in the students' academic achievement can be attributed to the technology-supported learning environment. Standardized regression values were calculated to provide information about the unique contribution of each learning environment scale to the Academic Achievement scale. Regression coefficient values (β) (as given in Table 5.6) indicate that five of the nine TROFLEI scales uniquely account for a significant ($p<0.001$, $p<0.01$, $p<0.05$) amount of variance in academic achievement. These are Task Orientation, Investigation, Cooperation, Differentiation and Technology Teaching. The β values for the significantly associated scales ranged from -0.11 for the Cooperation scale to 0.20 for the Technology Teaching scale, which is the highest value and is significant at $p<0.001$. The data show that the values of the Cooperation and Differentiation scales are negative which implies that these two scales influence the academic achievement negatively. This is somewhat understandable, especially within the Indian classroom settings, as the pressure on achieving in the examination is on the individual student and they would not like to cooperate academically with other students in the same classroom for fear of decreasing their grades. Also, the teachers who differentiate a lot in the classroom may give an idea to the students that the teacher is being partial or biased in his or her approach towards a selected few. These could be the probable reasons for negative correlations on these two scales. It is again evident from the data that the technology-supported learning environment in a science classroom may help in improving the academic achievement of the students as both the correlation and regression coefficients have a positive and significant association with the academic achievement scores.

5.6.4 Summary

From study of the statistical analysis of associations between the students' perception of their technology-supported learning environment and their attitude towards science, academic efficacy and academic achievement it is clear that technology-supported learning environments have a positive and significant association with the three student outcomes. This also justifies the development of the new scale of Technology Teaching as it correlates with the three outcomes scales.

5.7 ASSOCIATIONS WITH THE QTI

5.7.1 Association of Students' Perception of their Teacher-Student Interactions with Attitude Towards Science

Associations between the perceptions of teacher-student interactions measured using the QTI and the attitude of students towards science were explored using simple *(r)* and multiple correlations *(R)* followed by the regression analysis between the QTI scales and the Attitude Towards Science scale. The data thus obtained have been presented in Table 5.7. From the data, it can be deduced that out of the eight scales of QTI only six scales have a significant association with the Attitude Towards Science scale. These scales are Leadership, Helping/Friendly and Understanding which have a positive and significant correlation and Uncertain, Dissatisfied and Admonishing which have a negative and significant correlation. The scales with which there is no association are Student Responsibility/Freedom and Strict. The correlations for the significant scales of the QTI range from -0.02 for the Student Responsibility/ Freedom scale to 0.30 for the Leadership scale.

Table 5.7

Associations between the QTI Scales and Attitude Towards Science in terms of Simple Correlation (r), Multiple Correlation (R) and Standardised Regression Coefficient (β).

Scale Name	Attitude Towards Science	
	r	*β*
Leadership	0.30**	0.14**
Helping / Friendly	0.20**	0.01
Understanding	0.25**	0.10
Student Responsibility / Freedom	-0.02	-0.05
Uncertain	-0.20**	-0.04
Dissatisfied	-0.20**	-0.02
Admonishing	-0.30**	-0.16***
Strict	0.04	0.01
Multiple Correlation	R = 0.34***	
	R^2 = 0.12	

*** Significant at p<0.001, ** Significant at p<0.01, * Significant at p<0.05
n = 705

The multiple correlation (R) between students' perceptions as measured by the different scales of the QTI and the Attitude Towards Science Scale (as seen in Table 5.7) is 0.34 at the individual level of analysis, which is statistically significant (p<0.001). The R^2 value indicates that 12 percent of the variance in the students' attitude towards science can be attributed to the students' perception of teacher-student interactions. Standardized regression values were calculated to provide information about the unique contribution of each QTI scale to the Attitude towards Science scale. Regression coefficient values (β) indicate (as given in Table 5.7) that two of the eight QTI scales uniquely account for a significant (p<0.001, p<0.01) amount of variance in attitude towards science, these are Leadership with a value of 0.14 and Admonishing with a value of -0.16. The *β* value for the Admonishing scale is negatively significant which implies that the admonishing behaviour of the teacher will have a negative influence on the attitude of the students towards science. On the other hand, a high score on Leadership suggests that teachers with good and effective leadership qualities in a class may also affect the development of a positive attitude amongst students in a technology-supported learning environment.

5.7.2 Association of Students' Perception of their Teacher-Student Interactions with Academic Efficacy

Simple (*r*) and multiple correlation (*R*) along with the regression coefficient (*β*) were used to study the associations between the students' perception of the teacher-student interactions as measured by the QTI and their academic efficacy. Table 5.8 illustrates the results of the statistical analysis. Computation of data shows that out of the eight scales of QTI only six scales have a significant association with the Academic Efficacy scale. These scales are Leadership, Helping/Friendly, Understanding, Student Responsibility/Freedom and Strict which have a positively significant correlation and Admonishing which has a negatively significant correlation. The scales with which there is no association are Uncertain and Dissatisfied. The correlations for the significant scales of QTI range from -0.08 for the Admonishing scale to 0.23 for the Leadership scale.

The multiple correlation (*R*) between students' perceptions as measured by the different scales of QTI and the Academic Efficacy Scale (as seen in Table 5.8) is 0.26 at the individual level of analysis, which is statistically significant ($p<0.001$). The R^2 value indicates that six percent of the variance in students' academic efficacy can be attributed to the students' perception of their teacher-student interactions. Standardized regression values were calculated to provide information about the unique contribution of each QTI scale to the Academic Efficacy scale. Regression coefficient values (*β*) indicate that two of the eight QTI scales uniquely account for a significant ($p<0.01$, $p<0.05$) amount of variance in academic efficacy, these are Leadership with a value of 0.19 and Student Responsibility/Freedom with a value of

0.11. The β value for these two scales is positively significant which implies that the leadership of the teacher and giving the students some freedom, opportunity and responsibility could go a long way in improving their academic efficacy.

Table 5.8

Associations between the QTI Scales and Academic Efficacy in terms of Simple Correlation (r), Multiple Correlation (R) and Standardised Regression Coefficient (β).

Scale Name	Academic Efficacy	
	r	β
Leadership	0.23**	0.19**
Helping / Friendly	0.18**	0.01
Understanding	0.17**	-0.02
Student Responsibility / Freedom	0.16**	0.11*
Uncertain	-0.00	0.02
Dissatisfied	-0.04	-0.02
Admonishing	-0.08*	-0.05
Strict	0.09*	0.01
Multiple Correlation	$R = 0.26$***	
	$R^2 = 0.06$	

*** Significant at $p<0.001$, ** Significant at $p<0.01$, * Significant at $p<0.05$
n = 705

5.7.3 Association of Students' Perception of their Teacher-Student Interactions with Academic Achievement

Simple (*r*) and multiple correlation (*R*) along with the regression coefficient (*β*) were used to study the associations between the students' perceptions of the teacher-student interactions as measured by the QTI and their academic achievement. Table 5.9 illustrates the results of the statistical computation.

Table 5.9

Associations between the QTI Scales and Academic Achievement in terms of Simple Correlation (r), Multiple Correlation (R) and Standardised Regression Coefficient (β).

Scale Name	Academic Achievement	
	r	*β*
Leadership	0.16**	-0.05
Helping / Friendly	0.16**	-0.03
Understanding	0.23**	0.20***
Student Responsibility / Freedom	0.10*	0.14**
Uncertain	-0.21**	-0.12*
Dissatisfied	-0.21**	-0.08
Admonishing	-0.24**	-0.11*
Strict	-0.00	0.00

Multiple Correlation $R = 0.33$***

$R^2 = 0.11$

*** Significant at $p<0.001$, ** Significant at $p<0.01$, * Significant at $p<0.05$
n = 705

Seven of the eight scales of the QTI have a significant association with the academic achievement scores. These scales are Leadership, Helping/Friendly, Understanding and Student Responsibility/Freedom, which have a positive correlation and Uncertain, Dissatisfied and Admonishing which have a negative correlation (p<001, p<0.05). The scale with which there is no association is Strict. The correlations for the significant scales of QTI range from -0.21 for the Uncertain and Dissatisfied scales to 0.23 for the Understanding scale.

The multiple correlation (R) between students' perceptions as measured by the different scales of the QTI and the academic achievement scores (as seen in Table 5.9) is 0.33 at the individual level of analysis, which is statistically significant (p<0.001). The R^2 value indicates that 11 percent of the variance in students' academic achievement can be attributed to the students' perceptions of their teacher-student interactions. Standardized regression values were calculated to provide information about the unique contribution of each QTI scale to the academic achievement scores. Regression coefficient values (β) indicate (see Table 5.9) that four of the eight QTI scales uniquely account for a significant (p<0.001, p<0.01, p<0.05) amount of variance in academic achievement scores, these are the Understanding scale with a value of 0.20, Student Responsibility/Freedom with a value of 0.14, Uncertain with a value of -0.21 and Admonishing with a value of -0.11. The β value for the two scales is positively significant which implies that the proper understanding of the students needs and providing them with care along with giving them some freedom, opportunities and responsibility may help in increasing their academic achievement scores. On the other hand, uncertain and admonishing behaviour by the teacher may lead to a decrease in students' academic achievement.

5.8 GENDER DIFFERENCES

5.8.1 Introduction

The last research question was to investigate whether gender differences occur in students' perception of their technology-supported learning environment in a science classroom and their teacher-student interactions along with differences in their attitude towards science, academic efficacy and academic achievement in a technology-supported learning environment. In the sample of 705 students taken from 15 classes, there were 379 (53.8%) male students and 326 (46.2%) female students. In this section, the gender differences with respect to technology-supported learning environments, teacher-student interaction and association with the attitude, efficacy and achievement have been discussed.

5.8.2 Gender Differences and Technology-Supported Learning Environment

The means and standard deviations for each of the male and female groups were computed followed by a test of significance of difference between means (*t*-test for independent samples) on the nine scales of the TROFLEI. The data obtained are presented in Table 5.10.

Two of the nine scales of the TROFLEI, i.e. Student Cohesiveness with a t value of 0.41 and Cooperation with a t value of 0.60 are statistically significant ($p<0.01$). In the two scales, which are statistically significant, females have a higher mean score than males (see Table 5.10). This means that female students responded that they show more cohesiveness within their group and help and support one another, also they show more cooperation with one another on learning tasks in a technology-supported science classroom environment. Figure 5.4 depicts the respective means of male and female students on the nine scales of TROFLEI.

Table 5.10

Means, Standard Deviations and Significance of Difference between Means for Gender Differences in Students' Perceptions of Learning Environment as measured by the Modified TROFLEI

Scale	Gender	Mean	Mean Difference (M-F)	Standard Deviation	*t*
Student Cohesiveness	Males	3.90	-0.02	0.53	0.41**
	Females	3.92		0.58	
Teacher Support	Males	3.36	-0.03	0.71	0.43
	Females	3.39		0.77	
Involvement	Males	3.31	-0.05	0.70	0.98
	Females	3.36		0.72	
Task Orientation	Males	4.03	-0.11	0.60	2.55
	Females	4.14		0.57	
Investigation	Males	3.57	0.02	0.70	0.23
	Females	3.55		0.72	
Cooperation	Males	3.74	0.03	0.66	0.60**
	Females	3.77		0.74	
Equity	Males	3.76	-0.05	0.75	0.84
	Females	3.81		0.78	
Differentiation	Males	3.34	-0.01	0.65	0.12
	Females	3.35		0.68	
Technology Teaching	Males	4.06	-0.18	0.66	3.71
	Females	4.24		0.61	

** Significant at $p<0.01$
Males: n = 379; Females: n = 326

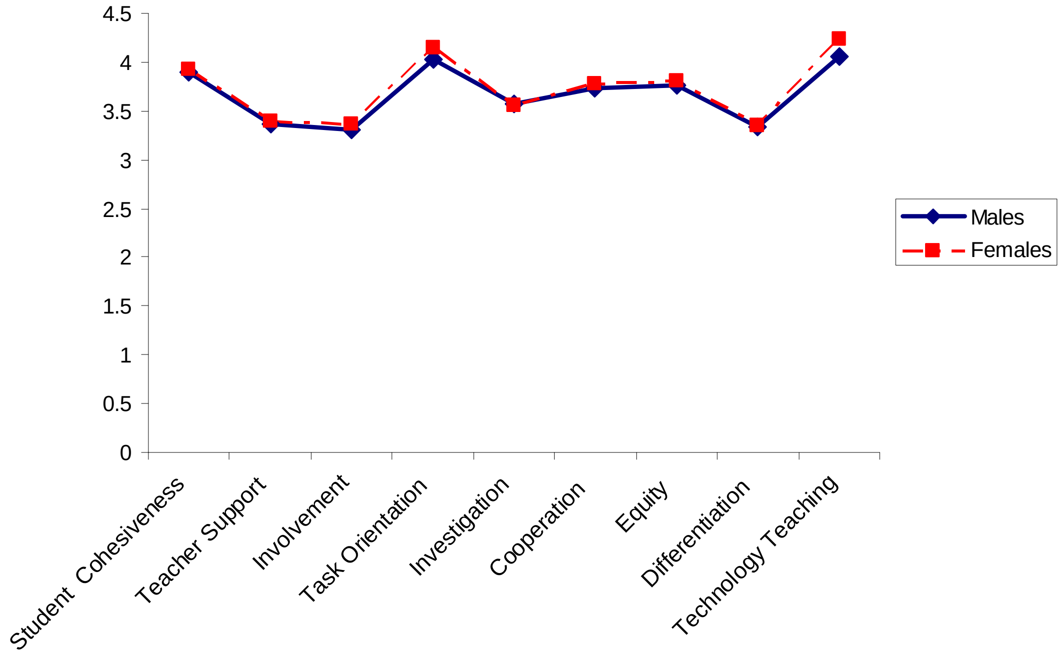


Figure 5.4. Mean scores of male and female students on the nine scales of the TROFLEI.

5.8.3 Gender Differences and Perceptions of Teacher-Student Interaction

The means and standard deviations for the two gender groups were computed followed by a test of significance of difference between means (*t*-test for separate samples), to identify any gender differences on the eight scales of the QTI. The data obtained statistically are presented in Table 5.11.

Table 5.11

Means, Standard Deviations and Significance of Difference between Means for Gender Differences in Students' Perceptions of Teacher-Student Interaction as measured by the QTI Scale

Scale	Gender	Mean	Mean Difference (M-F)	Standard Deviation	*t*
Leadership	Males	4.02	-0.08	0.75	1.42
	Females	4.10		0.68	
Helping/ Friendly	Males	3.60	-0.10	0.81	1.35
	Females	3.70		0.78	
Understanding	Males	3.80	-0.16	0.71	2.97
	Females	3.96		0.70	
Student Responsibility / Freedom	Males	3.10	-0.01	0.70	0.31
	Females	3.11		0.67	
Uncertain	Males	2.61	0.16	0.78	2.57
	Females	2.45		0.79	
Dissatisfied	Males	2.84	0.26	0.76	4.16
	Females	2.58		0.83	
Admonishing	Males	2.55	0.18	0.83	2.84
	Females	2.37		0.85	
Strict	Males	3.45	-0.03	0.65	0.39
	Females	3.48		0.66	

Males: n = 379; Females: n = 326

The data analysis reveals that there are no gender differences in students' perceptions of their teacher-student interactions in a technology-supported science classroom environment. Thus, both male and female students perceived their teacher-student interactions in a similar manner, thus signifying homogeneity in the group. Figure 5.5 represents the mean scores of the male and female students on the eight scales of the QTI.

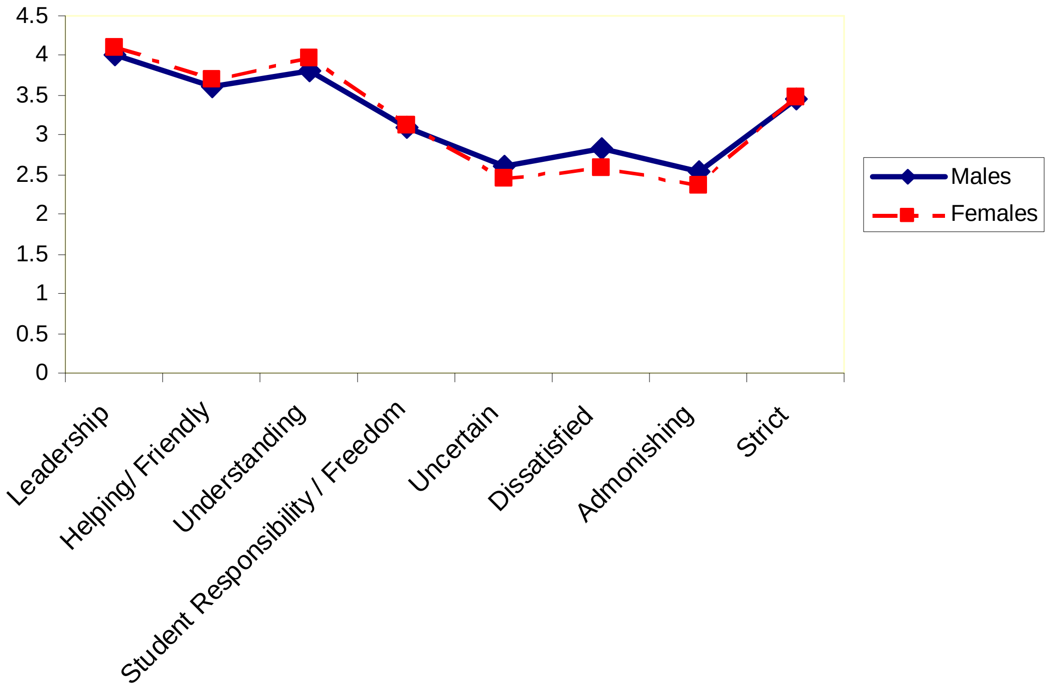


Figure 5.5. Mean scores of male and female students on the eight scales of the QTI.

5.8.4 Gender Difference on Attitude Towards Science, Academic Efficacy and Academic Achievement

Gender differences on attitude towards science, academic efficacy and academic achievement were also investigated. The means and standard deviations for the two groups were computed followed by a significance of the difference between means (*t*-test), to find out gender differences on the three student outcomes. The data are shown in Table 5.12.

Table 5.12

Means, Standard Deviations and Significance of Difference between Means for Gender Differences in Attitude Towards Science, Academic Efficacy and Academic Achievement

Scale	Gender	Mean	Mean Difference (M-F)	Standard Deviation	t
Attitude Towards Science	Males	3.75	-0.04	0.64	0.83
	Females	3.79		0.63	
Academic Efficacy	Males	3.44	-0.07	0.53	1.60**
	Females	3.51		0.62	
Academic Achievement	Males	61.41	-3.23	21.21	2.01
	Females	64.64		21.38	

** Significant at $p<0.01$
Males: n = 379; Females: n = 326

From the data analysis it is evident that there are no gender differences between male and female students in their attitude towards science and academic achievement in a technology-supported learning environment. However, the difference between male and female students in academic efficacy is statistically significant with a *t* value of 1.60 ($p<0.01$). Thus, female students feel more motivated and more confident than do male students in a technology-supported learning environment.

5.9 SURVEY OF STUDENTS' REACTIONS TOWARDS LEARNING SCIENCE IN A TECHNOLOGY-SUPPORTED CLASSROOM

In order to further evaluate the reactions, whether favourable or unfavourable, of the students selected for the study, towards learning science through a technology-supported classroom, the investigator prepared a Technology-Supported Classroom Evaluation Survey containing 20 items. This survey was administered to a sample of 50 students across 15 classes who had studied science through the technology-supported classroom and earlier responded to the TROFLEI questionnaire. Each item in the survey could be responded in terms of 'Yes', 'No' and 'Doubtful' categories. A copy of this evaluation survey is attached as Appendix D. After the administration of the survey, the responses given by the students were transferred to an Excel worksheet and the frequencies of responses to each item in terms of 'Yes', 'No' and 'Doubtful' responses were noted to arrive at an index of the students' reaction towards different aspects of the technology-supported classroom. This was mainly done to determine the effectiveness of the use of technology in learning science at the secondary level. The obtained frequencies were converted into percentages for the purpose of interpretation. The results are shown in Table 5.13

Table 5.13

Responses to the Technology-Supported Classroom Evaluation Survey

No.	Item	Yes	%	No	%	Doubtful	%
1	I found learning science in a technology-supported classroom interesting.	40	80	4	8	6	12
2	I was able to learn faster through technology-supported classroom.	34	68	9	18	7	14
3	I was more attentive while learning in technology classroom that what I am in the classroom	39	78	6	12	5	10
4	I felt that I was getting better individual attention in the technology-supported classroom	33	66	7	14	10	20
5	I could follow the subject matter on the television screen easily than the text book.	27	54	6	12	17	34
6	I found remembering facts in science easier after studying in the technology classroom.	27	54	8	16	15	30
7	I found teaching of science by the teacher to be livelier in technology classroom.	39	78	6	12	5	10
8	Responses to questions were scored quickly in the technology classroom.	36	72	6	12	8	16
9	The knowledge of results was very motivating for me to study science in the technology classroom	31	62	7	14	12	24
10	The teacher was able to correct my mistakes in an effective manner.	36	72	5	10	9	18
11	Learning through technology class was an enjoyable activity as compared to regular class room teaching.	37	74	6	12	7	14
12	The atmosphere while studying science through the technology classroom was more relaxed than in the regular classroom.	35	70	3	6	12	24
13	There was a feeling of group learning in the technology classroom than in the regular classroom.	32	64	5	10	13	26

Table 5.13 *Contd.*

14	The teacher was more helpful in the technology-supported classroom.	27	54	6	12	17	34
15	I could revise my lesson better in a technology-supported science classroom.	24	48	12	24	14	28
16	I found the questions asked at the end of the topic easy to answer	30	60	7	14	13	26
17	Learning science through technology classroom was very boring.	9	18	30	60	11	22
18	I was not afraid of answering questions asked on the television screen as compared to when teacher asks questions.	36	72	6	12	8	16
19	I found learning science through the technology classroom to be a waste of time and effort.	9	18	32	64	9	18
20	I would look forward to learning science through technology-supported classroom	35	70	6	12	9	18

Table 5.13 shows that the students' responses toward the effectiveness of the technology-supported classroom in terms of frequencies and percentages of responses to different items in the Evaluation Performa under different response categories namely 'Yes' 'No' and 'Doubtful'. In this study, responses given by 60% and above in the sample were considered to be significant for the purpose of discussion of results.

The obtained results indicate the overall positive reactions of the students regarding the technology-supported science classroom. It can be concluded that the students have been able to perceive the merit of technology- supported classes in line with the advantages of the use of technology which have been highlighted by several writers and researcher's details of whom have been given in Chapter 2. At the same time, having been long exposed to the classroom teaching by the teacher and being dependent upon text books, they have also been somewhat doubtful about the relative superiority of technology vis-à-vis text books, subject-matter and availability of help when needed. Almost 70 to 80% of the students in the group look forward to learning science in technology-supported classrooms rather than through more conventional methods. They also perceive their technology-supported science classes to be more interesting, livelier and more enjoyable. The students responded that they were more attentive, they found answering questions easier and the atmosphere more relaxed in the technology-supported science class. Students also felt that they were able to learn faster and the teacher paid individual attention to them in such classes. In these response lies the success of the present experiment in particular and of the general superiority and hence desirability of introducing the technology-supported classrooms for teaching of science at secondary stage in our schools.

To conclude, the results of the present experimental study are in line with the results reported earlier by investigators as reported in Chapter 2. These investigators had reported results favouring the use of technology in school classrooms over conventional methods of teaching in science and mathematics subjects. The results reported earlier have largely been corroborated by the results from the present study. However, the present study also provides a valuable insight regarding the basis on which the technology-supported classrooms score over regular classroom teaching in terms of students' reactions – something about which information was not available earlier. The present study can therefore be acclaimed, in all humility, to be successful in achieving its main objective of reporting the effectiveness of the technology-supported classroom in teaching science at the secondary level.

5.10 CHAPTER SUMMARY

This chapter has presented the descriptive statistics to support the nature of technology-supported science classroom learning environment using the TROFLEI and the students' perception of their teachers' interpersonal behaviour using the QTI in term of their means and standard deviations. The results show that the students perceive their technology-supported learning environment and their teacher interactions in a positive manner. The mean score values on the Attitude towards Science scale and the Academic Efficacy scale are also high. Also the students' perception of their technology-supported learning environment in a science classroom and their teachers' interpersonal behaviour are associated in a positive and significant manner with attitude towards science, academic efficacy and academic achievement data. Results on investigation of gender differences suggest that there exists a gender difference in technology-supported learning environments as measured by the TROFLEI. On the other hand, no gender differences were reported in the teacher interpersonal behaviour as assessed by the QTI. In terms of the two attitudinal outcomes, gender differences in favour of females were reported only on the Academic Efficacy scale. Finally, on evaluating the reactions of students towards studying science through a technology-supported classroom, more than 70% of the students responded that they enjoyed attending such classes and were looking forward to studying science through such classes. Such results show that the overall objective of the study has been achieved as the effectiveness of the technology-supported science classrooms has been established at the secondary level in a school in Jammu, India.

CHAPTER 6

QUALITATIVE DATA ANALYSIS

6.1 INTRODUCTION

For a number of years now, workers in various areas of educational research, especially the field of educational evaluation, have claimed that there are merits in moving beyond the customary practice of choosing either qualitative or quantitative methods and instead combining qualitative and quantitative methods within the same study (Cook & Reichardt, 1979; Firestone, 1987). In the rapidly growing field of classroom learning environments, studies involving qualitative methods have provided rich insights into the classroom life (Rutter et al., 1979; Stake & Easley, 1978). To date, however, only limited progress has been made in realizing the potential advantages of combining qualitative and quantitative methods within the same study in research in learning environments. Although a few studies combining the two methods have been carried out in the last decade (Aldridge & Fraser, 2000; Fisher, Waldrip, Harrison, & Venville, 1996; Waldrip & Fisher, 1996), this study is unique as it provides result on the first ever study in India using the Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) to study the learning environments of technology-supported science classrooms along with the Questionnaire on Teacher Interaction (QTI), which has been used once before in Indian science classrooms.

In Chapters 4 and 5 of this thesis, the quantitative data analysis has been presented using information collected from 705 students in 15 classes using two classroom environment instruments, the TROFLEI and the QTI. This chapter reports the qualitative analysis of information obtained by interviewing the students who had completed the classroom environment questionnaires in order to further validate the findings from the quantitative data and to examine the construct validity of the TROFLEI and the QTI in Indian technology-supported science classrooms. The extent to which a test measures an intended hypothetical construct is generally referred to as construct validity (Gay, 1992). The students' interviews were also used to determine the overall effectiveness of the technology-supported classroom in the teaching of science at the secondary level.

As reported in Chapter 3 of this thesis, three students from each of 15 classes were interviewed one at a time for the purpose of establishing the construct validity of the TROFLEI and QTI and to get an overall view of the nature of technology-supported classroom learning environments and the teacher-student interactions in such classrooms. In all, 45 students were interviewed and their conversations were audio taped and later transcribed. Questions for the interview were based on the items under different scales of the TROFLEI and QTI to which the students had earlier responded and were organized in a semi-structured manner. Three questions from each scale of the two questionnaires were selected to form an interview schedule. A copy of the interview schedule has been included as Appendix E.

Descriptions of each scale of the TROFLEI and QTI have been provided in Chapters 2 and 3 and their means and standard deviations given in Chapter 5. The construct validation of the instruments is discussed in the following sections.

6.2 COMMENTS FROM INTERVIEWS ON THE TROFLEI SCALES

The mean for each scale of the TROFLEI for the total sample is provided in the title of each of the following subsections.

6.2.1 Student Cohesiveness Scale (Mean = 3.91)

It is evident that Student Cohesiveness measures the extent to which the students know and help each other and are supportive of one another. The quantitative analysis of the Student Cohesiveness scale demonstrates that the value of the mean is high, which means that there is fellowship and cohesiveness amongst students when studying science in a technology-supported environment. The interview results also supported the high mean score for this scale. Students perceived their technology-supported classroom environment to be cohesive. The questions from the Student Cohesiveness scale that formed a part of the interview schedule were: 1) Do you make friends with students in this class? 2) Do students in this class like you? 3) Do you get help from other students in this class?

Some students' perceptions about cohesiveness are reflected in the following comments.

> *Student 1: I make friends easily in this class. Almost all the students in the class are my friends and like me a lot and help me whenever I need it, be it in my studies or in other class activities.*

> *Student 2: I try to be friendly with my classmates. However there are a few students with whom I am not so friendly but whenever I face any difficulty in the class, my friends help me and support me.*

> *Student 3: I am a very friendly person and have good relations with my classmates. We work like a team in the class and are very helpful towards each other.*

> *Student 4: We share cordial relations with each other in the class and always rally around each other in times of trouble.*

> *Student 5: I am very popular in my class. All the students are familiar with me and we help each other in class activities.*

> *Student 6: I am friendly with my class fellows but I share close bond with a few of them specially girls. However I always get help and support from them in studies or in other co-curricular activities.*

> *Student 7: I get all the support, help and affection from my class mates as we share great rapport with each other and I am liked by them.*

> *Student 8: I am a bit introvert and need time to open up and be friends with other persons. I have few friends as compared to other students in this class. I get help only from my close friends and not other students of the class.*

Student 9: All the students in the class like me, I am also very fond of them and always get help from them. Although some of them are very close to me and we share a sacred bond with each other.

Student 10: I have good relations with all my classmates and I like their company very much and they too are equally fond of me. I have both boys as well as girl students as my friends.

Student 11: I share warm and affectionate relations with all my class mates. They genuinely try to help me.

Student 12: I am not very comfortable in making friends easily and feel hesitant approaching people. Some students like me and try to make me part of their group.

Student 13: All the students in the class know me and I consider them my good friends. I think I don't get the desired support from all of them when I need it. However my close friends help me.

The above comments shed light on the extent of student cohesiveness in the technology-supported science classroom. Most of the students feel that the students help each other and are supportive of each other in the time of need. Students make friends easily and help one another thereby suggesting a healthy relationship amongst students. There is cohesiveness amongst the students in the class which is reflected in their interview comments. Students generally appear to have a helpful nature towards one another and back each in both academic and co-curricular activities. The results thus obtained from the student interviews were consistent with the mean score as obtained through quantitative analysis. The interview also supports the construct validity of the Student Cohesiveness scale for the TROFLEI and does assess the degree to which students get along with one another.

6.2.2 The Teacher Support Scale (Mean = 3.38)

It is intended that the Teacher Support scale intends to measure the extent to which the teacher helps, befriends, trusts and is interested in students in a class. The mean score obtained after quantitative analysis of the Teacher Support scale is high, which means that students find their teachers to be supportive and helpful when studying science in a technology-supported environment. The interview results also supported the high mean score for this scale. The questions from the Teacher Support scale that formed a part of the interview schedule were: 1) Does the teacher go out of his/her way to help you? 2) Is the teacher interested in your problems? 3) Do the teacher's questions help to understand the topic?

Some students' perceptions about their teacher support are reflected in the following comments.

> *Student 1: My teacher really goes out of her way to help in solving my problems. She considerately listens to my problems in the class and is always ready to give me extra time whenever I require. Her questions in the class acts like a check -o- meter to check my level of knowledge of what is being taught in the class.*

> *Student 2: My teacher is a little reserved. She sometimes shows some friendliness towards students and tries to remove our doubts regarding the topic by providing extra notes and tips. I love her question –answer sessions as it helps me in clearing my doubts.*

> *Student 3: She listens to my problems and tries to help me. But I want her to adopt a more caring and helping attitude. Her questions in the class really help in understanding the topic very well.*

> *Student 4: My teacher shows indifferent attitude towards our problem and maintains a distance from the students, so I always feel cautious in*

approaching her for help. However her questions always keep me on my toes and I am more alert in the class.

Student 5: My teacher always shows keen interest in my problems and very patiently makes me understand the topic.

Student 6: She helps me in my studies, although she is not very demonstrative in showing her caring attitude. Her questions always keep me attentive in the class and help me in understanding the topic.

Student 7: My teacher really takes pain in solving our problems. She conscientiously listens to our difficulties and very politely makes us understand the chapter. I find her questions most interesting session in the class.

Student 8: She always encourages us to ask for help without any hesitation or fear. I always find her cool and composed while listening to our difficulties. Her questions help me in testing my level of understanding of the topic.

Student 9: My teacher handles my queries very patiently and warmly. She never gets irritated while attending to my problems and guides me how to be better in studies. The question and answer sessions in the class are very beneficial to the students.

Student 10: My teacher's positive attitude in the class gives me the courage to ask for help without any hesitation. She never gets tired by our demands of explaining the topic again and again. I feel very satisfied after attending her class.

Student 11: My science teacher is very co-operative and helpful. She always takes extra effort in explaining the difficult topics to each and every student. Her questions in the class give me confidence and make me sure about my own abilities.

Student 12: The teacher does not always go out of his way to help me but he listens to my problems carefully. His questions help me to grasp and understand the topic and enable me to check my own level of knowledge in the subject.

Student 13: He helps me but not in the manner I like him to. Sometimes he asks me to come after the class for help. However his questions do help me to understand the topic.

From these comments, it can be inferred that generally students perceived their teachers to be helpful, supportive and cooperative in a technology-supported classroom environment. Students also highlighted the positive attitude of some teachers, which they thought was an important aspect of teacher support as they would ask for help openly only from those teachers who showed a friendly attitude towards them. The teachers' support in terms of answering questions and clarifying doubts was considered very significant by the students. A few of the students also reported in their comments that they required more support than that being provided. The interview comments of students on the scale of Teacher Support were consistent with the mean scores from the quantitative data and the scale does appear to assess the extent to which the teacher is supportive of students thus supporting its construct validity.

6.2.3 Involvement Scale (Mean = 3.33)

The Involvement Scale measures the extent to which students have attentive interest, participate in discussions, perform additional work and enjoy the class. The mean score obtained after quantitative analysis of the Involvement scale suggests that the responses lie between sometimes and often, which means that students are generally involved in the classroom activities, give their opinions and discuss their problems in a technology-supported environment. The interview results also supported the mean score for this scale. The questions from the Involvement scale that formed a part of the interview schedule were: 1) Do you give your opinion during class discussions?

2) Are your ideas and suggestions used during class discussions? 3) Do the students discuss with you how to go about solving problems?

Some students' perceptions about their involvement in the classroom are reflected in the following comments.

Student 1: I freely express my opinion during class discussion, and my views sometimes get noticed and sometimes out rightly rejected. As I share good relations with my classmates, they often come to me to discuss their problem.

Student 2: I feel shy in involving myself in class discussion as I do not have enough confidence to articulate my views. It is only sometimes students come to me for getting answers to their problems.

Student 3: I like to be a part of the discussions in the classroom. However, I try to put across my views and suggestions when I am very much sure about them. Students often come to me without any hesitation for solving their problems.

Student 4: If I think I have enough knowledge to be part of the discussion only then I give my opinion. If my fellow students and teacher find my views relevant, they definitely use them in the class discussion. I am very friendly with my class fellows so they often come to me to discuss their problems which are related to studies as well as of a personal nature.

Student 5: I like to take active part in the class discussions and put across my views without any fear or hesitation. And my views almost always find very positive response in the class. As I am very friendly, students who face difficulties, come to me for help.

Student 6: Sometimes I do take part and sometimes I am just a passive participant in these class discussions as I cannot put forth my thoughts and views effectively. My ideas are not very often discussed in the class. Students *do come to me to find solutions to their queries and I always try to extend my support to them.*

Student 7: We do not have discussions in our class so there is hardly any chance to be part of these discussions. We usually help each other in studies and other class activities.

Student 8: I take part in group discussions as our teacher encourages us to discuss our ideas freely in the class. My classmates do come to me for seeking help in solving their problem but I think they prefer to go the teacher for the same.

Student 9: We do not have discussions in our class but I freely express my opinion whenever teacher asks. My classmates always come to me for solving their problems which are usually of personal nature.

Student 10: I am a very confident person and never hesitate to give my opinion in class whenever there is any discussion. We all share very close bond with each other and help each other in solving problems.

Student 11: I share my opinion with my classmates during discussions and they usually listen to my suggestions. We help each other in the class.

Student 12: I feel hesitant in expressing my opinion during class discussion as I do not like adverse comments of my classmates. I participate in these discussions only sometimes and my views are often appreciated. Students do come to me to discuss about their problems which may not be related to studies.

Student 13: I do not generally participate in these discussions as I dread the reactions of my teacher and students. Whenever I put forth my views in the class, they do become part of the overall discussion. I try to solve the problems of other students if I can.

Information from the students' interviews reveals that generally, students are involved in class discussions with their friends and teachers; their ideas and suggestions are used by other students and they help each other in solving their problems. Some of the students also revealed that they did not participate in class discussions as either their teacher did allow such a practice in the class or they felt hesitant in airing their views because of peer pressure. Overall, the students' perception about their level of involvement in the class activities in a technology-supported classroom as observed through their interviews is consistent with the mean score obtained through quantitative analysis. The construct validity of the Involvement scale was supported as the comments are about the students' participation in the class activities.

6.2.4 Task Orientation Scale (Mean = 4.08)

The Task Orientation scale measures the extent to which it is important to complete the activities planned and stay focussed on the subject matter. The score on this particular scale was very high and thus suggests that students in a technology-supported classroom are aware of the task they need to accomplish and are in a state of readiness to learn. The teachers also orient the students from the point of view of completing their tasks well on time and keep on encouraging them throughout the academic session. The interview results also supported the very high mean score for this scale. The questions from the Task Orientation scale that formed a part of the interview schedule were: 1) Do you know the purpose of studying in this class? 2) Are you always ready to study in this class? 3) Do you know how much work you have to do?

Some students' perceptions about their task orientation are reflected in the following comments.

> *Student 1: Yes I am very much aware of the purpose of studying science. It makes me more knowledgeable and it is also very important from my career point of view. Science is my favourite subject so you will find me ever ready to attend this class*

Student 2: Studying science is very important to me as I want to be a scientist. It helps me to understand the principles of science and ignoring science in today's world is inexcusable. I am also aware of the fact that it demands lot of hard work.

Student 3: Science clears many myths and superstitions and it is a very interesting and informative subject. It is very important from career point of view.

Student 4: It teaches how things work and in fact it gives answers to each What, Why and How. It demands a lot of hard work and I am ready for it.

Student 5: I study science to get good marks which is necessary for me to excel in life as I am planning my career in the field of engineering. So I never miss this class and I am very clear how much hard work is involved in it.

Student 6: Science helps me to understand and see things in a different way. I find this class very interesting, experiments and hands-on classroom study gives me the opportunity to explore and discover the principles that govern these processes.

Student 7: Science makes me acquainted with the mysteries of life. It is a very interesting subject but involves a lot of hard work.

Student 8: I look forward to attend the science class as it encourages and cultivates in me a love and appreciation of science and develops the skills of inquiry and observation.

Student 9: Science is very interesting subject and I know what is to be done in this class. It also involves a lot of hard work. I love drawing diagrams and practical work in science.

Student 10: I like studying science. It is an interesting subject and our teacher also teaches us in a nice manner. However some concepts are difficult to learn.

Student 11: It is a very absorbing subject and the teacher clears all my doubts. I get hands-on experience to understand scientific concepts in the lab and I always look forward to attend this class as it is very important for my future career.

Student 12: I know it is very important to attend the science class as it gives me right kind of help in understanding and applying important concepts of science. It requires a lot of work to be done.

Student 13: I find science to be one of the easiest subjects in the school. It is interesting and helps me gain knowledge about the world around us.

The interviews indicate that the students are clear about their task in the technology-supported environment. They know the purpose of studying in this class and the amount of work that needs to be done. Students have a positive perception about their task orientation. The responses made by the students demonstrate that students in Indian schools are very much involved with their studies. The system of education is examination driven and hence students are oriented towards attaining excellence. Interviews reveal that students' are generally interested in studying science and also want to choose science as a career option. This shows that the students' responses are consistent with their TROFLEI scores for this scale and their comments about the Task Orientation scale support its construct validity.

6.2.5 Investigation Scale (Mean = 3.56)

The Investigation Scale measures the extent to which students use their skills and processes of enquiry for problem solving and investigation. The mean score obtained for the Investigation scale suggests that the responses lie between sometimes and often, which means that students usually investigate their ideas and find answers to their questions. The questions from the Investigation scale that formed a part of the interview schedule were: 1) Do you carry out investigations to answer questions and test your ideas? 2) Do you find out answers to questions by investigating? 3) Do you solve problems by using information obtained from your own investigation?

Some students' perceptions about investigation are reflected in the following comments.

> *Student 1: I hardly carry out any investigation to test my ideas and to answer my questions. We do some experiments in the school lab under the supervision of our teacher. Mostly we take the help of teacher and books to find out answers.*

> *Student 2: I would love to do experiments to find my answers but I do not have the privilege to indulge in this activity more often as there is no such facility at my home and we get very less time in school labs. So I rely more on books and the teacher to obtain information.*

> *Student 3: I have never done any experiments or investigations to test my ideas. In school lab I do some experiments, but mostly they are related with the curriculum. I can test some of my ideas in the school lab with the permission of the teacher*

> *Student 4: I am very much interested in doing every kind of investigation to test new ideas and always try to find means to satisfy my urge. I keenly watch all programmes related to science on TV channels and follow their instructions to do experiments at home. In school we do have science labs where we do the practical and substantiate what is taught in the class.*

Student 5: In our school, not much stress is laid on doing experiments just to test new ideas. We have to follow our curriculum and are allowed to do only those experiments which are mentioned in our books. I usually take help from the books and my teacher to solve my problems.

Student 6: To solve my problems and test new ideas, most of the time I get assistance from my teacher and the books. I also get information for my answers from internet. School science lab is one place where I get some time to test things under the directions of my teacher.

Student 7: I love experimenting and investigating. I feel that science lab is the best place in the school as we undertake enjoyable activities. We can get answers to some of the questions through investigation but we mostly take help of the teacher.

Student 8: Investigation and experiments are confined to science lab only. So after coming out of lab, I depend mostly on my books and teachers to find answers to my questions.

Student 9: Sometimes I do some easy and interesting experiments at home to understand some scientific concepts, but most of the time books and teacher help me to clarify my doubts. Generally our teachers demonstrate experiments in the classroom.

Student 10: I take help of my teacher to find answers to my questions, I also surf internet to get the desired help. No experiments for me.

Student 11: Teachers guide us to get correct answers to our problems. I depend more on books and teachers to clarify scientific concepts rather than doing experiments myself.

Student 12: I devote only my science lab period for experiments and investigations. After that it's only books and notes given by my teacher that help me to get solutions to my problems.

Student 13: I love to spend more time in science lab than in any other place to do science experiments. Our teacher mostly demonstrates the experiment to us and I wish we could get more time for experimentation

The student's interviews indicate that students enjoy doing investigations especially in the science laboratories. Most of them responded in interviews that more time should be given for experimentation and to investigate their ideas. The interviews also reflect that students mostly depend upon books and their teachers for finding answers to their questions. However, it was also deduced that the investigative spirit of the students was not developed on a regular basis by the teachers, especially during the day-to-day classroom teaching. Therefore it is one area that needs further investigation. The students' comments indicate that the Investigation scale of the TROFLEI does assess the perceptions of students regarding their investigative learning environment and thus support its construct validity.

6.2.6 Cooperation Scale (Mean = 3.75)

The Cooperation scale in the TROFLEI measures the extent to which students cooperate rather than compete with one another on learning tasks. The mean score obtained for the Cooperation scale suggests that the students' responses lie between sometimes and often but more towards often, which implies that students in a technology-supported environment are generally cooperative towards each another and help each other in doing assignments and other class activities. The questions from the Cooperation scale that formed a part of the interview schedule were: 1) Do you cooperate with other students when doing assignment work? 2) Do you share your books and resources? 3) Do you cooperate with other students on class activities?

A few students' perceptions about cooperation in the classroom are reflected in the following comments.

Student 1: I cooperate with my class mates in doing assignments and other class activities. However I do not like share to my notes as there is stiff competition in the class to get good marks and I want to see myself at the top.

Student 2: I have good relations with my class fellows and I always cooperate with them in every class activity, project or assignment. Though there is tough competition to get good marks I never think twice to share my books and notes with my friends in the class.

Student 3: We all are very cooperative and supportive in the class and often give suggestions to each other. My notes and other related material is result of my hard work and I want to reap benefit of this hard work alone and do not want others to bask in the same glory. Hence I do not share all my notes with other students.

Student 4: Though I am very cooperative and helpful but there are some areas where I do not like to extend my hands of cooperation. I simply do not want to give access to my precious notes and study material to any one in the class.

Student 5: I am very friendly cooperative person and always help and give support to all my class mates in doing assignment work, in completing projects or in any other academic activity. I also exchange books and notes with other students.

Student 6: We have a healthy competition in our class but that does not deter us from cooperating and helping each other in class assignments, sharing books and notes.

Student 7: I never hesitate to offer help and cooperation to other students in whatever task assigned to us in the class. I often share my books and exchange notes

Student 8: I always assist my friends in the class whenever they face any difficulty in class assignments or in other task given to us by teacher. However I share my notes with only those who are part of my own group.

Student 9: I am always ready to lend a hand to those who are in need of my support and cooperation in doing assignment work. I also share my books and resources with other students.

Student 10: In our class we work like a team and offer assistance and back each other in every class activity. We also help each other on learning task by sharing books and other resources.

Student 11: Yes, I believe in cooperation, by cooperating with each other we get new ideas and are able to clear our doubts and can complete our assignments on time. So you can find me cooperating with every other student every time and have no reservations at all in sharing my books and resources.

Student 12: I am very confident person and never hesitate to give my support and cooperation to other students when doing assignment work. We all share a very close bond and exchange our books and notes without any fear of getting left behind in the race.

Student 13: Yes, I often cooperate with other students in the class activities without any hesitation. But I simply cannot exchange my notes with any one as I always want to achieve first rank in the class and I do not want to share my hard work.

The students' interviews reveal that there is cooperation amongst the students in a technology-supported classroom. However, some students were reluctant to share their resources, for example, books and notes, with other students because of healthy competition in their class. There was a general feeling of camaraderie between the students which is a positive sign as it contributes to the development of a group learning environment in the classroom. Students also responded that by cooperating with one another in the classroom, new ideas are formed, which adds to their knowledge and also helps in developing team spirit amongst students. The student's comments were consistent with the meaning behind this scale and hence supported the construct validity of the Cooperation scale.

6.2.7 Equity Scale (Mean = 3.78)

The Equity scale measures the extent to which students are treated equally by the teacher. The results of the quantitative analysis suggest that the mean score of this scale is high and lies between sometimes and often but more towards often, which suggests that the teacher generally treats the students with equality and gives them proper attention and encourages them in a technology-supported environment. The questions from the Equity scale that formed a part of the interview schedule were: 1) Does the teacher give you as much attention as to other student? 2) Are you given the same opportunity in the class? 3) Do you receive the same encouragement from the teacher?

Some of the students' perceptions about equality in the classroom are reflected in the following comments.

> *Student 1: My teacher always treats me equally and gives me the same attention and encouragement as to other students. I never find her discriminating with her students.*

> *Student 2: She does not have any favourite group in the class. I never feel that she is neglecting me because of some other student. She always encourages and pushes me to work harder.*

> *Student 3: My teacher is famous for her equality in the class. I never saw her disregarding me or my problems. In fact you will always find her encouraging all of us.*

> *Student 4: Our teacher is fair in her dealings in the class. I respect my teacher a lot because of this quality. She freely mingles with the students so*

that they do not feel hesitant or shy in asking for her help. She encourages me to take part in co-curricular activities

Student 5: I am really proud to have such a nice teacher who sees all her students without any prejudice and encourages us all to excel in our respective fields by providing us equal opportunity. She always tries to involve weaker as well as bright students in class activities so that no one is left behind.

Student 6: My teacher always engages each and every student in class activities by providing them equal chance to accomplish their task so that they always feel motivated and important.

Student 7: I have never faced any problem with my teacher's behaviour. She epitomizes fair mindedness and equality. She always tries to devise some way to absorb all the students in class activities.

Student 8: Nobody feels ignored or mistreated in our class because of our teacher's ability in handling and understanding the thought process of students. She makes every student in the class feel important. However she does give some extra work to weak students in the class.

Student 9: My teacher gives me attention, encourages me to do well, but sometimes I feel she gives more importance to bright students.

Student 10: She is a good teacher and understands our strengths and weaknesses and guides us accordingly. I never felt neglected in her class.

Student 11: She always treats me well, gives me proper support and encouragement but sometimes I feel she gives more opportunities to a particular group of students.

Student 12: There are some students who get more attention and opportunities than me and I want my teacher to be more sympathetic and sensitive towards other students also. She should equally encourage all of us.

Student 13: My teacher is very good in providing equal opportunities and encouragement to all of us. She never ever tries to undermine the efforts of any student.

Students' interviews indicate that generally they perceived that they were being given equal attention by the teacher in the classroom. The students were being given ample opportunities to do various activities and they also received encouragement from their teachers to perform better with academic content. Some students also responded that teachers give more attention to only selected students who performed well in the class and not to all the students. Again the responses were consistent with the meaning of the Equity scale and thus supported the construct validity of this scale.

6.2.8 Differentiation Scale (Mean = 3.35)

The Differentiation scale in the TROFLEI measures the extent to which teachers cater for students differently on the basis of ability, rate of learning and interests. The mean score on this scale suggests that the students' responses lie between sometimes and often but more towards sometimes, which implies that the teachers usually do not differentiate between students in a technology-supported environment. The teachers try to teach in the same manner to all the students and assess their students using same standards. The questions from the Differentiation scale that formed a part of the interview schedule were: 1) Are you given tasks that are different from other students? 2) Are you assessed in a different manner? 3) Do the Students who work faster than you move to the next topic?

Perceptions of students about differentiation in the classroom are reflected in the following comments.

Student 1: In our class our capabilities are judged in the same manner. I am given the same task that is given to other students and our teacher teaches us the same topic and does not try to teach students differently.

Student 2: We are all given the same task and our teacher employs the same measures to evaluate our performance. We move to the next topic only when everyone in the class has completed it.

Student 3: My teacher teaches as per the common syllabus and similarly we are given tasks accordingly. There are no different books for bright or weak students. All are judged on the same pattern. However some extra tests are given to bright and weak students.

Student 4: My teacher does no adopt any special strategy to analyse the intelligence level of the students and give common assignments in the class. We are all taught the same lessons in the classroom.

Student 5: My teacher uses same techniques to teach all the students in our class. She treats them alike. I however prefer her to adopt different approach while taking tests to cater to different group of students as per their learning capabilities.

Student 6: My teacher usually gives tough assignments to the intelligent students to make sure that they do not become complacent. While for evaluating weaker students, a lenient approach is adopted so that they do not feel inferior.

Student 7: My teacher's mantra is to teach and guide students as per their intelligence level and use such methods which can prove to be a good tool for assessing their performance on the basis of their ability. She implements this philosophy in our class with great success.

Student 8: My teacher believes that every individual is different, and every one has a distinct identity so it is not wise to apply same criteria to teach or to judge a class comprising of so many individuals and I believe in her belief because I have seen tremendous change in the attitude of the students of my class.

Student 9: My teacher uses different techniques to teach weak students because sometimes they need extra attention and time to comprehend the topic. I am also judged as per my learning capabilities especially during oral tests.

Student 10: I am given assignments in the class as per my abilities and sometimes also judged accordingly.

Student 11: We are given same tasks but my teacher assesses us differently. She evaluates weak students leniently while the work of bright students is checked thoroughly.

Student 12: Our teacher before assigning any task or assessing any student takes different factors such as level of intelligence, power of grasping etc. into account and then proceeds ahead. We all move to the next topic together.

Student 13: I do not think my teacher does something different for different students in our class. She adopts same methods to assess the performance of every student. However she devotes some extra time to teach weak students so that they are able to understand the topic easily and come up to the level of other students.

From the students' interviews, it can be inferred that the students are generally not being differentiated in the science class. They are being taught in a manner suitable to all the children although some students have reported that teachers do give extra attention to weaker students and give them easier tests. It is noteworthy that in Indian classrooms the class size is usually large which makes it difficult for the teacher to provide attention to all students especially when the class duration is just 40 minutes. Overall, the students' comments are consistent with the meaning of the Differentiation scale thus supporting its construct validity.

6.2.9 Technology Teaching Scale (Mean = 4.14)

The results on the Technology Teaching scale were quite interesting. The reason being that this was a new scale developed for the purpose of this study and was being used for the first time as a part of the TROFLEI to assess the learning environments of the technology-supported science classrooms in India. The intention of this scale is to measure the extent to which students find learning science through the use of technology interesting, lively and informative. The highest mean of scales was obtained on the Technology Teaching scale as the student responses were mainly between often and almost always. This data show that most of the students liked studying science through a technology-supported classroom. The questions from the Technology Teaching scale that formed a part of the interview schedule were: 1) Do you find learning science in the technology classroom Interesting? 2) Do you find the audio-visual effects in the content matter to be appealing? 3) Do you look forward to learning science in the technology classroom?

Perceptions of students about their technology-supported science classroom are reflected in the following comments.

> *Student 1: I find learning science through technology classroom very interesting and lively. The graphics and the audio effects used in the content matter are very appealing and eye catching. I prefer to learn science through technology classroom as it helps me in understanding the topic in a better way.*

> *Student 2: Learning science through technology classroom was a fascinating experience, the graphics and audio kept me glued to the screen. The most vital aspect of learning science through technology is that the topic can be repeated again and again and I can learn at my own pace.*

> *Student 3: Technology-supported Classroom makes learning science an incredible experience. Use of sound and graphics puts life into the otherwise dull classroom. I always look forward to attend this class as it also helps me to understand the topic in an easy manner*

Student 4: It is a truly wonderful experience. Now I can say that learning science can be real fun. It is more informative than regular classroom as it demonstrates the topic in a lively manner and certainly helps me to comprehend the topic in a better way.

Student 5: Learning Science can be so easy! I had not realized before hand. Technology classroom has changed my perspective about the same. The use of audio and visual effects keeps me engrossed in the class, which facilitates better understanding of the subject.

Student 6: I find learning science through technology-supported classroom quite interesting. Eye catching graphics and sound really holds my attention in the class. I like to attend technology-supported classroom again and again as it makes learning so simple. More such classes should be organized in future.

Student 7: Technology class room is an attention grabber. It has all the ingredients to turn dull, boring and tired class into a lively environment. I never miss this class.

Student 8: Who will find it boring? You can see all the contents of the book turning into colourful attractive visuals with a sound to match. For me learning science through technology class room gives me opportunity to understand the topic in a much better way.

Student 9: It is indeed a wonderful way to learn science. As I can see all the concepts of science in the form of live pictures, which leaves an inerasable impression. Apart from science other subject teachers should also teach through the technology classroom.

Student 10: I find it interesting as content is in the audio visual form, which appeals to the students. However I can not deny the importance and role of books in studying science

Student 11: It is a different experience altogether. I always want to learn science through Technology class room as the topic is explained more clearly. I love the digital animation in the lessons specially the topic on nuclear reaction and dissection of frog.

Student 12: I find learning science through technology class room motivating. However studying from books has its own charm.

Student 13: Learning science through technology classroom is very appealing with attractive visuals and sound. Our teacher has also become more efficient after using computer in the classroom.

The comments given by the students show their love for the technology-supported classroom. Overall, the students found the classroom environment to be different and more conducive for learning. They found science classes to be more lively and interesting. Students also remarked that such classes left an everlasting impression on their minds and they could also understand the difficult concepts easily. Students responded that more such classes should be conducted using computers in the future and if possible in other subjects as well. Some of the students also reported on the increased efficiency of the teachers teaching science in technology-supported classrooms. The results thus obtained from the student interviews were consistent with the mean score as obtained through quantitative analysis. The comments also supported the construct validity of the Technology Teaching scale for the TROFLEI in Indian school settings.

To sum up, it can be inferred that the construct validity of the modified TROFLEI has been successfully established in a technology-supported learning environment in the Indian school setting and compares with the quantitative data obtained on the different scales of TROFLEI as reported in Chapter 5.

6.3 COMMENTS FROM INTERVIEWS ON THE QTI SCALES

The mean for each scale of the QTI for the total sample is provided in the title of each of the following subsections.

6.3.1 Leadership Scale (Mean = 4.05)

The Leadership scale of the QTI measures the extent to which the teacher provides leadership to the class and holds student attention. The high mean score of this scale suggests that the students look up to their teachers and feel that they teach confidently in a technology-supported classroom setup. The questions from the Leadership scale that formed a part of the interview schedule were: 1) Does the teacher know everything that is going on in the class? 2) Is your teacher a good leader? 3) Does your teacher act confidently?

Perceptions of students about the leadership abilities of their teachers are reflected in the following comments.

> *Student 1: The teacher is aware of everything that is happening in the class. We follow his instructions and he is very confident while teaching.*

> *Student 2: Our teacher being the controller of all activities in her class knows that some students are taking interests in studies, some are writing down things, sometimes they are making a noise etc. We follow her when assigned with some task and my teacher teaches with confidence.*

> *Student 3: Our teacher is very attentive and knows what is going on in the class. She teaches confidently and knows her subject very well. She acts as a good leader and takes charge of all the activities both within and outside the classroom.*

> *Student 4: Sometimes teacher may be unaware of the activities of the students but he usually knows every activity of the students in the classroom. We*

follow every instruction given by the teacher and he teaches confidently in the class.

Student 5: Our teacher knows everything that is going on inside the classroom, whether it is related to studies, discipline or naughtiness in the classroom. He also leads us for all activities in which students are busy, with full confidence.

Student 6: The teacher is very much aware of all the happenings inside our classroom. She holds the attention of all the students during teaching. She provides good leadership and is confident while teaching.

Student 7: Mostly, teacher knows everything that goes on in the class but rarely there are some activities like doing home work during class time etc. which are not in the knowledge of the class teacher. We follow him for every instruction and he is confident in his lecture delivery.

Student 8: Our teacher easily catches us when we make any mistake .He teaches in a very effective manner and understands our problems. I like his leadership qualities.

Student 9: Our teacher sometimes does not know what is going on in the class, especially when the students are doing some other work in the class or talking to one another and not listening to what he is teaching. He needs to improve the class discipline. Overall I feel that he teaches well.

Student 10: My teacher knows every activity that goes on in the class. He leads the students very confidently and helps us achieve our goals.

Student 11: Our teacher explains each and every thing clearly and he usually holds the attentions of all the students in the class. He is a very good science teacher and I enjoy his classes. He also organises co-curricular activities for us and takes us on field trips. He is a very confident person.

Student 12: All, but some activities are not noticed by the teacher such as when students are making cartoons on note book rather than noting down the instructions. However, our teacher is quite confident while teaching and knows his subject well.

Student 13: The teacher is in complete charge of the class like a leader. He knows what is going on in the class and he gives special attention to the students who are weak in studies. He also helps us in doing science practical and provides full support to the students in their studies.

From the students' interviews, it is clear that the students perceive their teachers as leaders. They believe that the teachers are confident while teaching and hold their attention. They also engage the students in all types of activities both within and outside the classroom. Only a few students thought that the teacher sometimes is unaware of certain activities of the students in the classroom such as making cartoons on the notebook or doing some other work when the teacher is teaching. This is sometimes true considering the nature of Indian classrooms where the average class consists of 45 students and thus it becomes difficult for the teacher to keep an eye on all the students. The interview data are also consistent with the high mean score for this scale and its meaning and thus support the construct validity of the Leadership scale of QTI.

6.3.2 Helping/Friendly Scale (Mean = 3.63)

The Helping/Friendly scale of the QTI measures the extent to which the teacher is friendly and helpful towards students. The mean score as obtained through the quantitative analysis of this scale suggests that the students consider their teacher to be friendly and helpful in classroom activities. The questions from the Helping/Friendly scale that formed a part of the interview schedule were: 1) Does the teacher help you in your work? 2) Do you depend upon your teacher? 3) Does the teacher allow you to take jokes in the class?

Students' perceptions about the helpful and friendly nature of their teachers are reflected in the following comments.

> *Student 1: Our teacher is very friendly and helps us out in all activities. We do enjoy some funny activities in the class but we do not make jokes on the teacher.*

> *Student 2: Yes, he helps in understanding the concepts in a friendly manner and explains the things whenever we ask a question on a particular topic. He also tells us interesting stories and tells us jokes during free period.*

> *Student 3: Our teacher helps us in our work and even explains the difficult topics by taking extra classes. We depend on our teacher for all the classroom activities. She allows us to crack some jokes only after the teaching is over and during free periods.*

> *Student 4: The teacher provides us full support whenever we require some help in our studies as we depend upon him for all our academic needs. In some leisure time we can do some funny things and some times our teacher also participates in such activities.*

> *Student 5: Our science teacher helps us in our work and also guides in other activities. We depend upon her for completing our syllabus. She is strict and accepts no nonsense behaviour from students.*

> *Student 6: In most of the tasks related to studies the teacher help us and frequently answers all our queries. He keeps us busy in the classroom but when the syllabus is complete we are allowed to have some fun like telling jokes or singing songs etc.*

> *Student 7: Yes, it depends upon the availability of our teacher and nature of the work, though for almost all academic work we have to rely upon our teacher. It depends upon the mood of the teacher to provide us with some time for having fun.*

Student 8: We ask our teacher to explain and tell things. She usually does and sometimes guides us in doing our home work also. We can have some fun in the class with the teacher which is usually after studies or when we have free time.

Student 9: Yes, my teacher helps us whenever he is asked for help in a particular task. We can depend upon our science teacher. Being in a board class, the teachers usually concentrates more on studies and less on fun.

Student 10: The teacher provides maximum possible help in all the tasks even goes out of his way to guide us especially during examination and for doing our home work. We can depend upon our science teacher. We also share some jokes during the class after the teaching is over.

Student 11: Our teacher is usually friendly with us but she is very strict during the class. We seldom joke in the class.

Student 12: Our teacher is very helpful in making us complete our work and we do depend upon this teacher. It depends upon the mood of the teacher if we can crack jokes in the class, which is usually during the free time at the end of the class.

Student 13: Yes, the teacher is friendly, cheerful and helping. Due to large number of topics in our syllabus, which need to be completed in a specified time, we get very less time for entertainment in the classroom.

From these comments it can be confirmed that students generally perceived their teachers to be helpful, supportive and friendly in a technology-supported classroom environment. The students indicated that they could depend on their teacher for all types of activities and the teacher would also allow them to have fun in the class although studies would always come first. The interview comments of students on this scale were consistent with the meaning of the Helping/Friendly scale of the QTI thus attesting to its construct validity.

6.3.3 Understanding Scale (Mean = 3.87)

The Understanding scale of the QTI measures the extent to which the teacher shows understanding and care of students. The mean score as obtained through the quantitative analysis of this scale suggests that the students perceive their teachers to be understanding in the sense that the teacher will listen to them and explain things to them in a technology-supported classroom. The questions from the Understanding scale that formed a part of the interview schedule were: 1) Does the teacher trust you? 2) Is the teacher willing to explain things again? 3) Does the teacher listen to you when you have something to say?

Students' perceptions about the understanding nature of their teachers are reflected in the following comments.

> *Student 1: The teacher trusts some of the students, especially those who do all the work given by her. The teacher listens to us and explains things on asking again and again.*

> *Student 2: Yes, only if we do our work the teacher thinks that we are trustworthy. If we do not understand any topic she explains to us till we understand properly. She does not allow us to interrupt in between her teaching but allows us to ask questions once she has finished explaining.*

> *Student 3: She trusts us but sometimes she does not when she finds out that we have told a lie. She explains the thing twice or thrice, if it is not understood in the first attempt. The teacher usually listens to us in the class.*

> *Student 4: He trusts only some of the students of our class as some students are naughty. He usually explains every point and repeats if required. He also listens to our problems.*

> *Student 5: Our teacher trusts us as we listen to whatever she has to say. She teaches very well and explains the difficult concepts again and again for our*

benefit. She listens to us and does not scold us when we interrupt her teaching.

Student 6: Yes, our teacher understands us, shows trust in us and responds to our queries whenever asked for.

Student 7: Our teacher always listens to us. If we want any topic to be explained again he is always ready to explain it so that we understand it completely. He always listens to the problems of the students in the class and tries to help in whatever way he can.

Student 8: The teacher trusts us and we can ask him questions to explain the topic again. He tries to explain but sometimes get irritated and says that we can't understand this topic.

Student 9: The teacher trusts all the students in the class. He teaches well and explains the topic in an effective manner. He usually listens to the problems of the students.

Student 10: The teacher thinks that every student of the class is not trustworthy. He explains every topic till we understand and if we have any thing to say he gives attention to us.

Student 11: He doesn't trust everyone, but he trusts only those students who are serious about there studies and follow the instructions of the teacher. Our teacher explains each topic in a simple manner so that every student understands it. He listens to our suggestions and allows us to ask questions in the class.

Student 12: Yes, our teacher repeats the topic as many times as possible in the class and we also ask him questions regularly during the progress of the class. I am not sure if he trusts all the students.

Student 13: Not necessary, it depends upon the teacher whom he trusts or not but usually he helps all the students and listens to their problems. He also repeats certain topics which are difficult but mostly he finishes things in one go.

From the comments of the students, it can be generalized that their teachers understand them and they explain things to them until such time as they completely understand the content of the topic being studied. The teachers also listened to the students and allowed them to express themselves freely which suggests a democratic classroom setup. Only a few students thought that the teachers did not trust them and are usually doubtful about their actions. The interview comments of students on this scale were consistent with its meaning thus supporting the construct validity of the Understanding scale of the QTI.

6.3.4 Student Responsibility/Freedom scale (Mean = 3.10)

The Student Responsibility/Freedom scale measures the extent to which the students are given opportunities to assume responsibilities for their own activities. After quantitative analysis the average mean score obtained suggests that students are not given a lot of responsibility in the classroom. This can be further observed from the comments made by the students during their interviews. The questions from the Student Responsibility and Freedom scale that formed a part of the interview schedule were: 1) Can you influence your teacher? 2) Does the teacher give lot of free time in the Class? 3) Is the teacher lenient?

Students' perceptions about the freedom and responsibility given to them in the class are reflected in the following comments.

Student 1: It is difficult to influence the teacher as she tells us what is to be done in the class. We are given free time only once the syllabus is covered and not during classes. Our teacher is not lenient with us.

Student 2: Yes, only if we do the work assigned by her then we can influence her to some extent. She is sometimes lenient and provides us free time only when we have completed our topic and in the free time we take up activities like quizzes and memory games under her supervision.

Student 3: Sometimes, we can influence our teacher by scoring good marks in tests assigned by her. She gives us some free time say 15-20 minutes, when she is in a good mood.

Student 4: Our teacher gives us opportunities to prove ourselves and then only we can influence her to give us some free time. She is quite strict in the class.

Student 5: Our science teacher is strict and does not show any leniency especially during the examination period. We get free time sometimes in the class for other activities but she insists that we revise what we have learnt. It is difficult to influence her.

Student 6: We can influence our teacher in co-curricular activities but not during teaching in the classroom. She is very soft spoken but is strict at the same time. We get some free time in the class but usually we are always busy in studies.

Student 7: Our teacher doe not get influenced by the students and is strict in her dealings with us. We usually do not get lot of free time in the class but some times our teacher takes two periods in a row, then we get some free time for other activities but under the supervision of our teacher only.

Student 8: Our science teacher sometimes gets influenced and she provides us with free time. However she is not that lenient when it comes to studies.

Student 9: Being in the board class we do not get lot of free time due to lengthy syllabus and our teacher is also not lenient. She is quite disciplined and deals firmly with naughty students.

Student 10: If our syllabus is completed in time, then we enjoy some games otherwise teacher usually takes on the revision in the classroom and engages us in studies. Our teacher sets difficult exam papers and checks them thoroughly.

Student 11: By completing our home work and other assignments given by the teacher we can influence him. He also understands our feelings and gives us free time only after completion of the chapter. He is lenient only when he is in a good mood.

Student 12: Sometimes we can influence our teacher by scoring good marks in our examinations but he does not provide us with a lot of free time and he is rarely lenient.

Student 13: In higher classes teachers are usually tough as there is lot of syllabus to be covered and there is less time. So we seldom get free time during the classes and it is only when the teacher is absent we are given a free period, which the students utilise either to play games or visit the library.

Students' interviews reveal that students perceive the teachers in the class are usually not lenient. The academic activities are taken seriously and not a lot of free time is given to the students although some students have expressed that free time is given usually after the teaching is over. However, most of them strongly responded that it is difficult to influence the teacher as he/she is the dominating factor in the class. This is generally true in Indian classrooms where teachers usually do not give much responsibility and freedom to the students as they feel that students may misuse it. The comments of the students are consistent with the mean score on this scale and thus support the construct validity of the Student Responsibility/Freedom scale of the QTI since their comments are closely related to this topic.

6.3.5 Uncertain Scale (Mean = 2.53)

The Uncertain scale of the QTI measures the extent to which teachers exhibit their uncertainty. The mean score of this scale suggests that the students responded that their teachers are not uncertain about their teaching and behaviour in the classroom. High mean scores on the Leadership, Helping/Friendly and Understanding scales also support this result on the Uncertain Scale. The questions from the Uncertain scale that formed a part of the interview schedule were: 1) Does the teacher acts as if he/she does not know what to do? 2) Is it easy to make a fool out of your teacher? 3) Is the teacher uncertain?

Students' perceptions about the nature of uncertainty of teachers in the class are reflected in the following comments.

> *Student 1: She does not show any doubt in her teaching and knows what she is doing in the class. It is not possible to make a fool of the teacher otherwise we will be in trouble.*

> *Student 2: Our teacher is confident and cooperative. It is very bad to make fool of the teacher as she gives us good education. Sometimes the teacher seems to be in a doubt when the students ask questions and she is unable to answer. She says that she will explain later.*

> *Student 3: Our teacher acts confidently in the class and she is always certain about all the activities. She scolds us if we try to make a fool out of her as some students try to play a prank on her.*

> *Student 4: The teacher has full control over the activities inside our classroom. While teaching she is fully confident in the class. We cannot make a fool of her and she is never uncertain.*

Student 5: Yes, sometimes teacher behaves as if she does not know how to go ahead especially when the students ask a tricky question. She is always certain in the class with respect to the task at hand.

Student 6: No, the teacher always knows what is to be done and at what time in the class. We have never tried to make fool of the teacher as we respect her and it is because of her that we are gaining knowledge.

Student 7: Our science teacher is a very effective teacher and she knows her subject very well. If she does not know the answer she will find the solution and tell us later but will never tell a wrong answer. I can't think of making a fool of her in my wildest dreams.

Student 8: Our teacher teaches the class in a very friendly manner and we can ask questions to her. She is never uncertain and explains things clearly. No body makes a fool of our teacher.

Student 9: No, the teacher's behaviour is always positive towards the students and teaches with full control. It is not easy for us make our teacher look uncertain or confused.

Student 10: Once in a while it is easy to note uncertainty in our teacher but mostly our teacher is very effective in delivering her lecture and it is not easy for us to make a fool of our teacher.

Student 11: Since our syllabus is so lengthy, we are always busy in the class. Hence we can't think of making a fool of the teacher. The teacher teaches well and tries to solve our problems in a prompt manner although there are certain questions to which she responds later.

Student 12: Due to serious and strict nature of our teacher we do not get any chance for funny activities and being an experienced teacher he has full control over our class.

Student 13: Not at all, he looks to be in full control of the class and he never gives us an opportunity to doze off in the class. No one tries to make a fool of the teacher other wise they will be reprimanded.

The students' interviews revealed that they do not perceive their teacher to be uncertain in the technology-supported classroom. The teachers were confident in their lecture delivery and it was also not possible to make a fool of the teacher. Also, since the teachers usually come well prepared to the class and know their subject well, they teach in an effective manner and explain the topic well. Like students, teachers are also constantly oriented to teach students from an examination point of view, thus stressing more on the academic content. These results are consistent with the results from the quantitative data for the scale which reported a low mean score. The comments also supported the construct validity of the Uncertain scale.

6.3.6 Dissatisfied Scale (Mean = 2.72)

The Dissatisfied scale of the QTI measures the extent to which the teacher shows unhappiness and dissatisfaction with the students. Again for this scale, the low mean score suggests that generally the teachers are not dissatisfied with the students and have a good opinion about them. The questions from the Dissatisfied scale that formed a part of the interview schedule were: 1) Does the teacher think that students don't know anything? 2) Does the teacher think that students cheat? 3) Does the teacher think that students can't do things well?

Students' perceptions about the dissatisfaction of teachers in the class are reflected in the following comments.

Student 1: Our teacher is very supportive and she never thinks that we don't know anything. In fact she tells us that students should work according to their strength.

Student 2: Generally, the teacher thinks that we are good students and will understand the concept but she thinks that some students being naughty in nature will cheat and also that good students will do well.

Student 3: No, the teacher thinks that we have some knowledge of the subject. Yes some students are there who can cheat in tests or examinations but the teacher is aware of them and she keeps watch over the students. The teacher is satisfied with our performance in the class.

Student 4: Only when we are unable to respond, the teacher says that we do not know anything but she helps us to understand better so that our responses increase in future. She knows that we can do better if we work hard. I feel that some students cheat during tests and the teacher deals with them strictly.

Student 5: No, the teacher does not think that we do not know anything as we gives answers to her questions. Some students do cheat when the teacher takes written tests. The teacher gives us different duties like making us class monitor, incharge of the class notice board etc. to ensure that we do the job well.

Student 6: Our teacher guides us whenever we fail to respond to her questions and she keeps on reminding us that cheating is bad and we would be bringing harm to ourselves if we do that. She encourages us to work according to our potentialities.

Student 7: No, the teacher never thinks that we do not know anything. She also does not think that we cannot do our work in a proper manner. However she does take care of the weak students who find it difficult to cope up with studies. I have seen that some of the naughty students cheat during class tests.

Student 8: When some students cheat during the class tests, our teacher gets angry and shows her dissatisfaction. She says that students who cheat will not be able to get good marks in examination. She thinks that the intelligent students of the class know all the things and can do their work properly.

Student 9: The, teacher feels that sometimes we do not perform well in this subject but he has faith in us and always keeps on encouraging us to perform better. He thinks that all students can do well and we should not cheat in order to obtain higher marks.

Student 10: Our teacher is happy with us whenever we give right answers for the questions asked by him. He is upset when we do not work properly but most of the times he wishes for our well being.

Student 11: Teacher shows his dissatisfaction only when we do not respond to the questions asked by him. He is satisfied that we do not cheat and discuss the problems openly with him to clarify our doubts.

Student 12: Our science teacher teaches in such an interesting manner that most of the students understand the topic and are able to give answers to the teacher. Our teacher encourages us to satisfy our curiosity and we are able to do the assignments as given by our teacher. However I fell that some students do copy during term tests.

The comments received after interviewing the students suggest that the teachers are not perceived as dissatisfied with the students in a technology-supported classroom setup and they also feel that most of the students do not cheat. The students also indicated that they perceive teachers think that they know the subject and are involved in the classroom activities. However, students did point out that the teachers are aware of which students cheat in their tests and deal with them strictly. Students' responses during interviews were consistent with the low mean score, as reported on quantitative analysis and again the comments supported the construct validity of the Dissatisfied scale.

6.3.7 Admonishing Scale (Mean = 2.47)

The admonishing scale of the QTI measures the extent to which the teacher shows anger/temper and is impatient in class. The result of the quantitative analysis report that the scale had a low mean score which suggests that generally the teachers do not exhibit admonishing behaviour and do not lose their temper immediately. The questions from the Admonishing scale that formed a part of the interview schedule were: 1) Does the teacher get angry quickly? 2) Is the teacher too quick to correct students' when they break a rule? 3) Is the teacher sarcastic?

Students' perceptions about the admonishing behaviour of the teachers in the class are reflected in the following comments.

> *Student 1: No, our teacher doe not get angry quickly. However she will tell us if we have done something wrong but she will not use sarcastic words.*

> *Student 2: On some students she gets angry very quickly, specially the ones who do not study and are always creating trouble. Otherwise she is very calm during her class. She corrects us whenever we make a mistake and does not insult us in the class.*

> *Student 3: It depends, usually the teacher does not get irritated but she does not spare us when we trouble her in the class. She makes the students understand and deals with them in a polite manner.*

> *Student 4: If students create trouble only then she gets angry otherwise she is very patient in listening to our queries and corrects us wherever necessary.*

> *Student 5: Not always, our teacher does not get annoyed every time and too quickly and she does not make bad remarks about the students.*

> *Student 6: Our teacher has a very friendly way of solving problems of students. He gets angry once a while when the students really trouble him or*

when they do not study but he takes care of the situation by making the students realize their mistakes.

Student 7: The teacher does not pass any comments on the students but tries to encourage them to work in a better manner. He corrects our mistakes and we appreciate this quality of his.

Student 8: It is the job of the teacher to correct our mistakes and it helps us not to make such mistakes in future. He does not get angry quickly and neither does he use sarcastic language.

Student 9: No, the teacher has always shown his calm temperament in the classroom and has accepted our feelings. He works with the students to identify their weaknesses and doesn't get angry with them. He also does not use any foul language.

Student 10: He tolerates the things only to a limit and once the limit is crossed, he applies his strictness to control the activities inside the classroom. He corrects our mistakes but never abuses or uses sarcastic language in the class.

Student 11: No, our teacher does not get angry quickly, rather he is always ready to correct us wherever he finds that we need to be put on the right path. He has never been sarcastic to students.

Student 12: We have not noticed any annoyance in our teacher during any activity and he always helps us in improving our behaviour. He does correct us when we do something wrong.

Responses of the students as received through the interview generally suggest that the teachers' behaviour is not admonishing in a technology-supported classroom setting. The teachers do not get angry quickly and also are not sarcastic in their language. However, the students feel that on some occasions the teacher does get angry quickly, if someone creates trouble in the class, and deals with the naughty students in a strict manner. The students' comments are consistent with the low mean score, on this scale and again the construct validity of the Admonishing scale was supported.

6.3.8 Strict Scale (Mean = 3.46)

The Strict scale of the QTI measures the extent to which the teacher is strict and demanding of the students. The high mean score on this scale suggests that teachers are generally strict in the classroom when dealing with students. This is true in the sense that in Indian schools the teacher is the sole authority who decides on the classroom activities and guides the students at each step of the learning process. The questions from the Strict scale that formed a part of the interview schedule were: 1) Is the teacher strict. 2) Does the teacher give difficult tests? 3) Are you afraid of your teacher?

Students' perceptions about the strict behaviour of the teachers in the class are reflected in the following comments.

> *Student 1: Yes, our teacher is strict when it comes to studies. She gives us regular tests and checks our papers thoroughly. No, we are not afraid of our teacher because she deals with the students strictly for their own good.*

> *Student 2: We are not afraid of our teacher but she is strict in the class and if a student is guilty then she scolds him or her. Her tests are generally easy but some questions are tough.*

> *Student 3: Yes, our teacher is very strict and we are sometimes afraid of her when we make noise or do not concentrate on our studies she scolds us. Her tests are difficult to attempt.*

> *Student 4: She is strict sometimes especially when we make mistakes. Otherwise she is friendly in nature. Usually she gives us simple questions to solve in the class but she doest strict marking of answer sheets.*

Student 5: She is strict but shows flexibility in dealing with good students. Tests assigned by her are neither too hard nor so easy so we are not afraid of our teacher.

Student 6: Our teacher is strict but that is only in the class while teaching. His tests are not so hard.

Student 7: Especially, during examination and studies he is very strict, though he assigns easy tests and also we are not scared of our teacher.

Student 8: Our science teacher is strict and always stresses on studies. She gives tough tests and we are sometimes afraid of her anger.

Student 9: If we have not completed our assignment he deals strictly with all of us, His tests are also tough to attempt but we are not afraid of our teacher as we can share our views with him.

Student 10: Yes, he is strict but he teaches science in an interesting manner. His tests are hard and we fear his evaluation which is tough.

Student 11: Our teacher is not so strict and deals with the students in a normal manner. He sets difficult question papers which are longer to attempt but his marking is very objective.

Student 12: The level of strictness depends upon the mood in which the teacher is in the class. He is usually strict with students who do not study. His test papers have difficult questions.

Student 13: Yes, our teacher is very strict. Since we are in a board class, he always stresses on hard work and keeps on taking revision tests. The students in the class know that it is beneficial for them hence they take it sportingly. We are definitely not afraid of our teacher.

The students' interviews reveal that the students perceive the teachers to be usually strict in the class and their tests are also tough. However, the students had a mixed reaction towards being afraid of the teacher. Since most of the academic activities in Indian schools are teacher driven so the teacher has an added responsibility of leading the class and to ensure proper discipline amongst the students. Therefore, the teacher is generally perceived as a strict disciplinarian person. The students' comments are consistent with the high mean score obtained. Their comments support the construct validity of the Strict scale.

To sum up, the construct validity of the QTI has been successfully established in a technology-supported learning environment in the Indian school setting and the students' comments compare with the quantitative data obtained on the different scales of the QTI as reported in Chapter 5.

6.4 COMMENTS FROM INTERVIEWS ON THE ATTITUDE SCALE

The mean for the Attitude scale of TROFLEI for the total sample is provided in the title of below mentioned subsection.

6.4.1 The Attitude Towards Science Scale (Mean=4.0)

The Attitude Towards Science scale of the TROFLEI assesses the attitude of students towards studying science in a technology-supported classroom. Results based on the quantitative data indicate that the mean score of the scale is high, which suggests that students generally have a positive attitude towards studying science and they have a liking for the subject. The questions from the Attitude scale that formed a part of the interview schedule were: 1) Do you look forward to lessons in this class? 2) Is this subject one of the most interesting school subjects? 3) Do these lessons make you interested in this subject?

Students' perceptions about their attitude towards science are reflected in the following comments.

Student 1: Lessons in this subject are very interesting as they involve lot of experiments and investigation and keep me engrossed in the class. Some of the lessons are fun to study.

Student 2: It is most fascinating subject because it helps me to understand the concepts of science and teaches me a lot of new things. Lessons in this subject are very interesting.

Student 3: I am not that much interested in science as my inclination is more towards literature and arts, and I find studying science tedious activity.

Student 4 : I can't think of my life without science, my future academics, my career all depends on how I score in this subject, so I just do not take this subject for granted. It is one of the most interesting subjects in the school

Student 5: Studying Science is real fun. I find the experimentation part very exciting as it helps me investigate and improve my knowledge. I always look forward to attending the science class.

Student 6: I look forward to study lessons in this subject as it is definitely going to open new avenues for me. Science is a very interesting subject and some of the lessons are fun to study.

Student 7: I find this subject most informative as I obtain knowledge not just by cramming from books but from doing experiments in the lab. I enjoy the class.

Student 8: Science is a good subject but somehow I haven't developed a liking for science as I don't like its mathematical part.

Student 9: I look forward to lessons in this subject because besides increasing my knowledge it also helps in sharpening the skills of inquiry and observation. Some of the lessons are very important as they give information about our environment.

Student 10: I like studying science but it involves a lot of hard work as compared to other subjects. I don't like making drawings and find that the vocabulary in science is difficult.

Student 11: It is a very absorbing subject and it really helps me in understanding the subject in a better way especially by doing experiments and verifying various facts and principles. I always look forward to study in this class.

Students' interviews reveal that mostly they are interested in studying science in school and find the subject very interesting. They love the experimental part and look forward to attending these classes. However, some students did suggest their dislike for science was because of the hard work involved. Overall, the interview data suggest a positive attitude in students for studying science in a technology-supported learning environment. These results are consistent with the high mean score, as obtained through the quantitative analysis of questionnaire data. The construct validity of the Attitude scale in TROFLEI is also supported.

6.5 CHAPTER SUMMARY

The results obtained from the interviews report that the students' comments regarding their psychosocial learning environment and their teacher-student interactions in a technology-supported classroom are consistent with the quantitative data results. This shows that the students have understood the meaning of the different scales of the two questionnaires and that such behaviour is exhibited by the students and teachers in a technology-supported learning environment and is measurable. This also supports the construct validity of the two instruments for use in Indian school settings. The students' interviews regarding their attitude towards science also reveal that students in technology-supported classrooms generally have a positive attitude towards this subject and consider it as an important part of their academic portfolio.

In the next chapter, the conclusions drawn for the study, the limitations of the study and scope for future research have been outlined.

CHAPTER 7

CONCLUSIONS

7.1 INTRODUCTION AND OVERVIEW OF THE THESIS

In modern times, technology has invaded our lives to such an extent that it is almost difficult to imagine any intellectual, industrial, economic, recreational, developmental, scientific, organizational and personal activity without the involvement of technology in some way or other. Technology has also invaded the field of education and is being regarded as a tool having immense educational possibilities. Technology has the potential to influence each and every aspect of education and its applications are clearly visible and expanding with respect to classroom teaching. Technology today, is becoming an integral part of the curriculum in schools and is proving to be a useful tool in the hands of the teacher in providing information and knowledge, improving the quality of student-teacher interaction and thereby, encouraging student participation in the learning process which is difficult to sustain in the case of conventional classroom teaching especially in over-crowded classes like the ones we have in India.

Technology in education refers to the use of computers, televisions, educational software, multimedia projectors, etc. during different stages in the instructional process. Technology may be used in different modes. Some of these are drill and practice, tutoring, instructional gaming and problem solving, simulation, word-processing, data-base management and multi-media interactive modes. The use of technology in classroom activities has its own characteristics and assumptions and is based on systematic and scientific techniques which involve a team-approach requiring teachers, graphic artists, computer specialists and educational technologists. A technology-supported classroom has several advantages but at the same time, it also has some limitations which are in the process of being minimized with new developments in this field.

Even though, studies and experiments involving technology usage have been conducted in other countries and also in India, yet the status of research in our country with respect to instructional uses of technology at the school stage can at best be described as in "infancy". This is primarily so because the instructional use of technology in our country at the school stage started late (in the year 1984 to be precise) when project CLASS was started in senior secondary schools and computers were introduced in schools. At present, the number of schools with computers in our country is quite large. Even where available, computers have mostly been used for learning computer languages rather than as tools of learning in the actual classroom settings especially in the state of Jammu and Kashmir situated in the northern part of India, where technology-supported infrastructure in schools is almost negligible and no research study concerning technology effectiveness in classrooms has been conducted. I was, therefore, motivated to undertake the present study in view of the above considerations.

The main objective of this study was to understand the impact of the use of technology in teaching science at the secondary level in a school in Jammu by understanding the psychosocial learning environments in a technology-supported science classroom and to determine its effectiveness in terms of selected learner outcomes. The study also described and analysed the teacher-student interactions in a technology-supported science classroom by exploring relationships between different variables that may affect such classrooms. The methodology of the study can be described as being quantitative in nature in which the questionnaire survey method has been extensively employed and the use of inferential statistics has been made to deduce results. The sample for the study consisted of 705 students from 15 science classes from grades six to 11, spread in the age group of 11 to 17 years. The reliability and validity of the questionnaires used in the study was established and their associations with learner outcomes like attitude towards science, academic efficacy and academic achievement were assessed. The methodology was also qualitative as the construct validities of the questionnaires were also established by analysing the results obtained through student interviews. Gender differences were also studied in the technology-supported learning environment.

7.2 MAJOR FINDINGS OF THE STUDY

The major findings of the present study are presented in relation to the research aims and objectives as stated in Chapter 1 under section 1.5. These findings are reported in the following subsections.

7.2.1 Research Objective 1:

To determine the reliability and validity of the modified form of the Technology–Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) for use with urban Indian secondary school students.

The TROFLEI was being used for the first time in India to assess the psychosocial learning environment in a technology-supported classroom hence it was modified to suite Indian school settings. For this purpose a new scale of Technology Teaching was developed and before the instrument could be tested for validity and reliability the inter-correlations of the newly developed scale with other scales of TROFLEI were determined. It was found that that all the scales were positively correlated with each other and that the inter-correlations were significant ($p<0.001$) as described in Chapter 4 of the thesis.

Three indices for scale reliability and validity were generated for both the Actual and Preferred Forms of the TROFLEI. The Cronbach alpha reliability coefficient was used as an index of scale internal consistency that indicates the reliability of the test items relative to other test items which are designed to measure the same construct of interest. Analysis of variance (ANOVA) results were used as evidence of the ability of each scale in the Actual Form to differentiate between the perceptions of students in different classrooms. A discriminant validity index (namely, the mean correlation of a scale with other scales) was used as evidence that each TROFLEI scale measures a separate dimension that is distinct from the other scales in this questionnaire. Using the individual student as the unit of analysis the alpha reliability values for the TROFLEI ranged from 0.67 for the Student Cohesiveness scale to 0.85 for the Equity scale in the Actual Form and 0.70 for the Differentiation scale to 0.86 for the Technology Teaching scale in the Preferred Form. The reliability results of the TROFLEI were consistently above 0.50. This suggested that TROFLEI can be considered a reliable tool (De Vellis, 1991) with Indian school students in a technology-supported classroom.

As reported in Chapter 4, the discriminant validity results (mean correlation of a scale with other scales) for the nine scales of the TROFLEI ranged from 0.34 for differentiation scale to 0.51 for the Cooperation scale in the Actual Form and between 0.34 for the Differentiation scale to 0.55 for the Cooperation scale in the Preferred Form of TROFLEI. These values suggest that the scales have discriminant validity but overlap somewhat. The analysis of variance (ANOVA) was used to determine the ability of the actual version of each TROFLEI scale to differentiate between the perceptions of students in different classes. The one-way ANOVA for each scale involved class membership as the independent variable and the individual student as the unit of analysis indicated that all the nine TROFLEI scales differentiate significantly between classes ($p<0.001$). Thus, students within the same class perceive the environment in a relatively similar manner, while the within-class mean perceptions of the students vary between classes. The eta^2 statistic (an estimate of the strength of association between class membership and the dependent variable) ranged from 0.09 for the Cooperation scale to 0.23 for the Teacher Support scale in the Actual Form of TROFLEI.

In order to further validate the modified TROFLEI questionnaire in the Indian setting, a factor analysis was carried out on the data collected. Principal components factor analysis followed by varimax rotation confirmed a refined structure of the Actual and Preferred Forms of the TROFLEI comprising of 72 items in nine scales as reported in Chapter 4. Nearly all of the 72 items have a loading of at least 0.35 on their *a priori* scale for the actual version. The overall loadings confirmed the factor structure of the TROFLEI. The results of the three indices and the factor analysis confirmed that the modified version of TROFLEI could be used with confidence in technology-supported science classrooms in Indian settings.

The Attitude Towards Science and the Academic Efficacy scales which are a part of the original TROFLEI were also validated for use in Indian school settings. The scale reliability for the Attitude Towards Science scale was 0.64 and for the Academic

Efficacy scale was 0.66. The reliability results of the two scales were consistently above 0.50. This suggested that these scales could be used as reliable tools (De Vellis, 1991) in Indian classroom settings to study the attitude of students and their academic efficacy.

Apart from the quantitative analysis, the construct validity of the TROFLEI was also supported by the qualitative data obtained by interviewing students using questions from the nine scales of the TROFLEI. The pattern of responses was generally consistent for the all the scales of the TROFLEI as reported in Chapters 5 and 6 of this thesis. This suggests that the TROFLEI is capable of measuring what it intended to measure. Thus the modified TROFLEI was found to be a reliable and valid tool for use with Indian technology-supported science classrooms.

7.2.2 Research Objective 2:

To further validate the Questionnaire on Teacher Interaction (QTI) when used in a technology-supported learning environment.

The results from the study confirm that the QTI is also a reliable and valid instrument for use with Indian school students at the secondary level in a technology-supported learning environment to assess the students' perceptions of their interpersonal relationship with their teachers. In order to determine the reliability and validity of the QTI, the same two statistical computations; the Cronbach alpha coefficient and ANOVA with class membership as the main effect.

As reported in Chapter 4, the alpha reliability coefficients for the different scales of the QTI using the individual as a unit of analysis ranged from 0.51 for the Strict scale to 0.79 for the Leadership scale. The reliability results of the QTI were consistently above 0.50 suggesting that the QTI could be used as a reliable questionnaire in Indian classroom settings (De Vellis, 1991). It was shown in Chapter 4 that the ANOVA results showed that all eight QTI scales differentiate significantly between classes ($p<0.001$, $p<0.01$). The eta^2 scores for the QTI ranged from 0.05 for the Dissatisfied scale to 0.23 for the Student Responsibility/Freedom scale. Therefore, the QTI instrument is able to differentiate between students perceptions in different classrooms. The QTI was further validated for use in Indian settings by finding the inter-correlations between all the eight scales and thus confirming the circumplex model of the QTI as reported in Chapter 4.

Apart from the quantitative analysis, the construct validity of the QTI was also supported by the qualitative data obtained by interviewing students using questions from the eight scales of QTI. The pattern of responses was generally consistent for all the scales of the QTI as reported in Chapters 5 and 6 of this thesis. This suggests that the QTI is capable of assessing the student-teacher interpersonal relationships. Thus, the QTI was found to be a reliable and valid tool for use with Indian technology-supported science classrooms.

7.2.3 Research Objective 3:

To investigate associations of students' perception of a technology-supported learning environment in a science classroom with attitude towards science, academic efficacy and academic achievement.

In order to carry out these investigations a simple and multiple correlation analysis along with the calculation of a regression coefficient was conducted between the nine classroom environment scales of TROFLEI and three student outcomes, i.e. attitude towards science, academic efficacy and academic achievement (the score obtained by the student in the annual examination at the end of the academic year).

The results of this investigation were quite encouraging as it was found that all the nine scales of TROFLEI indicated positive significant associations ($p<0.01$, $p<0.05$) with the Attitude Towards Science scale and the Academic Efficacy scale. The simple correlation values with the attitude scale ranged from 0.09 for the Differentiation scale to 0.42 for the Task Orientation scale. Similarly for the Academic Efficacy scale the values of correlation range from 0.32 for the Student Cohesiveness scale to 0.44 for the Task Orientation and Investigation scales as reported in Chapter 5. Furthermore, for academic achievement, eight out of nine scales of the TROFLEI were statistically significantly and positively associated with students' academic achievement ($p<0.01$) at the individual level of analysis. The values of correlation ranged from 0.11 for the Involvement and Cooperation scales to 0.30 for the Technology Teaching scale.

The multiple correlation (*R*) between students' perceptions as measured by the different scales of the TROFLEI with the Attitude Towards Science scale (R=0.50), Academic Efficacy Scale (R=0.60) and Academic Achievement (R=0.34) were all statistically significant (p<0.001), as reported in Chapter 5. To further analyse the associations between the TROFELI and the three student outcomes a regression coefficient (β) was calculated in order to understand which individual scale of the TROFLEI makes the largest contribution to explain the variance in three student outcomes. The regression coefficient values describe the influence of a particular environment variable on an outcome when all other environment variables in the regression analysis are mutually controlled. For the Attitude Towards Science scale regression coefficient values (β) indicate that five of the nine TROFLEI scales uniquely account for a significant (p<0.001, p<0.01, p<0.05) amount of variance in student attitudes towards science, these are Task Orientation, Investigation, Equity, Differentiation and Technology Teaching at the individual level of analysis. The β values for the significantly associated scales ranged from -0.11 for the Differentiation scale to 0.30 for the Task Orientation scale which shows that although Differentiation scale has a significant association with the attitude scale it is negative. This means that the influence of the differentiation environment variable is opposite to student's attitude towards science, i.e. the more differentiation perceived in the classroom the less the development of a favourable attitude towards science. The newly developed Technology Teaching scale was also found to be positively associated with the attitude scale and has a value of 0.20 which is significant (p<0.001). This again shows that the technology-supported learning environment has a healthy relationship with development of a positive attitude towards science, which in fact is the aim of this study.

As for the attitude scale, standardized regression values were also calculated for the Academic Efficacy scale. Regression coefficient values (β) as reported in Chapter 5, indicate that five of the nine TROFLEI scales uniquely account for a significant (p<0.001, p<0.01, p<0.05) amount of variance in academic efficacy. These are Involvement, Task Orientation, Investigation, Differentiation and Technology

Teaching at the individual level of analysis. The β values for the significantly associated scales ranged from 0.11 for the Investigation scale to 0.21 for the Technology Teaching scale, which is the highest value and is significant at $p<0.001$. All the β values are positive. Again from the data it is clear that the technology-supported learning environment in a science classroom has a positive effect on the academic efficacy of the students and may help in improving their academic efficiency.

Similarly, the regression coefficient values (β) indicate that five of the nine TROFLEI scales uniquely account for a significant ($p<0.001$, $p<0.01$, $p<0.05$) amount of variance in academic achievement, these are Task Orientation, Investigation, Cooperation, Differentiation and Technology Teaching at the individual level of analysis. The β values for the significantly associated scales ranged from -0.11 for the Cooperation scale to 0.20 for the Technology Teaching scale, which is the highest value and is significant at $p<0.001$. The data as mentioned in Chapter 5 show that the values of Cooperation and Differentiation scales are negative which implies that these two scales influence the academic achievement scale in an opposite direction. This is somewhat expected, especially with the Indian classroom settings, as the pressure on students to achieve in the examination is so much that they may not cooperate with other students in the same classroom academically for fear of affecting their grade. Also the teachers who differentiate a lot in the classroom give an idea to the students that the teacher is being partial or biased in his or her approach towards a selected few. These are the probable reasons for negative correlations on these two scales. Data from Chapter 5 also suggest that the technology-supported learning environment in a science classroom may help in improving the academic achievement of the students as both the correlation and regression coefficients have a positive and significant association with academic achievement.

Research Objective 3 of the present study is thus fulfilled as results suggest that the students' perception of a technology-supported learning environment in a science classroom is associated in a significant manner with attitude towards science, academic efficacy and academic achievement.

7.2.4 Research Objective 4:

To investigate associations of students perception of the teacher-student interaction with attitude towards science, academic efficacy and academic achievement in a technology-supported science classroom.

As in Research Objective 3, a simple and multiple correlation analysis along with the calculation of a regression coefficient was carried out between the eight teacher interaction scales of QTI and three student outcomes i.e. attitude towards science, academic efficacy and academic achievement (the score obtained by the student in the annual examination at the end of the academic year).

The data on simple correlation obtained from the investigation as reported in Chapter 5 illustrate that, out of eight scales of the QTI six scales have a significant association with the Attitude Towards Science scale. These scales are Leadership, Helping/Friendly and Understanding which have a positive and significant correlation and Uncertain, Dissatisfied and Admonishing which have a negative and significant correlation. The scales with which there is no association are Student Responsibility/Freedom and Strict. The correlations for the significant scales of QTI range from -0.02 for the Student Responsibility/Freedom scale to 0.30 for the Leadership scale. Similarly, for the Academic Efficacy scale, results of simple correlation reveal that six scales of the QTI have a significant association with the Academic Efficacy scale. These scales are Leadership, Helping/Friendly, Understanding, Student Responsibility/Freedom and Strict which have a positive and significant correlation and Admonishing which has a negatively significant correlation. The scales with which there is no association are Uncertain and Dissatisfied. The correlations for the significant scales of QTI range from -0.08 for the Admonishing scale to 0.23 for the Leadership scale.

Results for the simple correlation of academic achievement data with the QTI scales indicate that only seven of the scales have a significant association with the academic achievement scores. These scales are Leadership, Helping/Friendly, Understanding and Student Responsibility/Freedom, which are positive and Uncertain, Dissatisfied and Admonishing which are negative. The scale with which there is no association is

Strict. The correlations for the significant scales of the QTI range from -0.21 for the Uncertain and Dissatisfied scales to 0.23 for the Understanding scale.

The multiple correlations (*R*) between students' perceptions as measured by the different scales of the QTI with the Attitude Towards Science scale (R=0.34), Academic Efficacy scale (R=0.26) and Academic Achievement (R=0.33) were all statistically significant (p<0.001), as reported in Chapter 5. To further analyse the associations between QTI and the three student outcomes a regression coefficient (β) was calculated in order to understand which individual scale of QTI makes the largest contribution to explain the variance in three student outcomes. For the Attitude Towards Science scale regression coefficient values (β) indicate that two of the eight QTI scales uniquely account for a significant (p<0.001, p<0.01) amount of variance in attitude towards science, these are Leadership with a value of 0.14 and Admonishing with a value of -0.16 at the individual level of analysis. The β value for Admonishing is negatively significant which implies that the admonishing behaviour of the teacher may have a negative influence on the attitude of the students towards science which has to be discouraged.

Regression coefficient values (β) indicate that two of the eight QTI scales uniquely account for a significant (p<0.01, p<0.05) amount of variance in academic efficacy, these are Leadership with a value of 0.19 and Student Responsibility/Freedom with a value of 0.11 at the individual level of analysis. The β value for these two scales is positively significant which implies that the proper academic leadership by the teacher and also giving the students some freedom, opportunity and responsibility would go a long was in improving their academic efficacy.

For the academic achievement data regression coefficient values (β) indicate that four of the eight QTI scales uniquely account for a significant (p<0.001, p<0.01, p<0.05) amount of variance in academic achievement scores, these are Understanding with a value of 0.20, Student Responsibility/Freedom with a value of 0.14, Uncertain with a value of -0.21 and Admonishing with a value of -0.11 at the individual level of analysis. The β value for the two scales is positive and significant which implies that the proper understanding of the students needs and providing them care along with giving the students some freedom, opportunity and responsibility would help in increasing their academic achievement scores.

Thus, the investigation suggests that there are positive associations between students' perception of their teacher-student interaction and their attitude towards science, academic efficacy and academic achievement in a technology-supported learning environment.

7.2.5 Research Objective 5:

To investigate whether gender differences occur in students' perception of their technology-supported learning environment in a science classroom and their teacher-student interaction along with differences in their attitude towards science, academic efficacy and academic achievement in a technology-supported learning environment.

To study gender differences the sample was first analysed and it was found that there were 379 male students which accounted for 53.8% of the total sample and 326 were female students which accounted for 46.2% of the total sample. Both male and female students studied science in a technology-supported environment and had interacted with teachers in their class.

The association between gender differences and technology-supported learning environments was studied by computing their means and standard deviations followed by a significance of the difference between means (t-test), to find out gender difference on the nine scales of the TROFLEI. From the results reported in Chapter 5, out of the nine scales of the TROFLEI only two scales, i.e. Student Cohesiveness with a *t* value of 0.41 and Cooperation with a *t* value of 0.60 were statistically significant (p<0.01). In the two scales, which were statistically significant, females have a higher mean score than males. This meant that female students may show more cohesiveness within their group and help and support one another, also they may exhibit more cooperation with one another on learning tasks in a technology-supported science classroom environment.

The association between gender differences and their perception of the teacher-student interactions was also studied in the same manner and as per the results reported in Chapter 5 that there were no gender differences in their perceptions of the teacher-student interaction in a technology-supported learning environment. Thus, both male and female students perceived their teacher-student interactions in a similar manner, thus signifying homogeneity in the group.

Gender differences on attitude towards science, academic efficacy and academic achievement were studied using the same methodology as mentioned above. The statistical analysis has been reported in Chapter 5 and no gender differences were found. However, the difference between male and female students in academic efficacy was statistically significant with a t value of 1.60 ($p<0.01$). Thus female students may have a greater feeling of efficiency and effectiveness than do male students in academic matters in a technology-supported learning environment.

The findings suggest that some gender differences do exist in the psychosocial environment of technology-supported classrooms as measured by the TROFLEI. On the other hand, no gender differences were visible in the teacher interpersonal behaviour as assessed by the QTI. In terms of learner outcomes, gender differences in favour of female students were reported only on the Academic Efficacy scale.

7.2.6 Effectiveness of the Technology-Supported Classroom

Apart from the specific research objectives laid down for the study, the main aim of this research was to demonstrate the effectiveness of the technology-supported classroom for teaching science at the secondary level. For this purpose a Technology-supported Classroom Evaluation Survey containing 20 items was prepared and administered to a sample of 50 students from 15 classes who had studied science through such a setup and had given responses to the TROFLEI questionnaire earlier. Each item in the survey could be responded in terms of ‘Yes’, ’No’ and ‘Doubtful’ categories. The results obtained are given in Chapter 5 and responses of the students were converted to percentages for interpretation of results. The results of this evaluation suggested that 70 to 80% of the students expressed their satisfaction in studying science through the technology-supported classroom. The found learning in the technology-supported classroom to be interesting, they were more attentive in the classroom, the classroom was livelier and enjoyable, they found answering questions easier and responses to the questions were scored quickly. Overall, they found the classroom atmosphere relaxed and looked forward to studying science through a technology-supported classroom. Sixty to 70% students were of the opinion that they were able to learn faster in a technology-supported classroom. The teacher was able to give better individual attention and students developed a group feeling in such a classroom setup. Also the questions at the end of the lesson were easier to answer as compared to the ones asked by the teacher in the regular classroom. Students also felt that learning science through the technology-supported classroom was not boring and was not a waste of time. However, more that 30% of the students expressed their doubts as to whether they could follow the subject matter easily on the television screen and whether their teacher was more helpful in the technology-supported classroom.

Thus, the effectiveness of the technology-supported classroom in studying science at the secondary level has been demonstrated thereby achieving the overall aim of the study.

7.3 IMPLICATIONS OF THE STUDY

The present study has yielded results which have important implications for the introduction of information and communication technologies for the teaching of science at the secondary level in Jammu, India. The results of the present study have conclusively shown that the technology-supported classroom approach was preferred for studying science by the students. This calls for more efforts on the part of educators and educational technologists to interface technology in a practical manner with the teaching of science at the secondary stage so that it could effectively be used as a tool of learning for students in Indian classroom situations. Till now, technology in schools has been mainly in the form of computers, which are being used as devices for learning programming languages and other computer skills rather than as tools of learning in the classrooms.

The success of the present study calls for diminishing the proverbial 'long' distance between technology and the classroom so as to provide ample opportunities for the students to learn science and other subjects with the assistance of technology. This objective can be practically achieved only when teachers at the school stage, irrespective of the fact whether they are subject teachers or general line teachers, are trained in acquiring requisite skills in using technology be it computers, LCD projectors, digital software, etc with the same familiarity with which they use the text books and black boards in the classroom. The teachers need to develop specific skills to become better facilitators in technology-supported classrooms so that students are able to derive maximum benefits from their exposure to information and communication technology and also contribute towards developing healthy learning environments. This is a gigantic task indeed as the number of such teachers is very large and there is a paucity of good training institutions, expertise, hardware and software facilities as well as sufficient academic and political will to accomplish this laudable objective.

The success of technology in Indian classroom settings will depend to a large extent upon the availability of appropriate software and the right kind and quantity of computers and other hardware equipment to make its coverage extensive for the student community. This will require a great effort both by way of investment and by organizing a large number of expert groups comprising subject specialists, teacher educators, educational technologists, graphic designers, instructional technologists and computer programmers who would be required to go deeply into the ways and means whereby the large content areas in different subjects could be presented in an interesting multimedia mode for the learners of diverse abilities, of different age groups and socio-economic backgrounds in order to provide them the requisite opportunities for drill and practice, interaction, individual attention and on-the-spot feedback (on learner's performance) so that learners may be provided with adequate remedial and enrichment programmes of varying complexities to satisfy both slow learners as well as gifted students. In fact, efforts are needed to make technology-supported science classrooms learner based in the real sense keeping in view diverse learner backgrounds.

From the research point of view, lots of new research studies and innovative efforts will have to be made to keep the various technologies in the classroom up to date in light of new developments and keeping the modern educational requirements in view (e.g., visual and objects oriented approaches with seamless data transportability). It would surely be a great day when educationally relevant technologies emerge as important tools, in the arsenal of Indian teachers, to improve our state of affairs in education and ensure learners experience success and satisfaction in the process. This would also go a long way in making the teaching learning process in overcrowded classrooms more meaningful and learner centered besides changing the traditional role of teacher from the ‘provider’ of information, to the ‘facilitator’ of learning keeping in view the learners’ characteristics, aspirations and special needs.

Results from the present study do favour the enrichment of science teaching through the introduction of technology-supported classrooms in Indian schools. In other words, technology can and should prove to be an effective multimedia aid to strengthen the teaching methodology by helping teachers to provide individual attention, quick feedback and motivation for learners.

The findings of this study also have important implications for research in the field of learning environments as two important tools for assessing learning environments (TROFLEI) and teacher-student interactions (QTI) in a technology-supported environment have been validated for use in Indian school settings. In fact, the TROFLEI questionnaire has been modified for use in Indian schools and has been used for the first time in India. These findings will contribute significantly to the ever expanding field of learning environments and will also encourage researchers in India to take up such research studies as there are hardly any research studies concerning learning environments. Results from investigating the associations between students’ attitudes towards subject, academic efficacy and academic achievement with their technology-supported learning environments and teacher-student interactions suggests that positive associations exist between learner outcomes and their learning environments and if teachers want to improve their interaction with the students and their classroom learning environment, they should ensure that those behaviours that have been found to be empirically linked with the variables in the two instruments, should be present in their classrooms. This study contributed further by highlighting the use of both quantitative and qualitative methods for deeper understanding of the learning environments in a technology-supported science classroom.

7.4 LIMITATIONS OF THE STUDY

The main objective of this research was to study the impact of technology on the psychosocial learning environments of the secondary science classrooms in an Indian school and teacher-student interactions in such classrooms. This study required a technology-based setup to observe the classroom transactions; hence the choice of schools was quite limited. In the city of Jammu, where this study was conducted, the schools had good setups in terms of computer labs but the use of technology for academic activities in the classroom was negligible. Hence, for this reason the study could be undertaken in only one school where technology-supported classrooms were in place for teaching school subjects. More such schools would have added to the richness of this study as then cross cultural factors could have been studied.

One of the limitations of this study was that the sample size was small as only one school was involved and also the number of teachers was few, otherwise this study could have provided more information on the extent of teacher-student interactions in multiple schools. Another limitation of the study was the availability and access to technology-supported classrooms. Such a setup was not available in all the classes in the school in which this study was undertaken, thus a lot of time was consumed in arranging different classes in limited number of rooms available for the purpose. This research study also involved training the teachers in the use of technology which was a difficult task as pre-trained teachers who could be readily used for teaching through a technology-based setup were not available.

Although the statistical analysis of the questionnaire suggested that the TROFLEI and QTI were valid tools for use in Indian classrooms it was felt that due to the large number of questions students might have found responding to them a cumbersome activity and also there could be some words which the students might not have understood. This was overcome to some extent because after preliminary administration of the questionnaires, efforts were made to correct and improve those questions to which the students did not respond well.

7.5 DIRECTIONS FOR FUTURE RESEARCH

The present research, being the first of its kind to study the learning environments of technology-supported science classrooms in an Indian school setting and to understand the teacher-student interactions in such classrooms, is an important beginning to realize the importance of technology in improving the standard of science education in Indian schools, in terms of improvement in student achievement and disposition towards the learning of science. The results obtained from the study convincingly bring out the value of the technology-supported learning environments. However, the investigator is convinced that much work remains to be done in order to fully realize the potential of technology-supported classrooms in both developed and developing countries. It is therefore important that future research studies should be directed to tap this fertile area for improving the state of teaching and learning science in schools in general. On the basis of the results obtained in the present study important implications emerge for the improvement of the system of day-to-day classroom teaching and modifying teacher and student behaviour so that learning of science becomes a pleasurable activity rather than a painful process based on rote learning. Some of the probable areas of research which invite attention are as follows:

- It would be worthwhile replicating the present study involving a larger sample selected from several schools including more teachers and students from varied cultural backgrounds and from other states and regions of India. This would help in further establishing the reliability and validity of the learning environment instruments and also demonstrate the relative effectiveness of the use of technology in teaching science. On the basis of results from these studies, it would be possible to provide valuable inputs to various government agencies responsible for the promotion of education in different parts of India, managements of various educational institutions and practitioners of education, to seriously consider incorporating modern educational technologies for improving the teaching-learning process in the classrooms at various levels of school education.

- A fertile area for future research would be to develop customized learning environment instruments, taking into consideration the learning styles, orientations to learning, learning disabilities and cognitive styles of students at different levels of education in Indian and other cross-cultural settings. The investigator feels that there is still great scope for future research in the adaptation and translation of the TROFLEI, the QTI and other learning environment instruments into various Indian languages. This would go a long way in providing wider coverage of these learning environment instruments and contribute to the richness of data collected in diverse cultural settings in India. This could then be extended to other countries as well.

- The present study has demonstrated the effectiveness of the technology-supported classroom setup in studying science at the secondary level. Future research studies could also be directed to establish the effectiveness of technology in imparting instructions in other school subjects such as mathematics and social sciences, etc. In fact, effectiveness in teaching of languages such as English, Hindi and other Indian languages could also be enhanced through a technology-supported classroom.

- Another important direction which emerges from this study is to have research studies conducted using the technology-supported classrooms at the pre-school, primary, higher secondary and college levels, thereby enlarging its scope to cover varied target groups with different learning needs in diverse educational environments.

- An important area for future research in imparting education through the use of technology is to ensure the integration of various information and communication technologies with the school curriculum in such a manner that using technology for teaching comes naturally to teachers. This would involve the development of training modules based upon research evidence to prepare teacher educators, prospective, and in-service teachers to enable them to utilize the potential of technology-supported classrooms and maximizing learning outcomes.

- Future research studies need to be conducted in order to further enrich the technology learning environments in schools. Apart from ensuring effective usage of existing technologies, this may include evaluating new technologies, both available and emerging, which could be successfully integrated and used in classroom situations. It would also be interesting to conduct experiments involving virtual classrooms and online learning systems, etc. The use of future technologies like Tele-Immersion (enabling users in different locations to collaborate in a shared, simulated environment as if they were in the same physical room.) and interaction in virtual spaces also hold exciting possibilities in the field of technology-supported learning environments.

- Research studies are also needed to evolve and test the efficacy of new methods of assessment in technology-supported classrooms. One such example could involve the use of wireless handheld devices to enable the students to respond to questions asked by the teacher in between or after the lesson is taught. This would allow real-time monitoring of the effectiveness of teaching and also ensure quality of learning outcomes.

- Another important area that needs to be researched in the light of the results of the present study is the system of teacher education in India which needs to be reformed in light of modern educational requirements in terms of making the teachers more effective in the use of technology-supported classrooms. Further research studies need to be undertaken to evaluate the instructional strategies employed by the teachers when using technology for teaching purposes. It would also be useful to look into the development of instructional material and manuals for use by teachers and students as most of the teachers prepared by the teacher training institutions, especially in

India, are generally raw in the use of technology. This could have major implications for the teacher education system.

- Lastly, future research studies using technology-supported learning environments should explore possibilities for developing scientific creativity amongst students and teachers and enhance their creative potential. The aim of such studies should be to bring out new, novel and innovative styles of teaching and learning which are not only beneficial to a selected few but also to the educational community as a whole, helping prepare the 'citizens of future'.

7.6 CONCLUSION AND SUMMARY

A major contribution of the present study is the modification and validation of a widely-applicable and distinctive questionnaire (TROFLEI) for assessing students' perceptions of their actual and preferred classroom learning environments in a technology-supported secondary science classroom in Jammu, India. This questionnaire has been used for the first time and its reliability and validity was established in an Indian school situation. The Questionnaire on Teacher Interaction (QTI) was used along with the TROFLEI to study the students' perception of teacher interpersonal behaviour in a technology-supported learning environment and its reliability and validity was also established. This research, by examining the learning environment and its impact on student attitudes towards science, academic efficacy and academic achievement, has the potential to provide information to teachers on how technology can be used in creating a healthy learning environment and promoting improved learner outcomes. The construct validity of the TROFLEI and the QTI was also supported by the interview data collected from the students.

The reactions of students towards studying science through the technology-supported classroom were also investigated and students expressed the opinion that they found learning science to be more fun and a more enjoyable activity than in the regular classroom. They were more relaxed and were able to learn faster. The implications for teachers as outlined in this study suggest that teachers should use technology in order to create a healthy learning environment which promotes learning and improves teacher-student relationship, ultimately affecting the overall quality of the teaching learning process. The findings of this research can be broadly applied to the study of the learning environments in areas other than science such as mathematics, English, social sciences and regional languages etc. by researchers and practitioners of education.

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APPENDICES

APPENDIX A

Curtin University of Technology

Questionnaire on Teacher Interaction

Student Questionnaire

This questionnaire asks you to describe the behaviour of your teacher.

This is NOT a test.
Your opinion is what is wanted.

This questionnaire has 48 sentences about the teacher. For each sentence, circle the number corresponding to your response. For example:

	Never				Always
This teacher expresses himself/herself clearly.	1	2	3	4	5

If you think that your teacher always expresses himself/herself clearly, then circle 5

If you think your teacher never expresses himself/herself clearly, then circle 1

You also can choose the numbers 2, 3 and 4 which are in-between.

If you want to change your answer, cross it out and circle a new number.

Please answer all questions.

Thank you for your cooperation.

Class ____________________ Roll No___________________ Age ___________

Subject:

School:

Sex : ◯ Male ◯ Female

QTI (contd.)

		Never				Always
1.	This teacher talks enthusiastically about her/his subject.	1	2	3	4	5
2.	This teacher trusts us.	1	2	3	4	5
3.	This teacher seems uncertain.	1	2	3	4	5
4.	This teacher gets angry unexpectedly.	1	2	3	4	5
5.	This teacher explains things clearly.	1	2	3	4	5
6.	If we don't agree with this teacher, we can talk about it.	1	2	3	4	5
7.	This teacher is hesitant.	1	2	3	4	5
8.	This teacher gets angry quickly.	1	2	3	4	5
9.	This teacher holds our attention.	1	2	3	4	5
10.	This teacher is willing to explain things again.	1	2	3	4	5
11.	This teacher acts as if she/he does not know what to do.	1	2	3	4	5
12.	This teacher is too quick to correct us when we break a rule	1	2	3	4	5
13.	This teacher knows everything that goes on in the classroom	1	2	3	4	5
14.	If we have something to say, this teacher will listen.	1	2	3	4	5
15.	This teacher lets us boss her/him around.	1	2	3	4	5
16.	This teacher is impatient.	1	2	3	4	5
17.	This teacher is a good leader.	1	2	3	4	5
18.	This teacher realises when we don't understand.	1	2	3	4	5
19.	This teacher is not sure what to do when we fool around.	1	2	3	4	5
20.	It is easy to pick a fight with this teacher.	1	2	3	4	5
21.	This teacher acts confidently.	1	2	3	4	5
22.	This teacher is patient.	1	2	3	4	5
23.	It's easy to make this teacher appear unsure.	1	2	3	4	5
24.	This teacher makes mocking remarks.	1	2	3	4	5
25.	This teacher helps us with our work.	1	2	3	4	5
26.	We can decide some things in this teacher's class.	1	2	3	4	5
27.	This teacher thinks that we cheat.	1	2	3	4	5
28.	This teacher is strict.	1	2	3	4	5
29.	This teacher is friendly.	1	2	3	4	5
30.	We can influence this teacher.	1	2	3	4	5
31.	This teacher thinks that we don't know anything.	1	2	3	4	5
32.	We have to be silent in this teacher's class.	1	2	3	4	5
33.	This teacher is someone we can depend on.	1	2	3	4	5
34.	This teacher lets decide when we will do the work in class.	1	2	3	4	5
35.	This teacher puts us down.	1	2	3	4	5
36.	This teacher's tests are hard.	1	2	3	4	5
37.	This teacher has a sense of humour.	1	2	3	4	5
38.	This teacher lets us get away with a lot in class.	1	2	3	4	5
39.	This teacher thinks that we can't do things well.	1	2	3	4	5
40.	This teacher's standards are very high.	1	2	3	4	5
41.	This teacher can take a joke.	1	2	3	4	5
42.	This teacher gives us a lot of free time in class.	1	2	3	4	5
43.	This teacher seems dissatisfied.	1	2	3	4	5
44.	This teacher is severe when marking papers.	1	2	3	4	5
45.	This teacher's class is pleasant.	1	2	3	4	5
46.	This teacher is lenient.	1	2	3	4	5
47.	This teacher is suspicious.	1	2	3	4	5
48.	We are afraid of this teacher.	1	2	3	4	5

APPENDIX B

Modified TROFLEI Questionnaire

INSTRUCTIONS: **Please MARK LIKE THIS ONLY:**

- Use a blue/black biro or 2B pencil
- Do not use red pen or felt tip pen

SECTION A. Background Questions

	Yes	No
Does your family have a computer at home?		
Do you use your computer for school related work?		
Do you have access to the internet at home?		
Would your parent(s) like you to go to university after you leave school?		
Do you intend to go to university after you leave school?		

What type of job would you like when you leave school?
(Fill in ONE oval only or, if your preferred job is not listed, select "Other" and provide details.)

Vet	**Teacher**	**Accountant**	**Businessman**
Doctor	**Journalist**	**Nurse**	**Dentist**
Lawyer	**Builder**	**Chef**	**Model**
Scientist	**Pilot**	**Sportsperson**	**Fashion Designer**
Programmer	**Flight Attendant**	**Physiotherapist**	**Banker**
Actor	**Pharmacist**	**Psychologist**	**Don't Know**
Other *(please Specify)*			

____

____

Class ___________ **Roll No**________________ **Age** _________

Subject:

School:

Sex : **Male** **Female**

Which language do you mainly speak at home?

English **Hindi** **Punjabi** **Urdu** **Kashmiri**

SECTION B.

This section contains statements about practices that could take place in this class. You will be asked how often each practice takes place.

There are no 'right' or 'wrong' answers. Your opinion is what is wanted. Your responses will be confidential.

The actual column is to be used to describe how often each practice actually takes place in your class. The '*Preferred*' column is to be used to describe how often you would like each practice to take place (a wish list).

		ACTUAL					PREFERRED				
SN	**SC**	Almost Never	Seldom	Some times	Often	Almost Always	Almost Never	Seldom	Some times	Often	Almost Always
1	I make friends among students in this class.	1	2	3	4	5	1	2	3	4	5
2	I know other students in this class.	1	2	3	4	5	1	2	3	4	5
3	I am friendly to members of this class	1	2	3	4	5	1	2	3	4	5
4	Members of the class are my friends	1	2	3	4	5	1	2	3	4	5
5	I work well with other class members	1	2	3	4	5	1	2	3	4	5
6	I help other class members who are having trouble with their work	1	2	3	4	5	1	2	3	4	5
7	Students in this class like me	1	2	3	4	5	1	2	3	4	5
8	In this class, I get help from other students.	1	2	3	4	5	1	2	3	4	5
SN	**TS**	Almost Never	Seldom	Some times	Often	Almost Always	Almost Never	Seldom	Some times	Often	Almost Always
9	The teacher takes a personal interest in me.	1	2	3	4	5	1	2	3	4	5
10	The teacher goes out of his way to help me	1	2	3	4	5	1	2	3	4	5
11	The teacher considers my feelings	1	2	3	4	5	1	2	3	4	5
12	The teacher helps me when I have trouble with my work	1	2	3	4	5	1	2	3	4	5
13	The teacher talks with me	1	2	3	4	5	1	2	3	4	5
14	The teacher is interested in my problems	1	2	3	4	5	1	2	3	4	5
15	The teacher moves about the class to talk with me	1	2	3	4	5	1	2	3	4	5
16	The teacher's questions help me to understand the topic	1	2	3	4	5	1	2	3	4	5
SN	**IN**	Almost Never	Seldom	Some times	Often	Almost Always	Almost Never	Seldom	Some times	Often	Almost Always
17	I discuss ideas in class.	1	2	3	4	5	1	2	3	4	5
18	I give my opinions during class discussions.	1	2	3	4	5	1	2	3	4	5
19	The teacher asks me questions.	1	2	3	4	5	1	2	3	4	5
20	My ideas and suggestions are used during class discussions.	1	2	3	4	5	1	2	3	4	5
21	I ask the teacher questions	1	2	3	4	5	1	2	3	4	5
22	I explain my ideas to other students	1	2	3	4	5	1	2	3	4	5
23	Students discuss with me how to go about solving problems.	1	2	3	4	5	1	2	3	4	5
24	I am asked to explain how I solve problems	1	2	3	4	5	1	2	3	4	5

SECTION B (Continued)

		ACTUAL					PREFERRED				
SN	TO	Almost Never	Seldom	Some times	Often	Almost Always	Almost Never	Seldom	Some times	Often	Almost Always
25	Getting a certain amount of work done is important to me	1	2	3	4	5	1	2	3	4	5
26	I do as much I set out to do.	1	2	3	4	5	1	2	3	4	5
27	I know the purpose of studying in this class.	1	2	3	4	5	1	2	3	4	5
28	I am always ready to study in this class.	1	2	3	4	5	1	2	3	4	5
29	I know what I am trying to achieve in this class.	1	2	3	4	5	1	2	3	4	5
30	I pay attention during this class	1	2	3	4	5	1	2	3	4	5
31	I try to understand the work in this class	1	2	3	4	5	1	2	3	4	5
32	I know how much work I have to do.	1	2	3	4	5	1	2	3	4	5
SN	IV	Almost Never	Seldom	Some times	Often	Almost Always	Almost Never	Seldom	Some times	Often	Almost Always
33	I carry out investigations to test my ideas.	1	2	3	4	5	1	2	3	4	5
34	I am asked to think about the evidence for statements.	1	2	3	4	5	1	2	3	4	5
35	I carry out investigations to answer questions coming from discussions.	1	2	3	4	5	1	2	3	4	5
36	I explain the meaning of statements, diagrams and graphs.	1	2	3	4	5	1	2	3	4	5
37	I carry out investigations to answer questions that puzzle me.	1	2	3	4	5	1	2	3	4	5
38	I carry out investigations to answer the teacher's questions.	1	2	3	4	5	1	2	3	4	5
39	I find out answers to questions by doing investigations.	1	2	3	4	5	1	2	3	4	5
40	I solve problems by using information obtained from my own investigations.	1	2	3	4	5	1	2	3	4	5
SN	CO	Almost Never	Seldom	Some times	Often	Almost Always	Almost Never	Seldom	Some times	Often	Almost Always
41	I cooperate with other students when doing assignment work.	1	2	3	4	5	1	2	3	4	5
42	I share my books and resources with other students when doing assignments.	1	2	3	4	5	1	2	3	4	5
43	When I work in groups in this class, there is teamwork.	1	2	3	4	5	1	2	3	4	5
44	I work with other students on projects in this class.	1	2	3	4	5	1	2	3	4	5
45	I learn from other students in this class.	1	2	3	4	5	1	2	3	4	5
46	I work with other students in this class.	1	2	3	4	5	1	2	3	4	5
47	I cooperate with other students on class activities	1	2	3	4	5	1	2	3	4	5
48	Students work with me to achieve class goals.	1	2	3	4	5	1	2	3	4	5

SECTION B (Continued)

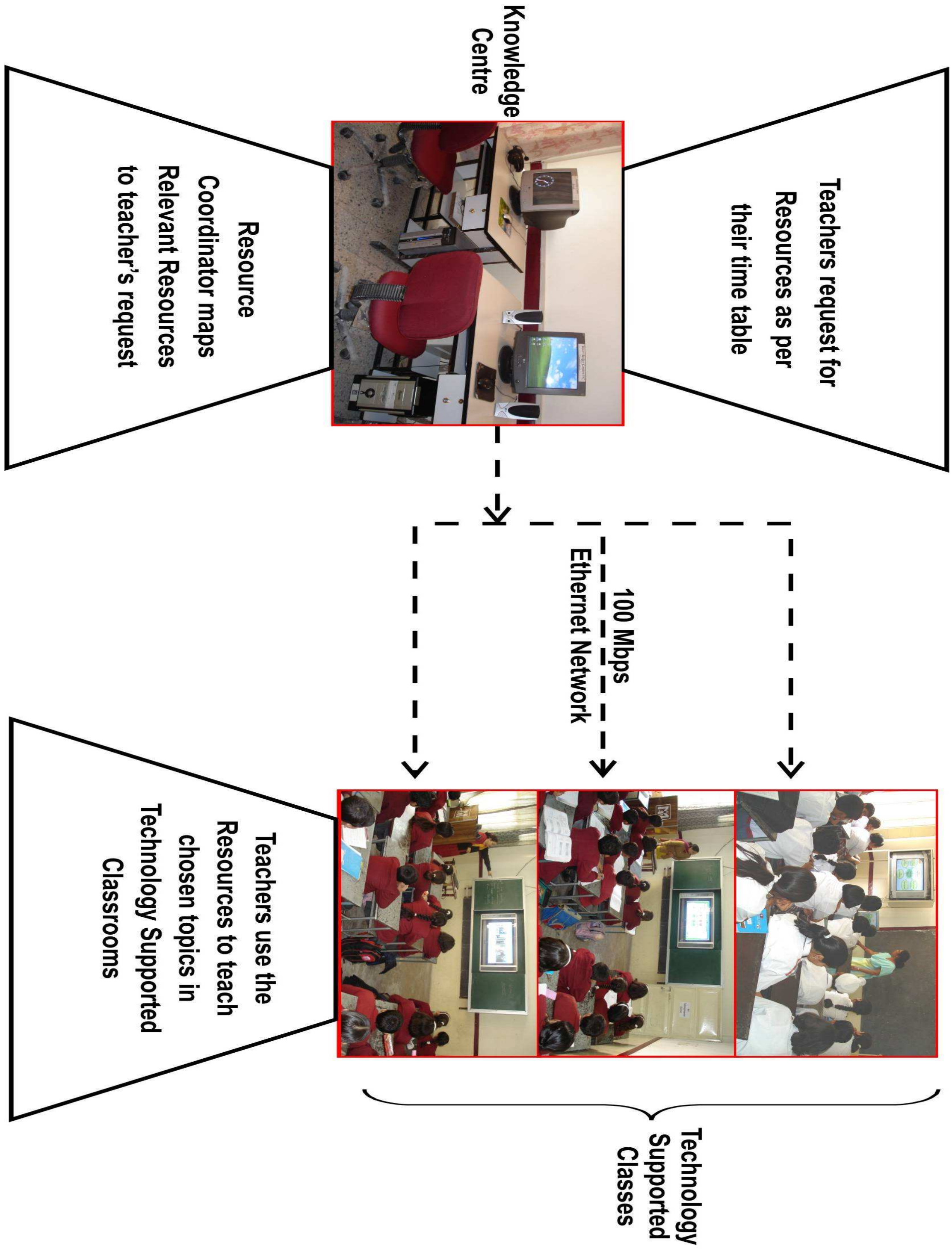
SN	EQ	ACTUAL Almost Never	ACTUAL Seldom	ACTUAL Some times	ACTUAL Often	ACTUAL Almost Always	PREFERRED Almost Never	PREFERRED Seldom	PREFERRED Some times	PREFERRED Often	PREFERRED Almost Always
49	The teacher gives as much attention to my questions as to other students' questions.	1	2	3	4	5	1	2	3	4	5
50	I get the same amount of help from the teacher as do other students.	1	2	3	4	5	1	2	3	4	5
51	I have the same amount of say in this class as other students.	1	2	3	4	5	1	2	3	4	5
52	I am treated the same as other students in this class.	1	2	3	4	5	1	2	3	4	5
53	I receive the same encouragement from the teacher as other students do.	1	2	3	4	5	1	2	3	4	5
54	I get the same opportunity to contribute to class discussions as other students.	1	2	3	4	5	1	2	3	4	5
55	My work receives as much praise as other students' work.	1	2	3	4	5	1	2	3	4	5
56	I get the same opportunity to answer questions as other students.	1	2	3	4	5	1	2	3	4	5
SN	**DI**	**Almost Never**	**Seldom**	**Some times**	**Often**	**Almost Always**	**Almost Never**	**Seldom**	**Some times**	**Often**	**Almost Always**
57	I work at my own speed.	1	2	3	4	5	1	2	3	4	5
58	Students who work faster than me move onto the next topic.	1	2	3	4	5	1	2	3	4	5
59	I am given a choice of topics.	1	2	3	4	5	1	2	3	4	5
60	I am given tasks that are different from other students' tasks.	1	2	3	4	5	1	2	3	4	5
61	I am given work that suits my ability.	1	2	3	4	5	1	2	3	4	5
62	I use different materials from those used by other students.	1	2	3	4	5	1	2	3	4	5
63	I am assessed in a different manner from other students.	1	2	3	4	5	1	2	3	4	5
64	I do work that is different from other students' work.	1	2	3	4	5	1	2	3	4	5
SN	**T T**	**Almost Never**	**Seldom**	**Some times**	**Often**	**Almost Always**	**Almost Never**	**Seldom**	**Some times**	**Often**	**Almost Always**
65	I find learning science in the technology classroom interesting.	1	2	3	4	5	1	2	3	4	5
66	I am able to learn faster through the technology classroom.	1	2	3	4	5	1	2	3	4	5
67	I am more attentive in the technology classroom.	1	2	3	4	5	1	2	3	4	5
68	I find the technology supported science class to be lively.	1	2	3	4	5	1	2	3	4	5
69	I am able to get additional information and update my knowledge in the technology classroom.	1	2	3	4	5	1	2	3	4	5
70	I find the audio and visual effects in the content matter to be appealing.	1	2	3	4	5	1	2	3	4	5
71	I am motivated to learn further in the technology classroom.	1	2	3	4	5	1	2	3	4	5
72	I look forward to learning science through technology classroom.	1	2	3	4	5	1	2	3	4	5

SECTION B (Continued)

SN	AS	ACTUAL: Almost Never	Seldom	Some times	Often	Almost Always
1	I look forward to lessons in this subject.	1	2	3	4	5
2	Lessons in this subject are fun.	1	2	3	4	5
3	I dislike lessons in this subject.	1	2	3	4	5
4	Lessons in this subject bore me.	1	2	3	4	5
5	This subject is one of the most interesting school subjects.	1	2	3	4	5
6	I enjoy lessons in this subject.	1	2	3	4	5
7	Lessons in this subject are a waste of time.	1	2	3	4	5
8	These lessons make me interested in this subject.	1	2	3	4	5
SN	**SSE**	**Almost Never**	**Seldom**	**Some times**	**Often**	**Almost Always**
9	I find it easy to get good grades in this subject.	1	2	3	4	5
10	I am good at this subject.	1	2	3	4	5
11	My friends ask me for help in this subject.	1	2	3	4	5
12	I find this subject easy.	1	2	3	4	5
13	I outdo most of my classmates in this subject.	1	2	3	4	5
14	I have to work hard to pass this subject.	1	2	3	4	5
15	I am an intelligent student.	1	2	3	4	5
16	I help my friends with their homework in this subject.	1	2	3	4	5

APPENDIX C

Technology-Supported Classroom Setup



APPENDIX D

SURVEY OF STUDENTS' REACTIONS TOWARDS LEARNING SCIENCE IN A TECHNOLOGY-SUPPORTED CLASSROOM

1) I found learning Science through technology classroom interesting.
Yes/No/Doubtful.

2) I was able to learn faster through technology-supported classroom.
Yes/No/Doubtful.

3) I was more attentive while learning in technology classroom that what I am in the classroom. Yes/No/Doubtful.

4) I felt that I was getting better individual attention in the technology-supported classroom. Yes/No/Doubtful.

5) I could follow the subject matter on the television screen easily than the text book.
Yes/No/Doubtful

6) I found remembering facts in science easier after studying in the technology classroom. Yes/No/Doubtful

7) I found teaching of science by the teacher to be livelier in technology classroom.
Yes/No/Doubtful

8) Responses to questions were scored quickly in the technology classroom.
Yes/No/Doubtful

9) The knowledge of results was very motivating for me to study science in the technology classroom Yes/No/Doubtful

10) The teacher was able to correct my mistakes in an effective manner.
Yes/No/Doubtful

11) Learning through technology class was an enjoyable activity as compared to regular classroom. Yes/No/Doubtful

12) The atmosphere while studying science through the technology classroom was more relaxed than in the regular classroom. Yes/No/Doubtful

13) There was a feeling of group learning in the technology classroom than in the regular classroom. Yes/No/Doubtful

14) The teacher was more helpful in the technology-supported classroom. Yes/No/Doubtful

15) I could revise my lesson better in a technology-supported science classroom. Yes/No/Doubtful

16) I found the questions asked at the end of the topic easy to answer. Yes/No/Doubtful

17) Learning science through technology classroom was very boring. Yes/No/Doubtful

18) I was not afraid of answering questions asked on the television screen as compared to when teacher asks questions. Yes/No/Doubtful

19) I found learning science through the technology classroom to be a waste of time and effort. Yes/No/Doubtful

20) I would look forward to learning science through technology-supported classroom. Yes/No/Doubtful

APPENDIX E

INTERVIEW SCHEDULE OF THE TROFLEI & THE QTI

INTERVIEW SCHEDULE OF THE MODIFIED TROFLEI

1) **Student Cohesiveness**

Q1. Do you make friends with students in this class?
Q2. Do Students in this class like you?
Q3. Do you get help from other students in this class?

2) Teacher Support

Q1. Do you make friends with students in this class?
Q2. Do Students in this class like you?
Q3. Do you get help from other students in this class?

3) Involvement

Q1. Do you make friends with students in this class?
Q2. Do Students in this class like you?
Q3. Do you get help from other students in this class?

4) Task Orientation

Q1. Do you know the purpose of studying in this class?
Q2. Are you always ready to study in this class?
Q3. Do you know how much work you have to do?

5) Investigation

Q1. Do you carry out investigations to answer questions and test your ideas?
Q2. Do you find out answers to questions by investigating?
Q3. Do you solve problems by using information obtained from your own investigation?

6) Cooperation

Q1. Do you cooperate with other students when doing assignment work?
Q2. Do you share your books and resources?
Q3. Do you cooperate with other students on class activities?

7) Equity

Q1. Does the teacher give you as much attention as to other student?.
Q2. Are you given the same opportunity in the class?
Q3. Do you receive the same encouragement from the teacher?

8) Differentiation

Q1. Are you given tasks that are different from other students?
Q2. Are you assessed in a different manner?
Q3. Do the Students who work faster than you move to the next topic?

9) Technology Teaching

Q1. Do you find learning science in the technology classroom Interesting?
Q2. Do you find the audio-visual effects in the content matter to be appealing?
Q3. Do you look forward to learning science in the technology classroom?

INTERVIEW SCHEDULE OF THE QTI

1) Leadership

Q1. Does the teacher know everything that is going on in the class?
Q2. Is your teacher a good leader?
Q3. Does your teacher act confidently?

2) Helping/Friendly

Q1. Does the teacher help you in your work?
Q2. Do you depend upon your teacher?
Q3. Does the teacher allow you to take jokes in the class?

3) Understanding

Q1. Does the teacher trust you?
Q2. Is the teacher willing to explain things again?
Q3. Does the teacher listen to you when you have something to say?

4) Student Responsibility/ Freedom

Q1. Can you influence your teacher?
Q2. Does the teacher give lot of free time in the Class?
Q3. Is the teacher lenient?

5) Uncertain

Q1. Does the teacher acts as if he/she does not know what to do?
Q2. Is it easy to make a fool out of your teacher?
Q3. Is the teacher uncertain?

6) Dissatisfied

Q1. Does the teacher think that students' don't know anything?
Q2. Does the teacher think that students' cheat?
Q3. Does the teacher think that students' can't do things well?

7) Admonishing

Q1. Does the teacher get angry quickly?
Q2. Is the teacher too quick to correct students' when they break a rule?
Q3. Is the teacher sarcastic?

8) Strict

Q1. Is the teacher strict?
Q2. Does the teacher give difficult tests?
Q3. Are you afraid of your teacher?