Introducing Indian middle school students to collaboration and communication centred design and technology education: A focus on socio-cultural and gender aspects

A Thesis

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by

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DECLARATION

This thesis is a presentation of my original research work. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature, and acknowledgement of collaborative research and discussions.

The work was done under the guidance of **Dr Sugra Chunawala**, at the Tata Institute of Fundamental Research, Mumbai.

[Swati Mehrotra]

In my capacity as supervisor of the candidate's thesis, I certify that the above statements are true to the best of my knowledge**.**

[**Sugra Chunawala]** Date:

I dedicate this work to Sensei Ikeda

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CHAPTER 1

INTRODUCTION

This thesis examines Indian middle school students' attitudes towards technology and provides details of development of collaboration and communication centered design and technology (D&T) education units and their trials in three different socio-cultural settings in India. The study first examines students' attitudes towards technology, using survey questionnaires followed by interviews. Development and trials of D&T units followed the survey.

Three D&T units developed were set within the real-life contexts of students and sought to engage in groups, both boys and girls from rural as well as urban areas. For the trials of the units, we followed the modified form of Design-Make-Appraise (DMA) approach that consisted of roughly six steps, which included: investigating and motivating, designing, planning, communicating the design, making and finally evaluating and communication of evaluation.

This thesis focuses on analysis of communication that occurred while students engaged in the D&T units. Both formal (communication intentionally built into the units by researchers) and informal (communication that took place while students worked in groups) communication were analysed, within the broad framework of socio-cultural theory. Apart from students' communication, evidences of student collaboration leading to increase in knowledge were also made.

1.1 Background and motivation

Technology is recognized as 'a complex social enterprise' (AAAS 1993, p. 41), and the nature of the enterprise is far from clear. Technology has slippery boundaries and the meaning of the term itself has evolved over time. According to MacKenzie and Wajcman (1999), technology has three layers of meaning. At the first level, technology refers to physical objects - cars, refrigerator, computers; on the second level it includes human activities - that is, the use of the physical objects; and the third level is the "know-how"- the information required to use, repair, design and produce the physical objects. The common factor tying all the layers of meaning is the involvement of humans (as creators, users). MacKenzie and Wajcman (1999) explain that without human activity, technology is devoid of purpose and reason. In other words, technology that does not serve humanity's purpose is pointless.

The complexity of technology and its multiple meanings are evident in the way people have different ideas about technology and relate to it differently. An important area of research pursued in the domain of technology education is students' understanding of technology and technological concepts and activities. There have been studies in many countries to know students' attitudes towards technology. Most of these studies have been carried out using PATT (Pupils' Attitudes Towards Technology) questionnaire prepared by researchers in the Netherlands in late 1980's (Raat and de Vries, 1985). Later the PATT questionnaire was administered to about 22 countries round the world. The results of the survey show that students have a positive attitude towards technology but their knowledge of basic concepts in technology may be limited. Further these PATT studies have revealed that students see technology as a collection of products that are 'high-tech' and not as processes (de Vries, 1996). It was also found that students ignore social aspects of technology (Rennie and Jarvis, 1995b). Despite the research in the area of finding out students' attitudes towards technology, de Vries (2003) has suggested further need to investigate students' understandings of technology.

In the Indian context a few studies have been conducted that have tried to know students' attitudes towards technology (Rajput et al., 1988; Bhattacharya, 2004). Rajput et al. used the PATT instrument to learn the differences in the rural and urban students' understanding of technology in the state of Madhya Pradesh. The study was useful but there was a need for more in-depth studies. Since Indian schools do not have formal technology education, student's ideas of technology are more likely to be influenced by factors other than school learning such as gender and experiences in school and at home as well as interactions with technological artefacts. The need to carry out an in-depth study of students' attitudes, guided by literature in the area motivated us to develop questionnaires to probe further Indian students' ideas about technology.

1.1.1 Antecedents of Design and Technology Education in the Indian context

In order to understand research done in the area of D&T education in India, we must understand that India does not have a tradition of D&T education at the school level and technology education as engineering is introduced post school. Since the country's independence in 1947, a series of well-conceived policy statements has been announced. They include the Scientific Policy Resolution (1958), The Technology Policy Statement (1983), The National Policy on Education (NPE, 1986), and a series of Industrial Policy Resolution Statements beginning in 1948, the latest being Science and Technology Policy (2003). It is generally accepted that science, technology, and education are critical ingredients for national economic and social development. The New Policy on Education (NPE, 1986) put forth by the Indian Government recognized the importance of technology for personal and social development that led to the National Curriculum Framework (NCF, 2000) introducing 'Science and Technology' textbooks at the secondary school level. These books presented technology in the paradigm of applied science. This treatment of technology had a negative potential for meeting specific, learning objectives of both science and technology (Ramadas, 2003). Later (NCF, 2005), these Science and Technology books were renamed as 'Science' books.

If we look at the history of education in India, manual crafts (which had some design component) have had an importance place in society. There have been schools based on Gandhi's philosophy of *Nai Talim* that have emphasized arts and crafts in their curriculum for unified process of living and learning. The Education Commission reoriented the *Nai Talim* program to activities that catered to the needs of science and technology (S&T) based society. So in the lower primary grades activities such as paper-cutting, clay modelling, needlework and kitchen gardening were introduced while activities such as pottery, weaving, model making were offered as choices for upper primary grade students. The higher secondary students (Grade XI and XII) were provided actual work experience in workshops, farms and commercial establishments. These activities had a design component but its integration within the subject was superficial. Learning and mastering of skills was given importance in all these activities. However today there does not exist a single school that has followed this philosophy meaningfully (Paranjape, 1999).

Apart from reorientation of Basic Education scheme (*Nai Talim*), SUPW (Socially Useful Productive Work), art, crafts were introduced as separate subjects for school students. Most of these subjects emphasised more on skills and less on content knowledge. Apart from the above-mentioned subjects that were included in the regular stream of study, the vocational and technical education was a separate stream. The vocational and technical stream had a target to enrol about 25% of higher secondary students (NPE, 1986) but in reality, even in the year 2000, the enrolment achieved was merely 5%. One of the reasons for this state of affairs is that the vocational stream has been accorded a low status in the Indian education system (a stream not meant for ‘bright’ students). According to Natarajan (2004), in India elements of technology were included in the curriculum in a piecemeal fashion. Technology education in whatever form it exists today has a mixed identity.

1.2 Gender and technology

There is a disproportionately low involvement of females at all levels of technology (Weber and Custer, 2005) and the contribution of women to the field of technology is by and large invisible. Technology is often seen as complicated and “high-tech”, and unsuitable for women. Women appear to play the role of users and consumers alone and not that of designers and developers of technology. Their areas of contribution, like child rearing, housekeeping, nutrition and agriculture, have been deemed to be either non-technological or low in technology (Wajcman, 1991).

Technology is a gendered subject, where males outnumber females in most of the countries in the world. Layton (1993, p. 33) suggests, ‘… “gendering” of experience is nowhere more obvious than in technology’. Engineering, just as science and mathematics, is seen as a masculine profession (Chunawala and Ladage, 1998; Rosser, 1992; Harris, 1997). Despite efforts to make the study of technology an integral part of all students’ general education, it is still perceived to be a male subject (Gloekner and

Knowlton, 1996). In India women form a small part (about 22% at graduate level) of the technology/engineering community in India (INSA report, 2004) and of those who clear engineering examination over 30% remain unemployed (Parikh and Sukhatme, 2004).

S&T is also intertwined with gender through the medium of language. Several researchers (Gurer and Camp; Cohn etc.) have pointed out that the language use in technology is "gendered". Cohn (1987) analysed the language used in technology related teaching courses and found it laden with gendered imagery.

Technology is a social endeavour, involving both men and women so there needs to be systematic efforts to include all students in the study of technology and make it meaningful for them. Technology education offers one of the ways in which young children could be provided a holistic picture of technology. However, there is no single reform that will quickly transform the study of technology so that it becomes more attractive and attentive to the needs and interests of girls and young women. Both the examination and reformation of technology education must be comprehensive and systemic due to the diverse factors that shaped the current state-of-affairs over time (Welty, 1996).

According to John Gilbert (2005), three sets of reasons underpin the introduction of technology education at the school level and these include: economic, social and educational. The growing importance of technology in all the spheres of life has made it imperative that we have a formal program of study introduced for children at a young age. Despite its apparent importance, technology education has not gained a strong foothold in the school curriculum in many countries of the world. This is especially true for India.

Thus there is a need to introduce D&T education at the school level that encourages both boys and girls to participate in technology and also to reform the existing technology activities. This can be done by making technology education classroom activities collaborative and introducing scope for communication so that both girls and boys, as well as students from different socio-cultural settings can associate themselves with it and find them meaningful and acceptable rather than a compulsion.

1.3 Collaboration and communication for inclusive technology education

Humans naturally have a tendency to work in groups and in our social interactions with others, we communicate - attempt to transmit our ideas, thoughts and emotions to others through verbal and non-verbal ways. Language (which could be verbal or non-verbal) plays an important role in mediation and negotiation in technological activities (Medway, 1994). Vygotsky (1978) has emphasized the role of language in his theory of development of cognitive functioning. According to him language is a dominant psychological tool for seeing, talking, acting and thinking. Language is used to accomplish ways of representing ideas, interpreting and evaluating events and experiences, and constructing explanations. In a technological activity, ideas may be expressed through modelling, discussions, drawings, diagrams, gestures etc. These actions afford opportunities for participants to contribute to the clarification and modification of the artifact under construction mediated by the use of language as well as tools (Rowell, 2002). In the real world of technological activity, 'despite differences among individual interpretations and constructions and among object worlds, participants do communicate, negotiate, and compromise; in short, they design' (Bucciarelli 1994, p. 81).

Despite demonstrated importance of talk, socialization and teamwork for all round development, there is limited appreciation that skills needed for collaboration need to be deliberately fostered in the context of classroom activities. There is lack of studies done in the classroom environment that focus on communication and collaboration aspects. There is a need for research in the existing classroom contexts with students engaged in meaningful tasks that can be done collaboratively.

D&T activities provide a potentially rich environment for fostering collaborative learning - both, for expression and accommodation of individual perspectives as well as providing opportunities for group work. According to Hendley and Lyle (1996), interactions and discussions within collaborative groups help students in developing many skills that are desired and are outlined in curriculum in various countries. They further consider ‘classroom talk’ to be a key factor in development of some important skills: namely critical thinking, reflection and evaluation.

At the international level it is accepted that technology education plays an essential role within the school education system that aims to prepare technologically literate citizens in ‘an increasingly complex technological world with diminishing natural resources’ (Mawson, 2003, p. 2). There have been various approaches that have guided the technology education curriculum in different countries around the world that have technology education at the school level. For instance, in the UK, the technology education curriculum has been derived from the arts and the craft curriculum while in the US the precursor of technology education has been industrial arts. The technology education curriculum in Australia is largely influenced by UK model. In all these approaches, collaboration and communication, though mentioned in the curriculum in the form of “key skills” do not get translated into classroom practices to produce joint outcomes (Hennessy and Murphy, 1999). There is a need for research that can feed into pedagogy the ways in which collaboration can be encouraged in the existing classroom practices.

1.4 Our study

In the view of introducing Indian middle school students to technology education, we developed three technology education units that were collaboration and communication centered and followed the modified form of DMA approach as suggested by Kimbell (1994). After developing the units, we wanted the units to go beyond our laboratory setting to actual classrooms and hence trials of the units were conducted in three socio-cultural settings with students from different backgrounds such as urban, rural, and different media of instruction in school such as Marathi and English. We conceptualized technology in our units to involve knowledge and skills that go beyond the classroom experiences to the real-life situations of the participants and wanted to situate the learning of technology in ‘authentic environments’ rather than in abstract and highly specialized kind of technology. Technology was seen in our units as a collaborative learning platform on which all the units were situated. We followed the socio-cultural and the shared cognition approach to studying technology. These approaches emphasize the importance of humans as well as the environment in which the technological processes take place. Our study was conducted in 3 phases and these are as follows:

Phase 1: Survey of students' ideas about technology. Before developing the units, we wanted to know students' conceptions of technology. According to Lewis (1999, p.45), 'understanding the conceptions (and misconceptions) that students have about aspects of technology is an important prerequisite for developing better teaching methods and improving learning in this area'. We developed survey questionnaires to identify students' ideas about technology and conducted interviews on a sub-sample. The survey study also served as a motivational vehicle for us.

Phase 2: Development and trials of three D&T units that were collaboration and communication centred, and which were situated in the real-life experiences of the students and the contexts they came from, i.e. all the units were contextualized in such a way that students in different socio-cultural settings could associate themselves with it. Trials of the units were conducted in 3 socio-cultural settings – the urban English, the urban Marathi and the rural Marathi medium settings. In each of the three settings, the units were tried at different times. The trials in each setting were learning experiences for researchers and the tasks in the units were modified based on the experiences of our trials.

Phase 3: The analysis of communication, both formal and informal, and collaboration that occurred while students were engaged in D&T tasks was carried out. The analysis of formal communication focussed on students' dialogues during two stages in the units: the design stage and after making the product. The analysis of informal communication consisted of observations related to roles played by students, conflicts and their resolution during the activities and communication through gestures. Collaboration was studied by observing the ways in which knowledge spread in groups in a setting through various means such as tools, practices and facts.

1.4.1 Background of the study

The genesis of the D&T Project at the Homi Bhabha Centre for Science Education (HBCSE) can be traced to a drawing competition held at the Centre on National Science day in 2002. The participants (over 75 students) in this competition were students from primary, middle and high schools (about 10-15 years, Grade 5 to Grade 9) from schools (in and out) of Mumbai. The participants constituted two groups: a junior group of 31 students (16 girls an 15 boys) from Grades 5 to 7, and the senior group which consisted of 45 students (19 girls and 26 boys) from Grades 8 and 9. The topics given to students for drawing a poster were 'Images of Science' or 'Images of Technology'. Students had to fill up a short questionnaire after they had completed their poster.

The posters were analysed using a variety of categories that were arrived at after a critical examination of all the posters and questionnaires by all the researchers. The analysis categories included: relevance of poster to the topic chosen, sex of humans depicted, kind of activities in which humans were shown involved, kind and number of objects shown, scenes depicted in the posters (whether domestic, inside classroom, industrial, space etc.), depiction of time aspect, academic subjects covered.

We observed that most drawings by students (of both junior and senior groups) on the topic of 'Images of Technology' had products related to communication and transport such as television, satellite, mobile phone, cars, airplane etc. A large proportion of the objects that were drawn belonged to the "luxury" category of objects rather than basic needs. Students seemed to view S&T less in terms of its beneficial and harmful aspects, and more in terms of a collection of objects, activities, models and ideas. Humans when drawn were shown to be operating or using objects of S&T, and never "making" or "designing". Over all these students seemed to have a positive attitude towards technology but limited concept of it. Another aspect that came through students' drawings was that praxis and action were more often shown than concepts and theoretical ideas. Senior group students indicated progression in time and drew future scenarios twice as often as junior students. In this study, girls tended to draw fantasy characters more often than boys. Another interesting finding of this study was that more girls related technology to warfare in their posters as compared to boys (Mehrotra et al., 2003).

This small study motivated us towards a more systematic effort to know about students' ideas and attitudes of technology. As a result an attitudinal survey was developed for Grade 8 students. Subsequently we felt the need to develop another survey for Grade 6 (11-14 year old) students since grade 6 is the entry to middle school. Two pictorial questionnaires were developed, one, which focussed on objects and was a sub-part of the Grade 8 questionnaire and the other aimed to find out students' ideas about technology in activities. Interviews on a sub-sample of students followed the questionnaire administration.

1.5 Rationale of the study

This is a mixed-method study that investigates students' attitudes towards technology and examines the possibility of introducing communication and collaboration centered technology education in the Indian middle school classrooms.

One of the major curricular concerns highlighted by the National Curricular Framework (NCERT, 2000,2005) is to provide education for a cohesive society so that opportunity and access to quality education are available to various groups of students such as girls, students from rural areas, students with special needs etc. We feel that technology education as a subject in the general education system has the potential to help in formation of cohesive society based on equality. Technology education has an advantage that all groups have the capability to visualise and redesign their environment. Therefore a well-planned D&T curriculum, especially in mixed ability and multicultural classrooms, can be an inclusive endeavour for the children of the rich as well as the dispossessed, for those in the indigenous or the modern mould, for girls and boys.

We believe that through D&T activities, group work (team work) can be introduced which would provide opportunities for practicing and developing ways of reasoning with language and also help in the development of soft skills which are needed for the world of work. These same kinds of opportunities may be unlikely to arise in teacher-led discussions or while working individually. This rationale has been used to justify group work and other forms of collaborative activity in our D&T units.

As researchers, we thought that in order to introduce students to collaborative D&T tasks, we needed to start with knowing what students think about technology. Communication and collaboration were important aspects of our research work, which the entire team (consisting of 4 members: 2 researchers and their 2 advisors) focussed on. The first part of our work comprised an attitudinal study, which helped us to know the ideas that students had towards technology. Being aware of students' attitudes before trying out the activities was helpful in order to know what students could learn, what they knew and how and why did they come to have certain ideas. The second part of the thesis involved development and trials of technology education units that were communication and collaboration centered and meant to engage both boys and girls from rural and urban areas.

Communication and collaboration are important elements of schooling and yet receive little attention in the regular classroom teaching and learning contexts in India. In a collaborative learning situation, two or more learners work together and construct knowledge through communication and the shared use of tools and representations. This requires learners to externalize their reasoning by means of communication, which may make them aware of possible deficits in their thinking (van Boxtel et al., 2000). Collaborative learning can contribute to better learning in problem solving situations (e.g. Mercer, 1996), as well as in discovery learning environments (Saab et al., 2005). Collaboration triggers learners to elaborate their thoughts as part of the communication (Dekker and Elshout-Mohr, 1998). Students use language to record observations, to describe investigations and to communicate findings in oral presentations and written reports and therefore there is a need for them to be able to communicate effectively. According to Kimbell et al. (1991) communication (both verbal and non verbal) plays an important role in any D&T activity and is essential at various stages in the DMA approach.

Though various researchers in the field of D&T have realized the importance of communication, there is a need to study the kinds of talks that occur while students are engaged in D&T tasks. There is a need to use a scheme for analysing the profile of talks in D&T tasks and see if these have contributed to the emergence to increased knowledge and common understanding. Cultural factors are known to have an influence on the kinds of talks that we engage into. Research has shown that in a classroom setting, boys and girls from rural and urban areas have preferential ways of learning and communicating/ expressing their knowledge and skills and so we were interested in knowing the kind of interactions that students working in single-sex and mixed-sex groups from rural and urban settings engaged into.

1.6 Theoretical framework of the study

Our dispositions to any subject/field are formed by a variety of means – both direct and indirect. It is now widely accepted that students progressively build their 'personal representations of the world' through their observations and experiences (Baron et al., 1999 cited in Solomonidou and Tassios, 2007). The outcomes of studying a particular subject do not necessarily have to be tangible but they influence thinking and capabilities of the learners. In case of technology education, students engaged in the study of technology do not only make technological artefacts and systems but their construction of concepts, thinking skills and capabilities to solve problems through interventions may improve (de Vries and Tamir, 1997). Even before any formal teaching of technology, students have their own ideas and impressions about technology and teachers need to be aware of these ideas, in order to prepare suitable learning activities (Moore, 1987). So questionnaires were constructed to find out students' ideas of technology-as-objects and technology-as-activities.

Technology involves various groups of people namely the clients, designers, makers and users who form a community of practice (Wenger, 1998). The structure of the D&T units, classroom organisation and the sequence of trials were all broadly located in socio-cultural (Vygotsky, 1986) and shared cognition (Lave and Wenger, 1991) theories that consider learners as active agents, responsible for their own learning, enhanced by their interactions with peers, family and their environment, including the objects around them. The term 'socio-cultural' is associated with research that draws explicitly on the developmental psychology of Vygotsky.

In our study the context of D&T units engaged groups of students in designing and making an artefact as a solution to a problem situation. The sequence of classroom activities during the trials of the units integrated formal communication at two stages: one where students communicate their design ideas and another, after their product evaluations. The formal communication was analysed using the socio-cultural discourse analysis method, while informal communication was studied in terms of the group dynamics and evidences of collaboration during the D&T units.

This study examines the nature of dialogues that students engaged in during formal communication of design and reflections on the product and also during informal communication that occurred while students worked within their groups. In order to analyse communication during formal oral presentations I have drawn on principles of socio-cultural discourse analysis as described by Mercer (2004). For analysis of informal communication, we have drawn largely from Vygotsky's socio-cultural theory that emphasizes that learning is socially and culturally embedded and that collaborative construction of shared knowledge is mediated through language.

Socio-cultural discourse analysis is particularly based on Vygotsky's conception of language as cultural and a psychological tool (Mercer, 2004). The term 'socio-cultural' discourse analysis refers not just to one particular method, such as the qualitative, interpretative procedure, but to the methodology as whole (which involves several methods, both qualitative and quantitative). The roots of socio-cultural discourse analysis lie in the Vygotsky's understanding of learning as a social process (Vygotsky, 1962). According to Vygotsky 'communicative events are shaped by cultural and historical factors and thinking, learning and development cannot be understood without taking account of the intrinsically social and communicative nature of human life' (Mercer, 2004, p. 139). Discourses are considered to be 'social modes of thinking' that guide the construction of knowledge (Mercer, 1995).

While a more formal method of analysis was followed for formal communication in our units, the informal communication has been analysed quite qualitatively has been reported as instances/examples under various heads, which have been derived after going through the videotapes as well as researchers' field notes several times and arriving at the categories.

1.7 Research objective and Research questions

The broad aim of the research was to develop and conduct trials of D&T education units among middle school students in differing socio-cultural contexts in India and analyse the communication and collaboration among students. The main research questions were:

Research questions

1 What are students' ideas of technology?

2 How do students engage in collaboration and communication centred D&T?

3 Are there differences in the ways students from various socio-cultural settings and genders communicate while they are engaged in D&T units?

Sub-questions asked were:

Students' ideas of technology

1a What kinds of objects/artefacts do students associate with technology?

1b What activities are considered technological?

1c Does the perception of an activity change when depicted as being done by males or females or by a person in an urban or rural area?

1d Are there gender differences in students' perceptions of objects and activities as technological?

1e What gendered stereotypes do students hold with respect to technological careers?

Collaboration

2a What are the evidences for collaborative learning in D&T units?

2b What kinds of informal communication occur in D&T tasks?

Communication

3a What is the nature of students' talk at the design stage and after making the product?

3b What are the differences in the talks of students from different socio-cultural settings at the design stage and after the making of the product?

3c What are the differences in talk between boys', girls' and mixed-sex groups at the design stage and after making the product?

1.8 Definitions of the terms

Collaboration- is the act of working together with others to achieve a common goal.

Collaborative learning- is an umbrella term for a variety of educational approaches involving joint intellectual effort by students and students and teachers together' (Smith and MacGregor, 1992).

Communication- refers to the exchange of information between individuals and groups. It can be verbal where words are exchanged between participants and also non-verbal through gestures. In the thesis, we have also used terms such as 'formal communication' and 'informal communication'. Formal communication refers to that step of the D&T units where students come in front of the class to present their work formally to others. Formal communication was specifically built into the units by the researchers. Informal communication refers to the communication that occurs within members of a group and also across groups while they are engaged in various activities of D&T units.

Socio-cultural settings- refers to the different contexts such as urban/rural, Marathi medium and English medium groups in which the D&T units were tried.

Gender- refers to the socially constructed roles, behaviour, activities and attributes that a particular society considers appropriate for men and women (World Health Organisation).

Girl friendly activities- refers to those activities that address girls' needs and tries to create and sustain interest among female students through various means.

Middle school students- refers to students in the age range of 11-14 years old studying between Grades 6^{th} and 8^{th} in the Indian school system.

Technology- is the know-how and creative processes that may assist people utilize tools, resources and systems to solve problems and to enhance control over the natural and made environment in an endeavour to improve the human condition (UNESCO glossary for 'technology).

Technology education- an opportunity for students to learn about the processes and knowledge related to technology that is needed to solve problems and extend human capabilities (ITEA, Technology for all Americans, TfAPP).

Design- refers to the purpose, planning, or intention that exists or is thought to exist behind an action, fact, or material object.

1.9 Overview of the thesis

This thesis reports an exploratory study in which Indian middle school students' attitudes towards technology were determined through a survey. This helped in the development of three technology education units, that were tried with students from 3 socio-cultural settings.

Chapter 1 is the Introduction. This chapter sets the context and provides a theoretical framework and background of the study. In this chapter we put forward our research questions as well as sub-questions that have guided our work. This chapter will familiarise the readers with the problem and its relevance to education. It defines some of the commonly used terms in the thesis.

Chapter 2 is the Review of literature. The review is under the heads: attitudinal studies, communication, collaboration and gender issues in D&T education. This chapter gives the background literature for all the major variables used in the study.

Chapter 3 describes the survey of students' attitudes towards technology. It describes the objectives of the survey, the methodology used, development of the questionnaires, details of sample and results and analysis of the survey. The analysis has been reported under the heads of objects, activities and words associated with technology, people who use/create technology, the temporal aspects related to technology, abundance/presence of technology in rural and urban area, the career aspirations of students related to technology and finally gender and technology issues related to the survey. Under all these heads comparison of responses of boys and girls have been compared. Most of the results reported in this chapter have been presented at the PATT- 18 conference held at Glasgow in June 2007 (Mehrotra et al., 2007 a).

Chapter 4 is titled Methodology: Development and trials of D&T units. This chapter comprises of the rationale and our ideology behind choosing particular D&T units for our trials. It describes the sample taken for our study and gives the general overview of the structure and implementation of the units. The details of development and trials of each of the three units- bag-making, making a model of windmill that could lift some weight and making a puppet and putting up a puppet show- have been explicated. This chapter also gives key observations made in various socio-cultural settings while the trials were conducted. The methodology for puppetry unit has been published as a chapter in a book (Mehrotra and Khunyakari, 2007).

Chapter 5 titled Formal communication in D&T units, reports the results of formal communication that occurred during the trials of the units in the 3 settings. The formal communication was analysed using the scheme developed by Dawes et al. (1992). The results of formal communication i.e. the kind of talks have been compared across the 3 settings and also comparisons between single-sex groups and mixed-sex groups have been made. The results indicate differences in the profile of talks that students engaged in while they were involved in different D&T units. The results of analysis of formal communication for puppetry unit have been presented at a conference (Mehrotra et al. 2007 c).

Chapter 6 discusses the results of informal communication and collaboration that took place while students engaged in the D&T units. Communication both verbal as well as non-verbal that occurred during the trials of the units has been analysed. Informal communication was analysed through a scheme that was developed by the researchers. Results of informal communication have been published in International Journal of Technology and Design Education (Mehrotra et al., 2007 b). Instances of collaboration that indicate learning or change in knowledge that occurred during the course of trials of the units have been analysed and reported. Along with communication, evaluation of products made by students has also been discussed.

Chapter 7 reports on the conclusions and recommendations of the study. The conclusions and alternative explanations of the findings are explicated in the chapter along with the strengths and weaknesses of the study. Implications and recommendations for future research studies and also for existing practice form a section of the chapter.

1.10 Summary

This study reports the efforts done by researchers to introduce D&T at middle school level in India. D&T units that were communication and collaboration centred were tried out with students from different socio-cultural settings. The study was planned within the framework of socio-cultural theory and shared cognition approach to technology and reports the differences with respect to communication that were observed within the settings and also across the settings, between mixed-sex groups and single-sex groups. The study reiterates the importance of introducing D&T tasks at the school level that have potential to be meaningful for students from various contexts of life and for broadening their concept of technology as well developing soft skills.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Introduction

This thesis examines students' ideas about technology and involves development and trials of three D&T education units at the middle school in three different Indian socio-cultural contexts. In this chapter an attempt has been made to review critical literature in the area of: a) attitudinal studies, b) communication, c) collaboration and d) gender and technology education.

Each of these areas forms a section of the chapter and reviews various positions and empirical studies relevant for the thesis. The study is broadly located in the socio-cultural framework. Communication and collaboration are important aspects around which the D&T units were centered, in which students worked in groups, pooling their cognitive, physical and material resources, towards a common goal. During their work, students communicated with their group members and across their groups verbally as well as non-verbally. Steps were deliberately built into the units whereby students were required to communicate and students' dialogues during this communication were analysed. Learning through collaboration was analysed at the level of group and then at the level of community/classroom.

Development of the D&T units was preceded by an attitudinal survey to find out the reasons why students associate certain objects, activities, professions and jobs to technology. The term 'technology' has multiple meanings - both broad and narrow ones, which are used by social scientists and engineers respectively (Mitcham, 1978). Many studies around the world have been carried out to elicit students' understanding of technology. This study in the Indian context was done for two reasons - one for the purpose of knowing students' ideas about technology in various socio-cultural contexts and secondly to aid us in the development of the D&T units itself. The section on attitudinal studies covers relevant survey instruments developed to understand students' ideas in the context of technology and the results obtained by using such instruments developed in various cultural contexts.

The section on communication covers the importance of communication in education in general and technology education in specific. This section brings out the theoretical framework for analysis of verbal data and discusses a spectrum of methods, both qualitative and quantitative for analysis of verbal data. The section concludes with providing justification for combination of qualitative and quantitative verbal data analysis methods to get a holistic picture of the situation.

The section on collaboration addresses the question of how group work impacts students' learning and discusses the meaning of the term 'collaboration'. It gives an account of various theories that address when and how peer interactions facilitate students' learning. The studies presented in this section of the literature review are mostly in the context of educational settings. The section highlights the importance of collaboration in technology education from the broad framework of Vygotskian theory.

The final section of the chapter reviews literature in the area of gender and technology education. The section elaborates the relationship between gender, technology and society, the problem of under representation of women in technology and presents theoretical models that explain the lack of women in technology. The feminist perspective on technical work has been discussed along with efforts being made to include women in technology education.

2.2 Students' attitudes and ideas about technology

Attitudes play an important role in guiding and predicting future actions. An attitude is a 'mixture of belief and emotion that predispose a person to respond to other people, objects, or institutions in a positive or negative way' (Coon, 1995, p. 661). Attitudes provide structure and consistency to our social environment and guide our behaviour (Wood and Wood, 1993). We experience the world through our observations and 'personal representations of the world' (Solomonidou and Tassios, 2007, p.114). In short, our past (as well as present) experiences are summarized into attitudes that serve in many ways to predict or influence future actions.

Attitudes are complex to understand and have three components: affection (feeling), cognition (knowledge) and conation (behaviour) (Shirgley et al., 1988). The cognitive component includes the opinions that reflect an individual's perception of and information on the attitudinal object (Corsini and Ozaki, 1984, p. 99). The affective component of an attitude refers to a person's 'feeling' or emotion concerning an attitudinal object (Heaven, 1982, p. 9). The behavioural component includes a person's pre-dispositions or readiness for action, as well as his/her actions concerning the 'behavioural object' (Gagne, 1977, p. 234).

Studies to elicit students' attitudes/conceptions in a particular subject or issue have been widely carried out in different parts of the world, including India. For example, students' ideas about various phenomena in science such as light, heat, force, motion, science, plants, scientists have been a focus of study for many researchers (Driver et al., 1985; Chunawala et al., 1996; Chunawala and Ladage, 1998; Natarajan et al., 1996).

2.2.1 Why do we need to know students' ideas about technology?

Technology conjures up various meanings in the minds of individuals. De Klerk Wolters (1988) has defined attitude towards technology as 'a certain negative or positive feeling towards technology based on certain knowledge and ideas about technology that may lead to a certain behaviour with reference to technology' (p. 41). Learning students' attitudes is essential to an understanding of what students' think of technology and what the curriculum intends to impart to the students.

Studies have shown that misunderstanding of concepts (or limited knowledge) among students may arise because of some classroom factors like teachers not understanding or taking into account their students' understanding or there may be mismatch between what teachers think/say and what students understand of it and this could have serious implications later. Hence, teachers need to know children's perceptions of technology and their 'teaching should allow for shared meanings to be established, communicated and assessed.'(Garton and Pratt, 1989, p.136).

Another reason for educators to find out students' ideas about technology is to aid in broadening students' existing understanding of technology. Research shows that students are hardly aware of the variety of technologies in the world and knowing students' ideas can help educators modify the curriculum and teaching methods so that an understanding of different types of technologies is developed (de Vries, 1996).

In a country like India, which does not have any formal technology education at the school level, student's ideas are more likely to be influenced by factors such as their parents' ideas, the opportunities available to them, socio-economic status, objects and situations. It would be helpful to know what students think and perceive of technology before trying to introduce them to a new program/course. The curriculum in many countries favours the voices of the dominant group and it needs to be restructured to include voices of many. So knowing about students' perceptions from various strata of society and both girls and boys would help in meaningful curriculum reforms.

2.2.2 Measuring students' attitudes and ideas about technology

Until about 1980's research in the area of technology education did not focus on the aspect of finding out students' ideas about technology. Considering that technology is a broad subject and people associate themselves differently with it, a need was felt for 'in-depth research on student understanding of technological concepts and processes and ways in which these can be enhanced' (Jones, 1997, p. 83). It is to be noted here that much of the research done in the area of technology education till this point was about finding the right definitions, curriculum issues, implementation, teacher training etc.

Most efforts at finding out students' attitudes towards technology have used either questionnaires with open and close-ended questions, alone or in conjunction with more open ended tasks such as getting the subjects to write and/or draw and also interviews. The next few paragraphs will discuss some questionnaires that have been developed around the world to know students' ideas about technology.

In the late 1980's Jan H. Raat and Marc de Vries in the Netherlands with their pioneering efforts in establishing the dimensions in students' attitudes towards technology developed the PATT (Pupil's attitudes towards Technology) questionnaires to probe students' (11-15 years) ideas about technology. The PATT questionnaires had three components: affective, cognitive and conative/behavioural. The questionnaire administration was followed by semi-structured interviews of the participants. Following their work, a number of attitudinal studies related to technology were initiated around the globe using the same or modified version of the instrument prepared by Raat and de Vries. In 1987, Bame and Dugger at Virginia Polytechnic, together with Marc de Vries adapted the PATT instrument for use in the United States. The PATT-USA instrument was then used in other countries such as South Africa, Hong Kong, Thailand, India, Australia, England etc. At present researchers in numerous countries have used this questionnaire or are using it, and they share their work at the PATT conferences which are held regularly. Results from most of the PATT studies show that students' positive attitude towards technology coexists with a limited comprehension of concepts. The results also indicate differences between boys and girls in their attitudes toward technology.

Various researchers have explored Science-Technology-Society (STS) linkages and Aikenhead et al. (1989) have pioneered research in this area. They developed an instrument called "Views on Science-Technology-Society" (VOSTS) consisting of 114 multiple-choice items that address topics in the area of STS. The questionnaire was administered to Grade 11 and 12 Canadian students. The unique feature of the VOSTS instrument has been that the items in the questionnaires have been derived from students' point of view rather than a theoretical or researcher point of view. Students respond to a particular issue by indicating their personal view, and the reason for it. There are opportunities for students to add their own ideas, if it did not appear in one of the prepared responses. The items in the instrument were empirically derived to reflect students' views and thus according to the authors these could be used by classroom teachers and researchers for comparing perceptions amongst group of students. The data obtained by administrating the questionnaires is qualitative in nature and is then interpreted by the researcher. Findings from VOSTS studies show that neither students nor teachers at school have clear ideas about how science operates or how scientific knowledge develops (Ryan and Aikenhead, 1992).

Another instrument that has been used to measure students' ideas about technology is the Technology Attitude Scale (TAS). This was developed in 1987 after the PATT-USA research (Becker and Maunsaiyat, 2002) and revalidated for use in Thailand. The three-part TAS instrument was designed specifically for use by classroom teachers to determine students' attitudes towards technology and concepts of technology. In 1993 the TAS instrument was adapted and validated for use by American teachers at the middle school. The results from this instrument showed that students have an interest in technology and that boys have a greater interest in technology as compared to girls. When the instrument was used with American students, it was found that American girls knew fewer technological concepts as compared to girls from Thailand (Becker and Maunsaiyat, 2002).

Attitudinal Technology Profile (ATP) was a questionnaire developed in South Africa by Ankiewicz et al. (1999). The aim of this questionnaire was to access the affective component of the content of technology education programs. The questionnaire had two sections. The first questionnaire addressed the understanding of the word 'Technological product' while the second part of the questionnaire had questions that would assess technological activity profile of the students. A pilot study using the ATP questionnaire was carried out with over 450 students and it was found that this instrument could be used only in developing countries where learners use English as their second language of instruction to complement the PATT questionnaire. The ATP questionnaire provided more reliable and valid results than did PATT applied in the South African context. The result from a survey using ATP questionnaire showed that South African students had a positive attitude towards technology education. Girls viewed boys as more competent in technology education than boys viewed themselves (Rensburg et al., 1999).

Understanding students' attitudes not only has implications for teachers but also for researchers, curriculum developers and parents. In the context of UK, Clare Benson and Julie Lunt (2007) conducted a questionnaire survey focusing on issues of teaching and learning related to primary D&T, with students (9 -11 years old) as well as teachers.

They specifically concentrated on (1) whether students enjoyed D&T, (2) the characteristic of D&T that they enjoyed and (3) children's perceptions of the value of D&T education. They found that children enjoyed the subject and felt that they were good at it. They felt that the subject would have value for them in their future lives since it involved practical activity. The characteristic of D&T that students enjoyed was working with others and that it had scope of using as well as developing one's ideas. This study was different from earlier studies as it aimed to find out students' attitudes towards D&T as a school subject rather than on a particular topic of technology or general affinity towards a field.

Apart from questionnaires, researchers have analysed students' drawings and writings to get an idea about what they think and know about various dimensions of technology. Rennie and Jarvis (1995a) developed three instruments/approaches that were adapted from the PATT study, to measure children's perceptions about technology. These instruments comprised of a questionnaire for upper primary school children, a picture quiz for lower as well as upper primary school children and a written drawing/writing activity combined with interviews for both the age groups. The instruments were found to be valid. The three instruments were tried on with children from Australia and England and have yielded interesting results that are reported in the next section.

2.2.3 Students' ideas about technology: results from a few studies

It is evident through the PATT research and other studies that even though the concept of technology that students hold is incomplete and vague but they still have a positive attitude towards technology and consider it useful for their future. Most students associate technology with computers, phones, hi-tech machinery, satellites, nuclear technology (de Klerk Wolters, 1989; Rennie and Jarvis, 1995b; Jarvis and Rennie, 1998; Jones and Carr, 1992; Rensburg et al., 1999). In children's drawings of technology, the human element is most often missed. This may be because 'people may be more difficult to draw than computers but it is more likely that pupils do not think of human beings in relation to technology' (de Klerk Wolters, 1989, p. 5). Rennie and Jarvis (1995b) have reported similar findings. Another related conception that students have of technology is that it is something modern, that is, there is a temporal association with technology. Students think that technology is modern and is associated with usage of modern gadgets. PATT studies have been conducted over time to learn if this brings changes in students' perceptions.

Correard (2001) carried out the PATT study in France, England and the Netherlands, 12 years after the first PATT surveys were conducted. She wanted to see if there was any change in the perceptions of secondary school students after 12 years of introduction of technology education curriculum in these countries. In her paper titled, 'Twelve years of technology education in France, England and the Netherlands: how do pupils perceive the subject' presented at the PATT 11 conference, she describes technology education curriculum and content in the three countries and then compares the results of the survey in 1980's with the one conducted in 1997/98. She found that in all the three countries students showed a real interest for technology, which was the case in the previous survey also. For students, technology was synonymous to novelty, computers and do-it-yourself. 'Curriculum' which was the second item on the questionnaire, in which students were asked the place of technology education in the mainstream education, the views of students in the three countries differed. English students considered technology to be of a high status, while French students had a negative image of technology (technology in France is often associated with students of lower ability), students in all the three countries lacked knowledge of professions related to technology. They thought of technology as contributing to prosperity and simplifying daily life. The study also found that boys and girls had the same enthusiasm for computers but for different purposes. Boys used computers with the aim of mastering a technology and acquiring new skills whereas girls saw it more as a utilitarian tool to help them achieve specific tasks. The study pointed out that there were links between: technology and unemployment, technology and pollution and a strong interest in computers as a tool. On the other hand, the 1980's survey had indicated that students did not make any link between technology and energy and students had made associations of manual work and dexterity with technology.

Technology is also closely associated with design and students, especially in those countries where design is present as a school subject, associate technology with ideas of model-making, designing, experimenting (Correard, 2001). That knowledge of science is essential for doing technology, is something that students in most countries believe. They tend to consider science as synonymous to technology (Bame et al., 1993; de Klerk Wolters, 1989). Students' ideas are also influenced by the kind of curriculum they follow. This was evident in Rennie and Jarvis' study (1995c), where they compared English and Australian students' perceptions about technology. They found that students from both the countries identified technology with products. But the difference between them lay in Australian students' emphasis on electrical products while English students stressed on design and model-making. This difference in perceptions was attributed to the way that technology education was presented in the curriculum of the two countries. In the National curriculum in England, design and making models forms an important component of the syllabus whereas in Australia there was no coherent approach to technology education at the primary level and students ideas are more likely to be formed by their experiences out of the school. Students' experiences in school and at home (MacKenzie and Wajcman, 1999) as well as interaction with kinds of technology have influence on attitudes towards technology.

Solomonidou and Tassios (2007) carried out a study with Greek (9-12 years old) primary school students, using semi-structured, personal clinical-types interviews. Their research was planned in two stages. The *first stage* comprised of investigating students' representations about technology using a phenomenographic research approach (suggested by Marton, 1981). Students could express their ideas through writing a text or by making a drawing. The *second stage* of the research investigated students' representations about (1) the concept of technology, (2) daily-life technologies, (3) technological change and (4) the impact of technological use in daily life. The results of the study indicated that most students thought of technology in terms of modern day products. Appliances/tools were hardly associated by them as technology. The representations of students could be categorized as those without humans (technology-oriented) and those with humans along with technical means (human-oriented). In the former category the representations showed technological developments without any connection to human activities while in the later category, technologies were related to human needs, uses and innovations. The researchers concluded that depending on the nature of these representations, students conceived technology differently. All the students in the study found it difficult to understand the concept of change. Regarding the impact of technological use: students with human oriented representations related impact of technological use on the natural environment whereas students with technological-oriented representations related impact of technology mainly to low efficiency of technology because of its extensive use.

Studies conducted by Rennie and Jarvis (1995a) using drawing/picture, writings and interviews of Australian and English students indicated that younger children had simple ideas about technology while older ones had complex and sometimes abstract ideas of technology. The drawings and writings reflected a wide range of views, which were mostly product related. Most students thought that technology was made by humans and was useful. They tended to equate technology with science, computers, electronics, modern devices etc. English children's ideas of technology were dominated by model-making in the design process. The researchers suggested that teachers could use these instruments to find out their students/ ideas about technology and tailor their teaching process accordingly (Rennie and Jarvis, 1995c; Jarvis and Rennie, 1996).

2.2.4 Studies done in the Indian context

The PATT survey instrument was used in the Indian context by Rajput et al. (1988) with secondary school students (16+ years) in rural and urban areas of the state of Madhya Pradesh. The aim of the study was to find out the extent to which the attitudes to technology varied in rural and urban areas and also among boys and girls. A total of 1,167 respondents from government run schools were selected from major towns and villages of Madhya Pradesh. The survey indicated that there was not much difference between urban boys and girls in their attitude to technology, their degree of interest towards technology, prospects of technology and their future career. However differences were found between rural boys and urban boys in scores for competency, nature and global significance of technology. This was one of the few studies on students' attitudes to technology done in the Indian context.

Another study in India conducted by the National Council for Science and Technology Communication (NCSTC) sought to solicit views of students on science, technology, independence and democracy (Raj, 2002). The study had a sample of about 50,000 Indian students of Std. XI (aged 16-17 years) from several schools located in 300 districts of 18 States. The findings suggest that over 60% of the students' sample considered technology to be applied science. Their responses such as 'scientists develop technology and then give it to a company for manufacturing' indicated that technology was subsumed within the large banner of science. Thinking of technology as 'applied science' has the danger of reducing technology to a product that can be used in daily life. In the study students also related Mathematics to technology. Thus students tended to associate some school subjects with technology. Interestingly, in a PATT study in the Netherlands students found that the relation between physics and technology was obscure (Raat and de Vries, 1985).

2.2.5 Identifying girls' and boys' ideas about technology

Students' attitudes are influenced by a plethora of personal and social factors. The attitudes that students have towards technology whether received through parents, peers, school or one's life have a profound influence on their current and future technological world and the choices they make. The socialization process and its effects influence how girls and boys differentially engage in technology. The studies referred to in this section bring out the fact that despite the intrinsic appeal of fundamental ideas of equality, there is compelling evidence that suggests men and women (at the school level as well as at the higher levels) are not equal players in technology possibly due to their socialization and the differential opportunities available to them.

Worldwide there are differences in the number of men and women engaged in technological fields. For example, in the US, at the professional level, only 13.8% women are in architectural and engineering professions (U.S. Department of Labour, 2005), while in India the output of women engineers is between 10-15% (Parikh and Sukhatme, 2004). The predominance of males at all levels of technological activity has created common perceptions that girls and women have lower abilities and interest in technology related subjects and careers. Thus studying the attitudes of girls and boys towards technology has been of long standing interest among researchers. Data collected from students has indicated that both male and female students tend to have interests in technology (PATT studies) but their interests may vary according to the domain of technology (Welty, 1996).

Welty's survey of 875 university students enrolled in technology course revealed that male and female students associated themselves with different kinds of technologies. While female students expressed an interest in medical and communication technologies, male students identified with automotive technology, computer technology, and automation. Both male and female students felt that technology 'makes life easier' Females equated technology with science and associated it with advancements more than male students did.

It is not only the college going boys and girls who have different attitudes towards technology but the same is the case with school going children. The Hong Kong Pupil's Attitudes Towards Technology (PATT-HK) conducted by Volk and Ming (1999) with over 3000 students found that there were significant attitudinal differences between junior secondary boys and girls in Hong Kong. T- tests in the category of gender with variables such as 'interest', 'role pattern', 'difficulties', 'consequence', 'curriculum' and 'career aspirations' were carried out. Results showed that boys and girls differed in all the variables. Boys had more positive attitude than girls in all variables except 'role pattern', which suggested that girls thought of 'technology' as an activity for both boys and girls. The study also showed that those students who had experiences with technical toys had more interest in technology as compared to the ones who did not have these experiences. Hendley et al. (1996) also show that boys and girls have differences in their attitudes towards technology and technical subjects. However, these gender differences were not found in other studies, for example Balogun (1985) in Nigeria and Prime (1983) in Trinidad and Tobago (cited in Volk and Mink, 1999). In the PATT South Africa study, the results showed that boys have a stronger view on dislike towards technology and girls have a strong gender discrimination view of technology (Rensburg et al., 1999).

Differences in attitudes of boys and girls towards technology have been found even at very young ages. Access and exposure to toys at a young age is a part of a child's technological education. Beginning at an early age children learn to play with and manipulate the toys they use. In this way, exposure to toys is typically part of the differentiated learning experiences between boys and girls as they progress through the common patterns of socialization (Nisbet et al., 1998). Browne and Ross (1991) observed that nursery children have clear demarcations along gender line for play preferences. Many children had strong views about what is considered as “boys’ stuff” and “girls’ stuff”. When children were asked to sort toys into what girls would like to play and what boys would like, toys were sorted as follows: for girls - it was dolls, doll’s house, felt pens and paper and for boys it was - Lego, Mobilo, wooden bricks and woodwork and toys for both were- books, puzzles and sand. From these observations it is clear children begin to have different socializations and differential access to toys from a very young age and perhaps this continues in their later life.

There is some research that focuses on the attitudes of adolescents and adults toward technology. A study conducted by the Margaret Honey and her team members from the Center for Technology in Education provides some insights on girls’ and women’s perspectives of technology (Honey et al., 1991). Their research team interviewed 24 adult technology experts (13 women and 11 men) and 80 early adolescents (41 girls and 39 boys) who were not particularly sophisticated about technology. The results of the study with adolescents coincided with results of the study with adult subjects. There were characteristic differences in the way males and females fantasized about the relationship between humans and machines. Interviews with adolescent children indicated that the technological fantasies of girls tended to be more about household helpers, machines to offer companionships, or devices to broaden their social and personal networks. On the other hand, boys imagined tools that could extend their power or tools that could overpower natural constraints (Brunner et al., 1990).

Among the adult technology experts, most women saw technological instruments as ‘people connectors, communication and collaboration devices’ (p.3). In contrast, most men envisioned technology as ‘extensions of their power over the physical universe.’

Most male technology experts reported growing up tinkering with mechanical and electrical devices. This tinkering with technology during childhood led to further education in and ultimately a career in technology for the males who also reported feelings of being in harmony with their technical occupations and did not report any internal conflicts. In contrast, women reported fewer experiences with technology in childhood. Many women said that they were encouraged to pursue a technical career by a mentor who was generally male. Ironically, some of the women recounted being inspired by the discouragement of others, often teachers, who said they could never succeed in a non-traditional carrier because of their gender (Honey et al., 1991).

2.2.6 Conclusion

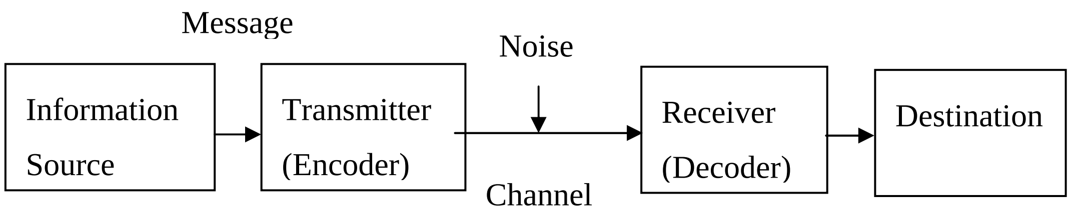
There is a critical need for all individuals to develop at least minimal levels of understanding of technology as it has profound influence on all parts of human life in the world (Custer, 1995). Efforts are being made around the world to give children a holistic understanding of technology and hence studies are being carried out to understand what students think of technology and what their technical aspirations are. Yet, according to de Vries (2003, p. 4) ‘research into pupil’s understanding of technological concepts is still very rare.’ A few efforts have been made in India at learning students’ ideas about technology (Rajput et al., 1988). But there is a need for more in-depth studies. Thus, at the Homi Bhabha Centre for Science Education, Mumbai a survey was undertaken to learn more about middle school students’ ideas about technology. This survey served as a precursor and input to the research and development of D&T units for introducing technology education in the Indian school system.

2.3 Communication

According to the Oxford dictionary of sociology ‘communication is the process of establishing meaning, found in all social situations’ (Marshall, 2004). The word communication has its origin in the Latin word, *communicare*, which means to impart or participate. When we communicate, we try to establish “commonness” with someone, that is, we try to share some information, an idea or an attitude. This sharing or exchange of information between individuals is through a common system of symbols, signs, or behaviour. The purpose of communication is to deliver messages through verbal or non-verbal modes.

The process of communication is two-way and involves a series of actions that involve a sender, a message, a receiver and a medium (Gordon, 1994). The success of the process of communication depends on the common meaning making between the sender and the receiver - which may be through language or agreed understanding of symbols.

Figure 2.1: Shannon Weaver model of communication



In 1940's Claude Shannon and Warren Weaver, two Mathematicians from the US put forth a mechanistic, linear model of communication, which held a transmission view of communication. Their model contained six elements - an information source, transmitter/an encoder, a message (content), a channel of transmission, a decoder/a receiver, and a destination (Figure 2.1). This model has been one of the most influential models of communication. But one of the drawbacks of this model is that it assumes that 'meaning' is contained in the message rather than its interpretation (Chandler, 1994).

Another view of communication that has gained importance in recent times is the relational view. According to this view, communication process is dynamic rather than linear and emphasizes dialogue as the basis of communication (Doyle, 2005). Here dialogue does not involve a mere exchange of information but depends on the quality of communication. The relational view of communication has been used to explain interpersonal relationships within a society.

2.3.1 Communication in the context of education

In the context of education, there has been a considerable focus on the relationship between communication and learning. Communication forms the crux of the education system. It involves externalization of thoughts in some form - oral, written, gestures or a combination of any of these. Communication in the classroom generally involves the teacher explaining facts to students or giving instructions and students in turn assimilating the information provided to them by teachers as well as the information that they get through reading books, talking with their peers and other modes of information. Students also provide feedback to teachers and there is often a lot of noise in the message and the medium. The value of information (content) and its communication (delivery) is considered to be of primary importance in education (MacBride, 1982). The importance of dialogues between teachers and students in pedagogy is emphasised by Burbules and Bruce (2001). Two traditions of dialogues exist in pedagogy and these include the prescriptive tradition and the discursive tradition. The prescriptive tradition regards dialogue as a way of ‘leading others to preformed conclusions’ while the discursive tradition views dialogue as a ‘way to guide the exploration of a student’ (p.1102).

The construction of knowledge is explained by two major theories - the constructivist theory and the socio-cultural theory. The *constructivist theory*, focuses on personal construction of knowledge through ‘interaction between individual’s knowledge schemes and experience of the environment.’ (Alexopoulou and Driver, 1996, p.1099) and the *socio-cultural theory* regards learning from others as an important way of knowledge construction.

Jean Piaget (1896-1980), a Swiss philosopher, natural scientist and developmental psychologist, was one of the main proponents of this paradigm of constructivist theory. For Piaget, learning occurs by overcoming cognitive conflicts. When an individual encounters ‘cognitive dissonance’ or cognitive contradictions there is a restructuring of his/her understanding and the individual thereby advances his/her knowledge and learning occurs. For Piaget, interaction with peers’ results in students confronting any differences in each other’s current understanding, explaining and defending their views and reconciling conflicts. In doing so, individuals reformulate their own thinking and alter their knowledge structures - that is, they learn.

Lev Vygotsky (1896-1934), a Russian psychologist and educator, put forward the socio-cultural theory of learning. In this theory, social interactions play a fundamental role in the development of cognition. The theory also highlights the importance of interactions with parents, peers or teachers (Vygotsky, 1986). Learning is viewed as a process in which students are actively involved in the meaning making process. This process involves ‘remaking the information and messages which teachers communicate in the classroom.’ (Jewitt et al., 2001, p. 6).

The paradigm of social-cultural theory also focuses on the role of language and discourse in shaping meanings. According to Vygotsky social experience of language is seen to shape cognition (Rogoff, 1990, Wertsch, 1991), and ‘inner speech’ develops from external speech via a gradual process of internalisation (Vygotsky, 1986).

Both the constructivists and the socio-cultural approaches emphasise how learning takes place but the role of interaction/communication between individuals and society is different in the two paradigms. My work is situated in the socio-cultural framework of knowledge construction and regards communication and collaboration with peers and teachers as important for knowledge construction.

2.3.2 Communication in the context of technology education

Studies related to communication in technology education can be broadly put in two categories. The first category includes studies where technology is used as a tool of communication that enhances teaching and learning (Educational Technology which uses internet or other computer aided models to enhance teaching and learning). The second category focuses on communication and interactions taking place between participants working on a technological task. Although fewer studies could be located in the second category, this is the category of interest to me and of relevance to the thesis and therefore will be focussed on in this section.

While the role of language and communication in general education is recognised, it is underplayed or not highlighted in technology education. The Standards for Technological Literacy (ITEA, 2000) spell out that students in grade 9-12 should learn that 'design process includes defining a problem,………..and communicating processes and results' (p. 97). Despite the need for communication in technology tasks, it remains one of the most neglected components of technology education. Various researchers such as Solomon and Hall (1996) have emphasized the purpose and importance of language in technology education. To quote them, 'Language is vital for almost all learning, for describing shapes, anchoring concepts, and making the tacit articulated…..' (p. 275). Other researchers such as Kimbell et al. (1991) in their APU (Assessment of Performance Unit) project, have emphasised inter-relationship between modelling ideas in the mind and modelling ideas in reality, which is described as "thought in action". (Kimbell et al., 1991, p. 20). According to them, ideas conceived in the mind need to be expressed in concrete form before they can be examined to see how useful they are.

Figure 2.2: The APU model of interaction between mind and hand (from Kimbell et al., 1991)

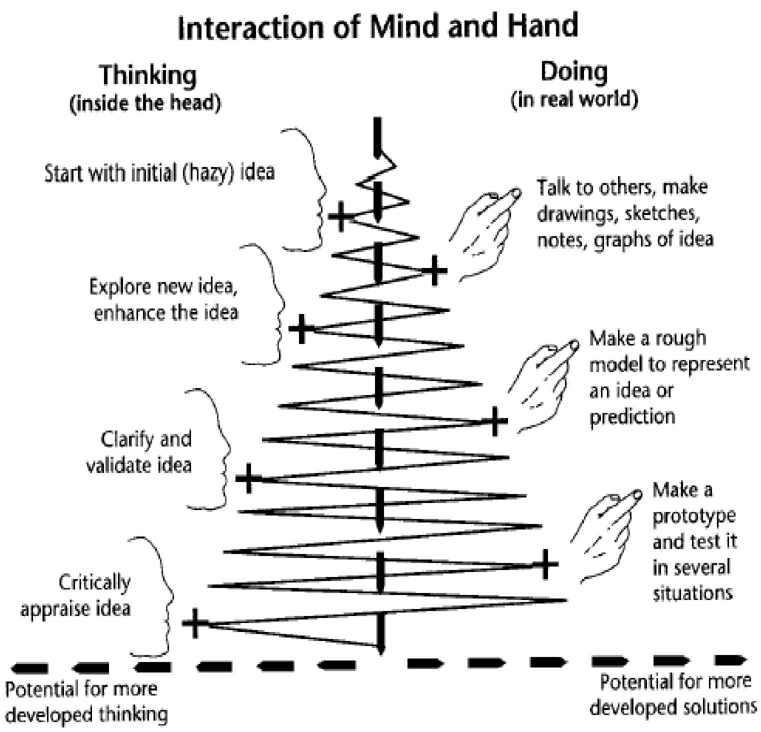


Figure 2.2 given gives the APU model of interaction between mind and hand. In technology tasks, forms of communication other than verbal are predominantly used eg, gestures, drawings and models. The language of technology is '….a concrete one- of images, symbols and models. Without this language it is just not possible to conceive of technological solutions' (Kimbell et al., 1996, p. 23).

Drawing and sketching in technology tasks

Drawings and sketches are ways in which ideas are commonly expressed in D&T tasks. Apart from eliciting ideas from students, sketches or drawings form an important kind of communication for purposes such as clarifying thoughts, for recording ideas (MacDonald and Gustafson, 2004), and 'off-loading' memory (Bilda and Gero, 2005).

In his book 'Engineering and the mind's eye', Ferguson (1992) has identified three kinds of sketches and has categorized them by the purpose they serve. *Thinking sketch* is the one in which the designers make use of drawings to support their thinking processes, especially non-verbal thinking. The second kind of sketch is the *talking sketch* where designers make use of the (shared) drawing to support group discussion, and the third kind of sketch is the *prescriptive sketch* where designers communicate design decisions to persons that are outside of the design process.

Stressing on the importance of drawing as a powerful mode for representing ideas and clarifying one's own thought, Anning's review (1997) uncovered that drawing is a neglected activity in primary schools. This neglect is attributed to the fact that teachers have inadequate understanding of the purpose of drawing and they undervalue it and therefore students are not able to draw. Anning put forward some strategies that can be used by teachers to encourage students to draw, and suggests that students need to be offered examples of what design drawings look like by asking them to 'sketch[ing] everyday objects from different viewpoints' (p. 233).

In her study of children's drawings in technology tasks, Hope (2000) examined the underlying processes, which contributed to children's ability to use drawing as a design medium. According to her, drawings help children in thinking about the products that they plan to make and she concluded that more understanding was needed about how children develop drawing skills.

That drawings are used to record ideas in D&T tasks was exemplified in a study by MacDonald and Gustafson (2004) in which elementary school students (Grade 6, 11-13 years), belonging to middle-class families residing in urban neighbourhood were asked to make models of parachutes. Students had to make two sketches of their model- one before making the model and the other after making it. It was found that students made drawings that were diagrammatic in nature after completing their products and there were no drawings made by them before making the product.

A similar finding was reported in a study carried out in India by Khunyakari et al. (2007) with middle school students from urban as well as rural areas, on the activity of designing and making a model of a windmill. Students' paper and pencil productions namely the exploratory sketches, technical drawings and procedural maps were analyzed. Technical drawings made by students followed conventions of leaders and arrows and exploratory sketches were used to conceptualize their design ideas. Students used a variety of ways such as occlusion, dashed lines, exploded and enlarged views and multiple perspectives to represent their ideas in a two dimensional way.

Gestures

Along with drawings, non-verbal communication or gestures also form an important part of communication. A gesture is a *wordless* message - a sign, signal, or cue used to communicate in conjunction with, or apart from, words - it is a nonverbal form of communication. Gestures provide resources for making sense of our talk, in other words, gestures provide medium in which 'development of discourse can piggyback' (Roth & Welzel, 2001, p. 103).

According to Roth (2003), students generally begin their explanations with a 'muddled talk' and that gestures precede verbal talk. In a study, he observed two students studying in Grade 10 involved in a physics (electricity) experiment and found that these students expressed much more than the words they uttered. He analyzed the gestures of these students, the materials presented along with the words uttered by them and formed a 'picture' of how the students understood the phenomenon. He found that when there were conceptual discrepancies between gestures and language, it indicated that students were ready for instruction. In his words, 'instruction will have greater impact on these students than on those whose gestures and words are consistent but incorrect.'(p. 7).

Athavankar (1999) experimentally investigated the creative potentials of mental imagery. His experiment was aimed at exploring how expert designers use their mental imaging abilities. In the experiment a designer was blindfolded and was asked to think-aloud how he would design a casserole with 6 matching bowls and thermal insulation. It was observed that the subject used hand gestures to assist him in developing spatial configurations. The video data also revealed that 'the designer appeared to be almost interacting with the evolving spatial configurations in his mind, as if he was continuously modelling it in 3-D space' (1.1.4). In the last few minutes, he was asked to quickly sketch his final product idea on paper. The video data of the designer's problem-solving session was then given to another designer who was asked to make a sketch from what the blindfolded designer was saying and gesturing. It was found that there was a close resemblance between the first designer's original sketches and the reproductions by the second designer. This experiment indicates that gestures complement verbal information and they have the power to define the invisible shapes present in the designer's mind.

Verbal communication

Along with drawings and gestures, verbal language is a powerful tool to facilitate reasoning in social contexts (Rojas-Drummond, 2002; Mercer, 1995; Speer, 2005). In the domain of D&T, Rowell (2002, p.2) states that participants communicate in a variety of ways- 'they not only draw but talk, write and gesture in participating with others to accomplish construction'. Rowell conducted her study with two of Grade 6 students who were assigned the task of building a robot with eyes that could light. She analyzed their talks in terms of complementary roles, participatory contributions and use of tools and that the tools and the materials used in the task served the purpose of shared referent.

The functions served by drawing/sketching may overlap with those of writing/talking. Kimbell et al. (1996) have highlighted the importance of communication in D&T tasks for 'clarifying ideas' and for 'recording and presenting' them. In D&T verbal communication is needed for 'articulating tasks that cannot be represented graphically' (Medway, 1994, p. 85). Language used for technological evaluation is vital for learning. A study by Fleer (1999), with 5-11 year old students, sought to find out the links between students' design ideas and the making and evaluation tasks by focussing on students' feelings and experiences. Students were asked to make a 'cubby building' (enclosure which will allow at least one child to hide inside the space). Data was recorded in the form of field notes while students worked on their tasks, video, photographs and students' works. Analysis of the data showed that students produced interesting design briefs - older students tended to focus on structural problems more than younger students. The questions that students came up with were mostly related to designing, structural problems, materials, fantasy and social issues. The open-ended learning environment allowed the teachers to observe the students and make assessments.

2.3.3 Importance of talk in peer groups

The socio-cultural approach claims that language is the most important tool available to humans for mediating the acquisition of knowledge and the development of thinking (Rogoff, 1990; Wertsch and Stone, 1985). In fact it is a 'tool of tools'.

In one of the earliest studies in the context of communication in the classroom with 13 years old children in England, Barnes and Todd (1977) observed that teachers (as opposed to learners) do most of the talking in classrooms, taking "responsibility for the content, pacing, and style of pupil contributions" (p. ix). In analyzing the dialogue amongst the groups of students, Barnes and Todd considered types of speech and their impact on the construction of meaning during group interactions. They identified 'qualitative' aspects of students' talk in terms of both, interaction and cognitive processes. They suggested that in the absence of a teacher, students were more likely to engage in open, extended discussions and arguments amongst themselves and this kind of talk helped them to take a more active and independent ownership of knowledge.

Problem solving tasks provide another forum where students can work on small groups and interact closely. During problem-solving tasks in groups, students tend to verbalize their thoughts while interacting with their peers. They learn to discuss and negotiate and give feedback and in this way become better at problem solving. Barbieri and Light (1992) studied 11-12 year old children working in groups on a computer task. Their interactions were videotaped and were analyzed and compared with those students working alone on the same task. It was found that there were significant differences for variables of planning and negotiation. Children who worked in pairs asked questions and gave explanations, which had the potential to lead to better organization and attainment of knowledge and, in the end, to extension of that knowledge. Teasley (1995) has also reported that students working in groups learned better than students working alone.

The literature reviewed till now strongly points to the fact that learning in groups is beneficial for knowledge construction. Studies carried out by Dawes and his colleagues (1992) have focused on the development of criteria for analyzing the classroom talk that occurs when children work in groups. The details of their criteria for analysing classroom talk are given in the section 2.2.5 under the sub-heading 'Combining the qualitative and quantitative methods - Mixed methodology'.

The findings derived from the study of Dawes et al. (1992) have led to other studies by Mercer et al. (1999), Wegerif et al. (1999) and Rojas-Drummond et al. (2002). These studies suggest that teaching primary school children the use of exploratory talk leads to improvement in their individual test scores on tests of non-verbal reasoning. These findings also confirm the fact that children learn to reason better individually when they work collaboratively in a group.

A study by Webb and Treagust (2006) investigated the effect of 'exploratory talk' on problem solving and reasoning skills in science classrooms in South Africa. This study was carried out with a group of teachers (science and mathematics) who were introduced to the notion of classroom discussions and trained in workshops to use interactive educational aids in their teaching (experimental group). The students who were taught science topics by these teachers were tested on Raven's Standard Progressive Matrices and their scores were compared with students who were taught by 'non-trained' teachers. The results of the study showed significant differences in the gains in scores in the Raven's test for the experimental group.

In conclusion, talk has been shown to be valuable for the construction of knowledge. Analyzing talks/interactions has been of interest to specialists from many disciplines such as linguistics, philosophy, psychology, sociology, computer science and cognitive science. And each of the disciplines has its own ideology, method and approach to analyzing interactions.

2.3.4 Gender and communication

Communication is a medium by which we come to know things and is heavily value laden. The meaning that we derive from interactions depends on our culture and background. From a very young age, children learn to recognize and take up roles based on 'discursive practices in which all people are positioned either male or female' (Nielsen and Davies, 1997, p. 125). By the time children enter pre-school, many of them begin to act, speak and behave according to the social norms for gender, though the content of their talk may vary with culture, socio-economic status and ethnicity (Davies, 1989 cited in Nielsen and Davies, 1997; Browne and Ross, 1991).

Studies carried out with children of very young ages (preschool) have shown that girls and boys have a clear idea of which games are meant for girls and which for boys and their communication, both verbal and non-verbal, while at play (and other activities) indicates this. Studying nursery children, Browne and Ross (1991) observed that children made spontaneous comments about different activities according to their gender. In one of the activities that involved playing with Lego, there was an assumption on boys' part that girls would make houses and boys would make vehicles and guns. This was observed in the way boys sorted out the blocks for play (doors, windows etc were given to girls and wheels and connectors were retained by them).

Non-verbal communication, in the form of drawings and texts can also reflect gender orientation of young children. Brunner et al. (1990) carried out a study in which they asked the adolescent students to write a reply to the following scenario, “If you were writing a science fiction story about the perfect school computer (a fabulous machine), what would it be like?” Most girls wrote about devices that connected people, helped in communication and collaboration, while the writings of boys indicated that they imagined technology as extensions of their power over the physical universe.

Gender differences in communication have been observed in students working in groups. Holmes-Lonergan (2003) carried out a study with the aims of determining whether preschool boys and girls behaved differently while working in groups involved in problem-solving tasks, and to find out whether children changed their verbal/non-verbal interactions depending on the tasks. The study was carried out in Florida with 3-5 year old children. Children worked in three kinds of groups (same sex boys, same sex girls and mixed sex groups) on three tasks, namely, copying a tinker toy (children's building toy consisting of pieces held together by pegs in holes) model, stringing coloured wooded beads and building a tinker toy structure. Each task lasted for about 20 minutes. Children’s conversations during these sessions were videotaped and transcribed. Verbal, non-verbal and task success measures were taken into account for the study. The results of the study indicated that in a conflict situation, girls use moderate, verbal persuasion tactics more often as compared to boys. Boys were more likely to use threats or physical force to persuade and less likely to provide rationales for their assertions and also tended to use direct commands more often than girls. It was also observed that girls working in same-sex groups displayed more cooperative behaviours while boys working in same sex groups displayed competitive behaviours.

In another study on problem solving tasks on a computer carried out by Barbieri and Light (1992), it was found that different gender pairings produced different patterns of interactions. Their study involved 11-12 year old students English students in a problem-solving task. Students worked in single-sex and mixed-sex groups. The post-test was similar to the pre-test and both were tasks that all students had to do. Verbal interactions occurring between pairs were analyzed. The categories under which the observations were made were planning, negotiation, integration of information search, error message elaboration and commentaries. Non-verbal interactions were also analyzed in the study. The results showed marked dominance patterns in mixed sex groups. The verbal measures were a fair indicator of the success of a pair at a task. In single sex boys' groups, one of the partners tended to control resources like the computer mouse, switches etc. more often whereas in the single sex girls' groups the partners shared the mouse use. In the mixed-sex groups boys controlled the mouse most of the time. These findings show differences in interactional styles between various types of gender pairing. Jones et al. (2000), have also reported similar findings. In addition, they also observed that boys used more individual-centered language and commands as compared to girls, who were found to be more relational in their approach.

In the context of D&T tasks that are collaborative in nature, communication involves verbal discourse, non-verbal interactions (sharing, gestures) and graphicacy skills that include writing and drawing (Dillenbourg et al., 1996). Technology education has often encouraged multiple ways of expression like drawing, writing, gesturing, modelling and talking. Multiple ways of expression are encouraged for various reasons such as, verbal communication for speed, graphic communication for style and depiction of parts, sketching for detail and precision and modelling for concretisation. For multicultural classrooms as in India, it is pedagogically useful to encourage various modes of engagement such as the tactile, the visual, the kinaesthetic, and the aural (Natarajan, 2004).

2.3.5 Analyzing verbal communication

This thesis will focus on analysis of verbal communication among groups involved in technology tasks and hence attention will be paid to communication as a subject of study. The study of communication examines the actual social process wherein significant symbolic forms are created, apprehended, and used. The language that people speak or write becomes research data only when it is transposed from the activity in which it occurred to the activity in which it is analysed. Verbal data makes sense only in relation to the activity context and to other social events and texts with which they are normally connected (Lemke, 1998). The theoretical framework for analyzing verbal data can be traced to various disciplines from which the specific methods of analysis are derived. The main methods are: a) Conversational analysis (CA), b) Discourse analysis (DA) and c) Protocol analysis (PA). The sub-sections that follow will briefly explain each of these methods of verbal data analysis.

Conversational analysis

Conversation analysis (CA) is a method of verbal data analysis pioneered by Harvey Sacks and his colleagues in late 1960's and early 1970's and has its roots in ethnomethodology (a field that was developed from sociology in 1960's). It is from this background that CA developed and was supported by researchers from a range of backgrounds, such as psychology, anthropology, communication etc.

In CA the goal is to study/examine messages exchanged in dyadic or small groups in order to discover the 'systematic and orderly processes that are meaningful to conversants' (Heritage, 1989), irrespective of the conversation being formal or informal/casual. CA focusses on the 'procedural analysis of talk-in-interaction, how participants organize their interactions to solve problems….' (ten Have, 2005). In the classroom context, CA provides a way of looking at the social world of the classroom as it is created in talk (Sacks, 1984).

The driving principle of CA is that research should be 'data-driven' rather than drawn from theoretical preconceptions or ideological preferences (ten Have, 2005). CA provides an idea of role, social relationships and power relations among the participants in a conversation. Research findings in the area of CA have proved useful in bringing out hidden aspects of human interactions, which help understand wider aspects of human life.

The process of CA involves recording the conversations of people in *natural settings* and then transcribing them using some standard notations developed (Jefferson, 1985).

It involves making detailed observations of the number of talk turns allocated to a particular person, number of interruptions, duration of pauses, word choices that the speakers make and overlaps. Analysis is generally detailed and conducted on small extracts of data that are transcribed. Table 2.1 shows the steps involved in doing CA.

Table 2.1: Steps involved in doing CA

Steps	Procedure
1	Formulate a research question
2	Production of materials to be analysed- conversations are recorded
3	Transcripts made from recordings (check them once against the recordings
4	Episodes to be analysed are selected from the transcripts on ground of a variety of considerations
5	Researcher tries to make sense of the episode using her/his common sense (one tries to establish local meanings of utterances and sequences independent of analytic interests of the project)
6	Researcher tries to explicate the interpretation, previously produced on common sense grounds. In this step the researcher uses both the details of interaction and her/his own knowledge as a means for the study of knowledge used by the participants in bringing off the sequence under consideration
7	Analysis is elaborated further- inspecting subsequent utterances, sequences
8	Comparison of analysis of current episode with other instances

CA does not start with a theory about what conversationalists are talking about but rather discovers patterns empirically. But this technique is not without its drawbacks. CA is more concerned about the content of the data rather than its context. The focus of CA is on studying recordings of naturally occurring interactions in particular settings (such as workplace situations etc.) and so it has been critiqued for using a restricted database for analysis and missing out on the context/background of the context. A criticism of CA is that one cannot decide the meaning of ‘words’ without a consideration of ‘non-verbal’ behaviour; one needs to consider the situation in total. According to Paul ten Have (1986), ‘Practitioners of CA are less given to philosophical reflection than to hard work. The ability to produce analytical results and empirically based findings about basic procedures of “talking together” is one of its main attractions.’

Discourse analysis

Discourse analysis (DA) is a broad umbrella term that covers a range of methodological devices. It is a cross-disciplinary method of inquiry, which studies the structure of texts and considers both their linguistic and socio-cultural dimensions in order to determine how meaning is constructed (Barsky, 2002). In the classroom context, students just do not speak words but instead draw on various discourses and genres connected with diverse social, historical, cultural and institutional relations (Wertsch, 1991).

In its conception as an aid to the study of linguistics, Zelig (1963) defined discourse analysis as a tool for the study of semantic meaning of sentences in a text, simply in the context of the surrounding sentences. DA as it originates today, emerged in the sociology of scientific knowledge and was later used in social psychology (ten Have, 2005). A discourse has two functions - one to communicate the message/content (transactional function) and the other function is to express social relations and personal attitudes (interactional function). These functions are performed by language almost simultaneously. However, linguists, psychologists, sociologists have tended to concentrate on either one of these functions. DA is a linguistic approach to verbal data analysis and has two methods.

a) Linguistic approach of working with grammatical and stylistic features: This method focuses on the transactional function of discourse and concentrates on how language is organized in units longer than sentences. Researchers in this tradition (who are linguists), base their work on the systematic grammatical and pragmatic features of verbal data. Analysis focuses on the language itself rather than its functions. According to Brown and Yule (1983, ix), in the linguistic paradigm of DA, one studies how 'humans construct linguistic messages and the way these messages are interpreted by those to whom they are addressed as well as how these are used for communication'. Educational research based on this approach has tended to study the structural organization of classroom communication between teachers and students. Studies have shown that in most classroom talk teachers *initiate* interactions, to which the students *respond* and then the teacher provides some follow-up or *feedback* (I-R-F).

b) Socio-cultural discourse analysis: Analysts who come from sociology or other social sciences background generally follow this approach of DA. This method of DA draws from the work of Vygotsky (1978) and considers language as a ‘cultural tool’ for learning. It is less concerned with the organizational structure of spoken language. The analysts who follow this method are more involved/interested with the content, function and the ways in which shared understanding is developed, in a social context over time (Mercer et al., 2004). This method of analysis involves identification of variable repertoires that is, how people’s descriptions change with respect to their position in a culture and sensitivity to context. This approach has been successfully applied in psychology. Socio-cultural discourse analysis differs from ‘linguistic discourse’ analysis in being less concerned with the organisational structure of spoken language and more with its content, function and the ways in which shared understanding is developed, in social context over time (Mercer et al., 2004).

Protocol analysis

Protocol analysis (PA) is a rigorous methodology for eliciting verbal reports of thought sequences as a valid source of data on thinking (Ericsson and Simon, 1993). PA is informed by the information processing approach and is also called the ‘think-aloud’ method. The basic assumption of this model is that humans can be instructed to verbalize their thoughts and they readily do so in such a way that the sequence of their thoughts is not altered and therefore their verbal reports are a valid data on their thinking process. According to the theory of verbal protocols (Ericsson and Simon 1980, 1993), people temporarily store steps of the problem on which they are working in their working memory and they are generally aware of what they are holding in working memory.

In this method, the first step is to ask the subjects to verbalize their thoughts and the information is recorded and transcribed which is called a verbal protocol. These reports are used as indicators of cognitive processes. The next step is to take the protocol and use it to infer the subject's problem space (i.e., infer the rules being used). This is done after the subject has finished her/his verbalization. This step involves coding the verbal reports in *a priori* categories formed earlier on the basis of task analysis. The steps in task analysis are matched against possible sequence of thought. Subjects are instructed to maintain their focus on solving the problem.

The verbal reports in PA can be: a) *Think-aloud (concurrent)* where the subjects are asked to verbalize the processes while they are engaged in a problem-solving task. Example: a subject given the task of mentally multiplying 24 by 36 (Ericsson and Simon, 1993). In this case the subjects directly verbalize the thoughts entering their attention while they are performing the task. There is no recall, and b) *Retrospective,* where subjects recall how they had arrived at a particular solution after they have finished a task. In retrospective verbal reports, it is believed that the subject draws out from his/her short-term or long-term memory depending on when the reports are generated. A good verbal protocol helps the researcher to abstract a theory of how a subject went about solving a problem.

The differences in the 3 techniques of verbal data analysis are presented in Table 2.2 and the method that will be used in this thesis is italicised.

Table 2.2: Comparison of methods used for verbal data analysis

Method	**Origin**	**Salient features**
Conversational analysis	Ethnomethodology	Examines interactions to provide insight of ways by which members in society interact. Data is collected in natural settings
Discourse analysis	Linguistics	Studies the structure of texts and considers both their linguistic and socio-cultural dimensions in order to determine how meaning is constructed
	Socio-cultural	Considers language as a ‘cultural tool’ for learning and is less concerned with the organization structure of spoken language.
Protocol analysis	Information processing approach	Humans can be instructed to verbalize their thoughts- Think-aloud method. Subjects are asked to verbalize the processes while they are engaged in a problem-solving task or after they have solved a problem

Qualitative and quantitative methods of verbal data analysis

The methods of verbal data analysis discussed above can also be categorized into qualitative or quantitative methods. Techniques like CA and DA are qualitative and do not require a great amount of coding of data or computer statistical analysis. Qualitative and quantitative methods of verbal data analysis have their strengths and weaknesses (Creswell, 2002). Based on the research questions as well as the aims of the study, the researcher decides which methods would be appropriate for his/her work.

The qualitative methods of verbal data analysis have the advantage of transcribed talk being available throughout the analysis. The categories used for data analysis emerge from the data so the analysis can be expanded to include new aspects of communication that emerge in the data. The weakness of this method is that it is difficult to use it when large volumes of data are involved because it is time consuming and also it is difficult for the researcher to make generalizations with this kind of method.

On the other hand, the quantitative data analysis techniques are able to handle large amount of data and are also amenable to statistical data analysis. However the weakness of this method is that categories of analysis are generally predefined and so the data has to be looked at in a particular way and consequently its richness is lost.

Combining the qualitative and quantitative methods - Mixed methodology

Newer methods of verbal data analysis combine the richness of both qualitative and quantitative methods. Mercer (1995) has used one such mixed method for analyzing classroom talk where children are involved in a computer-based activity. The qualitative aspect of this work focuses on relationship between particular interactions that occur at different times in the data while the quantitative data involves assessing the frequency of certain words in the data or comparing their incidences across data. This methodology has been used for analyzing teachers' as well as students' talk. The criteria for analysis used by Mercer et al. was initiated earlier by Dawes et al. (1992) and has been briefly mentioned earlier in the section 2.2.3. According to Mercer et al. (2004), this methodology tends to 'ease the tension between wanting to analyze talk as contextualized activity and also to provide generalisable results based on a large sample of cases.' The three categories of talk are:

Disputational talk: which is characterised by disagreement and individualised decision-making. There are few attempts to pool resources, to offer constructive criticism or make suggestions. Disputational talk also has some characteristic discourse features and short exchanges consisting of assertions and challenges or counter assertions.

Cumulative talk: in which speakers build positively but uncritically on what the others have said. Partners use talk to construct a common knowledge by accumulation. Cumulative discourse is characterised by repetitions, confirmations and elaborations.

Exploratory talk: in which partners engage critically but constructively with each other's ideas. Statements and suggestions are offered for joint consideration. These may be challenged and counter-challenged, but challenges are justified and alternative hypotheses are offered. Partners all actively participate and opinions are sought and considered before decisions are jointly made. Compared with the other two types, in exploratory talk knowledge is made more publicly accountable and reasoning is more visible in the talk.

One of the kinds of data in our work was students' dialogues during formal communication. This verbal data was analysed using the scheme developed by Dawes et al. (1992).

2.3. 6 Conclusion

The theoretical framework of this thesis utilizes Vygotsky's concept of learning as a social process. Although there have been studies of 'classroom talk', most of them have focussed on science, mathematics, language or geography classes and there have been relatively few studies in the area of technology education. Most of the 'classroom talk' studies done so far have focused on student-teacher interactions (Maybin et al., 1992) or enhancement of particular kind of interactions through some interventions (Edwards and Mercer, 1987; Fisher, 1993, Katz and Kratcoski, 2004). There is a need to examine communication aspects especially those that occur between students while working in small groups during students’ technology /problem-solving tasks.

2.4 Collaborative learning

Humans have a tendency to work in groups. Working together has been beneficial for humans in many economic and social activities from pre-historic times till the present. Much real-life learning happens in the context of groups or communities, with a purpose beyond the immediate learning situation.

Vygotsky (1978) has emphasized the importance of learning as a social process. Studies have shown that students learn more, have more fun and develop more skills by working together with others on complex conceptual information tasks (Johnson et al., 1991). There are two terms that are used for learning together in groups - one is ‘collaborative learning’ and the other is cooperative learning. Collaborative learning (CL) is a term used for a variety of educational approaches involving joint intellectual effort by students or by students and teachers together (Smith and MacGregor, 1992). CL is defined as ‘situation/interactions/mechanisms in which *two or more* people *learn* or attempt to learn something *together*- kind of *social contract’* (Dillenbourg, 1999, p. 1). The term ‘CL’ has British roots, based on the work of English teachers exploring ways to help students respond to literature by taking a more active role in their own learning (Mayers, 1991). In most of the CL approaches, students work in groups of two or more, trying to understand or find solutions to a problem at hand or make something. According to Roschelle and Teasley (1995, p. 70), collaboration refers to a ‘coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem.’ The proponents of CL claim that ‘the active exchange of ideas within small groups not only increases interest among the participants but also promotes critical thinking’ (Gokhale, 1995, p. 22). CL approaches are closely related to cooperative learning and are often confused with cooperative learning.

Cooperative learning stresses the *product* of working in groups. Learning in cooperative situation refers to problem solving where the participants of a group divide the work in such a way that that each member of the group is assigned a particular task and in the end all those tasks are put together to produce the solution to the problem (Dillenbourg et al., 1996). According to Panitz (1997), the cooperative learning tradition tends to use quantitative methods that look at achievement: that is, the product of learning. Co-operative learning is influenced by the philosophical writings of John Dewey stressing the social nature of learning and the work on group dynamics by Kurt Lewin (Panitz, 1997). In cooperative learning the task is split (hierarchically) into independent subtasks (Dillenbourg et al., 1996, p. 2), whereas in CL cognitive processes may be heterarchically divided and the participants maintain a 'shared conception of a problem' (Roschelle and Teasley, 1995). The following Table 2.3 tries to summarize the differences between cooperation and collaboration.

Table 2.3: Differences between cooperation and collaboration

Characteristics	Cooperation	Collaboration
Origins	Has largely American roots	Has British roots
Identity of individuals	It is an informal arrangement in which the participants maintain their separate identities and responsibilities	It involves individuals coming together and changing their individual approaches to a goal to allow for the sharing of resources and responsibilities
Division of labour	Hierarchically	Heterarchically
Subtasks	These are divided among participants	All tasks are mutually shared between the participants
Goal setting	Individual	Common

2.4.1 What is considered as collaborative?

The word 'collaboration' can be interpreted in various ways. There have been debates among scholars working in the area of CL about what is considered as 'collaborative'. According to Dillenbourg (1999), 'collaboration' has a variety of meanings and concerns three aspects of learning and these include (a) Situation (b) Interactions (c) Mechanisms.

(a) A **situation** is considered collaborative if the individuals involved in working together are more or less at the same level, can perform the same action and have a common goal. A situation is considered collaborative if there is:

- *Symmetry of action:* It is the extent to which the same range of actions is allowed to each individual in a group (Dillenbourg and Baker, 1996)
- *Symmetry of knowledge*: It is the extent to which the individuals possess the same level of knowledge or skills. According to Dillenbourg (1999, p. 7), there is 'no situation of pure knowledge symmetry'. No two individuals in the world have the same knowledge.
- *Symmetry of status*: It is the extent to which the individuals working in a group have a similar status with respect to their community (Ligorio, 1997, cited in Dillenbourg, 1999).

(b) **Interactions** are considered collaborative if they have the following criteria:

- *Interactivity among the peers*: It refers to the extent to which interactions can influence the cognitive processes of other members of the group.
- *Synchronicity:* It refers to the extent to which the individuals in the group are able to work together (respond and reason together)
- *Negotiability:* It refers to the ability of the participants to engage in discussions/dialogues to reach an agreement rather than imposing authority by any of the group members.

(c) Some **mechanisms** involved in individual learning are the same for learning in groups and these include:

- *Induction:* The phenomenon by which individual ideas are integrated to form a complete picture. Schwartz (1995) observed that pairs draw more abstract representations of the problem at hand than the representations drawn by each individual.
- *Cognitive load*: The horizontal division of tasks reduces the amount of processing performed by each individual. Reduced cognitive load helps the group members to improve their 'regulatory skills' rather than working alone (Blaye, 1989).
- *Self-explanations*: It is a learning strategy where students learn with greater understanding by explaining the study materials to themselves (Chi et al., 1989).

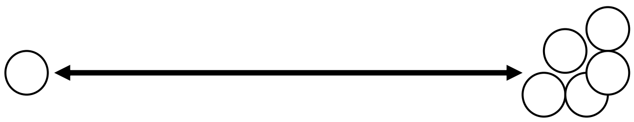
- *Conflict:* The conflict of ideas among members in a group can lead to individuals modifying their ideas and consequently learning occurs.

In addition to these, there are some mechanisms that are typical to the theories explaining the underpinnings of CL. These theories and the mechanisms involved are explained in the following section.

2.4.2 Theories of CL

The theoretical perspectives that explain cognition through collaboration can be broadly categorized into (a) Constructivist approach (b) Socio-cultural approach (c) Shared cognition approach. These theoretical perspectives differ in their conceptions of shared thinking (collaboration) but emphasize its role in cognitive development (Rogoff, 1990). These theories also share some assumptions about CL but the differences lie in the unit of analysis. The unit of analysis could be an individual or a group as shown in Figure 2.3.

Figure 2.3: Unit of analysis in collaborative learning



Irrespective of the unit of analysis, there are some shared *assumptions about learning* (Smith and MacGregor, 1992) that tie the theories together.

- Learning is an active, constructive process: To gain new information/skills, students need to work actively in order to integrate new knowledge with what they already know. In CL the participants do not simply take in new ideas but they also create something new with these ideas along with the ideas that they already possess.
- Learning depends on rich contexts: Learning is influenced by the context and activity in which it is embedded (Brown et al., 1989). CL activities engage students in challenging tasks. In CL tasks, students usually begin with a problem rather than beginning with facts. Instead of being mere observers, students become immediate practitioners.

- Learners are diverse: Students have multiple perspectives, backgrounds, learning styles, experiences, aspirations and teachers cannot assume a uniform approach in the classroom.
- Learning is inherently social: Students talk with each other and in talking much of the learning occurs. Golub (1988 cited in Smith and MacGregor, 1992, p. 2) has pointed out that "Collaborative learning has as its main feature a structure that allows for student talk: students are supposed to talk with each other…..and it is in this talking that much of the learning occurs."
- Collaborative learning actively engages the learners: In the CL environment, the learners are challenged both socially and emotionally as they listen to different perspectives, and are required to articulate and defend their ideas. Learners have the opportunity to converse with peers, present and defend ideas, exchange diverse beliefs, question other conceptual frameworks, and be actively engaged.

(a) Constructivist approach

The constructivist approach focuses mainly on individual aspects in cognitive development and has been inspired by the work of Piaget. Piaget's theory of cognitive development advanced during the 1970's and 1980's has influenced the field of collaborative learning. Piaget focused on individual cognitive development and examined the relationship between the individual and the society. He explained that individuals benefit from working with peers through resolving 'cognitive conflicts', which occur as a result of interactions with many people while working in a group.

Researchers working in the constructivist paradigm have borrowed from Piagetian theory, concepts such as conflict and coordination of points of view. The central idea is that through interacting with others, and through coordinating their approaches to reality with those of others, the individual widens his/her intellectual and cognitive 'vistas' (Doise and Mugny, 1984). According to Piaget, cognitive development through collaboration occurs 'if the partners have a common language and system of ideas and use reciprocity in examining and adjusting for differences in the opinions' (Rogoff, 1998, p. 685).

This paradigm resulted in increased research where the typical experimental set-up of studies was a three-stage process of pre-test, individual or collaborative learning and post-test. Children (5 -7 years old) worked either alone (control) or in pairs. The tasks in which students in these studies were typically involved were the Piagetian conservation tasks. The results of these studies indicated that in the post-test, students who worked in groups produced better results than students working alone. Working in pairs facilitated subsequent individual performance and the mechanism responsible for this improved performance was called 'socio-cognitive conflict' (Dillenbourg et al., 1996).

Piaget's theory (1976) proposes that when cognitive conflicts are created, it leads to increased levels of reasoning as well as learning. According to this perspective, conflict arises when there is a perceived contradiction between an individual's existing understanding and what the individual experiences. This leads the individual to question his/her beliefs and to try out new ideas (Forman and Cazden, 1985). According to Doise and Mugny (1984) students learn from others through disagreements when they identify and resolve conflicting viewpoints, present alternatives and give and request explanations. Individual cognitive development is seen as the result of 'a spiral of causality: a given level of individual development allows participation in certain social interactions which produce new individual states which, in turn, make possible more sophisticated social interaction' (Dillenbourg, Baker, et al., 1996, p. 3). According to Doise (1990, p. 46), the main thesis of the constructivist approach is that the individual learns ' ….through interacting with others, coordinating his/her approaches to reality with those of others …masters new approaches.'

Thus the socio-constructivist approach focuses on the individual's development with respect to social interaction, without really differentiating or identifying the underlying factors that enhance CL. In this approach social interactions are considered as contained in a 'black box' that encourage CL and the focus is on outcomes. A drawback of this approach is the paucity of information about development in situations other than laboratory settings.

(b) Socio-cultural approach

The socio-cultural perspective views learning as a social phenomenon that takes place in situations where learners participate in activities together, that is, it emphasizes the interdependence of social and individual processes in the co-construction of knowledge (John-Steiner and Mahn, 2002). According to this approach, individual development should be understood with reference to social and cultural contexts in which it occurs.

Socio-cultural approach focuses on the causal relationship between the social interaction and the individual cognitive change (Dillenbourg, 1996). An important concept in this approach is Vygotsky's concept of zone of proximal development (ZPD) in which 'The ZPD is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers' (Vygotsky, 1978, p. 86). In the context of CL it means that a learner would use the techniques that are learned during the collaborative effort with the companion when s/he tries a similar problem independently.

The basic unit of analysis is the social activity from which individual mental functioning develops. During analysis of an activity through the socio-cultural perspective, the researcher emphasizes the social context of the activity rather than the individuals participating in the activity, as was the case in the constructivist approach. According to Rogoff (1990), individuals transform the culture by their participation in it and along with this transformation, they alter the practices to 'fit the circumstances'.

The mechanism by which participants alter their participation in a joint activity is referred to as 'appropriation'. According to Rogoff (1991), appropriation refers to a process in which an agent reinterprets his own action or utterance under the light of what his partner does or says next. To understand appropriation let us consider A and B, who solve a problem jointly. 'A' performs first action. B does the next. B's action indicates to A how B interpreted A's first action, that is, B may have appropriated from A but A appropriates B.

In the socio-cultural approach, along with appropriation, scaffolding also plays an important part in CL. Bruner (1978) describes scaffolding as cognitive support given by teachers to learners to help them solve tasks that they would not be able to solve working on their own. It is a form of ‘vicarious consciousness’ in which students are taken beyond themselves with the aid of teachers or ‘more able peers’. In approaches that are influenced by Vygotsky, there is an asymmetry that accounts for learning (Roschelle, 1992).

ZPD and scaffolding were considered asymmetrical concepts where learning occurred because of differences among co-learners. However Fernandez et al. (2001, p. 53) have re-conceptualized the concept of ZPD and scaffolding to include learning even with peers of equal abilities. The results of their study indicated that when students interacted in groups a ZPD was created and that ‘the group version of ZPD is no longer the product of a teacher’s conscious intention’ (asymmetries are not essential) but was better understood as an interactive process of teaching and learning that rests on the maintenance of a dynamic contextual framework of shared knowledge, created through language and joint action, in which language was used in a dynamic and dialogical way to maintain and develop a shared context’. Thus in problem-solving tasks, children could mutually support each other’s progress in symmetrical groups.

Unlike constructivist approach, where social interactions were considered within a ‘black box’, in the socio-cultural approach, interactions between participants are considered important and have been the subject of study. According to Roschelle (1992) interaction by means of talking enables students to construct ‘relational meanings’. He suggests an integrated approach to collaboration and conceptual change. In his study, he analyzed collaboration as a process that could lead to convergence of meaning. According to him, in order to construct common ‘intelligible interpretations’ of what is taking place, actions have to be considered in relation to the situation in which they are embedded and participants have to orient themselves to these ‘situated actions’ to succeed in convergent conceptual change. He conducted a case study with two students engaged in discovery learning with ‘Envisioning machine’ (a computer simulation to explore concepts of velocity and acceleration). Students’ actions as well as talk during the task were recorded. It was observed that students negotiated a shared understanding of acceleration through a series of interleaved assertions, gestures, actions, requests for clarification, acknowledgments, elaborations, and other linguistic devices for signalling agreement and fixing troubles in shared understanding. During discourse, students referenced the representations by gaze, pointing, and other means, as a way of supporting the conversation and meaning negotiation. This study gave an indication of 'how students use coordinated language and action to establish shared knowledge, to recognize any divergences from shared knowledge as they arise, and to rectify misunderstandings that impede joint work' (Roschelle and Teasley, 1995, p. 7).

The idea of maintaining a common understanding in CL has been explained by Baker et al. (1999) through the process of 'grounding'. 'Grounding' refers to the interactive processes by which common understanding between individuals is constructed and maintained through language as the primary medium of grounding. Language itself may be the object of mutual understanding.

Theories of CL that are based on the socio-cultural perspective consider the activity with its social context as a unit of analysis rather than an individual in an activity. The ZPD, scaffolding, appropriation and grounding are important concepts underpinning CL in this approach. The drawback of this approach is the complexity of findings from research due to a large number of variables that the researchers need to deal with (e.g. group heterogeneity, task features, individual pre-requisites etc.).

(c) Shared cognition approach

The shared cognition approach focuses on the environment in which learning takes place. The environment consists of both physical and social contexts. Shared cognition aims at letting peers learn knowledge and skills in contexts where they are applicable (Brown, et al., 1989; Lave and Wenger, 1991). There are various schools of thought under the shared cognition approach: such as apprenticeship learning, situated cognition, legitimate peripheral participation, situated action etc.

The shared cognition approach has been influenced by Vygotsky's concept of ZPD that suggests that students are able to perform better on tasks when they engage in it with more able peers or teachers than alone. Another influence on shared cognition approach has been of John Dewey's idea of learning defined within the social unit (cannot be defined by outsiders) (Roschelle, 1995).

One of the theories within the shared cognition approach is that of *situated cognition*. Jean Lave and Etienne Wenger who are the pioneers of the *situated cognition* theory argue that learning is situated in social and cultural context in which it occurs.

Lave and Wenger have coined the term 'communities of practice' in their work *Situated Learning: Legitimate Peripheral Participation* (1991) to describe an informal, continuous, and naturally occurring learning process that was typical of traditional apprenticeships. They studied five communities, which included midwives, tailors, quartermasters, butchers, non-drinking alcoholics and observed that the nature of situation has a bearing on the learning process. They used the analogy of 'old-timers and newcomers' to illustrate this process. According to them, within any community, 'newcomers enter at its periphery, but as they become active and engaged…, they move steadily to its centre, eventually assuming the role of old-timer' (p. 98). They situate learning in certain forms of social co-participation and examined the types of social engagements that provided the proper context for learning. For them, co-participation led to collective learning in a shared domain of human action/endeavour leading to formation of 'communities' that shared understanding concerning 'what they are doing and what that means in their lives' (Lave and Wenger, 1991, p. 98). Communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly. Not all people coming together form a community of practice. There are certain characteristics of community of practice and these are:

- *Domain:* To be a member of any community of practice, one must be committed to the domain and should have knowledge and competence, which distinguishes members of one domain to another. Members of a community value their collective competence.
- *Community*: Members of community of participation engage in joint discussions

and share information with each other and are motivated.

- *Practice*: Members of a community of practice are practitioners. They develop shared resources: experiences, stories, tools, ways of addressing problems - in short a shared practice.

Brown et al. (1989) have further developed the theory of situated cognition and have suggested a model of *cognitive apprenticeship.* In this situated cognition approach both activity and environment are important and learning occurs as a result of social interactions and collaboration through 'cognitive apprenticeship'. Thus when authentic situations are created during learning that are similar to real life situations it is easier to transfer learning across situations, that is, cognitive apprenticeships are less effective when skills and concepts are taught independent of their real-world context and situation.

Cognitive apprenticeship is aimed at teaching the processes that experts use to handle complex tasks. The focus of this learning (through guided experience) is on cognitive and metacognitive skills, rather than on the physical skills and processes of traditional apprenticeships (Conway, 1997). According to Brown et al. (1989, p. 24), 'cognitive apprenticeship supports learning in a domain by enabling students to acquire, develop and use cognitive tools in authentic domain activity. Learning, both outside and inside school, advances through collaborative social interaction and the social construction of knowledge.' Cognitive apprenticeship involves the following steps:

- *Modelling*: It involves an expert carrying out a task so that students can observe and build a conceptual model of the processes that are required to accomplish the task.
- *Coaching*: It consists of observing students while they carry out a task and offering hints, feedback, modelling, reminders, etc.
- *Articulation*: It includes any method of getting students to articulate their knowledge, reasoning, or problem-solving processes.
- *Reflection*: It enables students to compare their own problem-solving processes with those of an expert or another student.
- *Exploration*: It involves pushing students into a mode of problem solving on their own. Forcing them to do exploration is critical, if they are to learn how to frame

questions or problems that are interesting and that they can solve (Collins et al., 1989, 481-482).

Within the shared cognition approach another perspective describes learning as a process of “*guided participation*” shared between the child and others in contexts of participation. Guided participation involves the bridging of different perspectives among the more and less experienced participants, and also the way each participant's involvement in the activity is structured (Rogoff, 1990).

Recent research has highlighted some techniques within the shared-cognition paradigm that support learning. Experts supporting novice’s learning is one such method using techniques such as scaffolding, tutoring, Socratic dialogue etc. Wood et al. (1976) studied how adults support preschool children in their learning and found that adults structured their tutoring according to skills of the children, their needs and their response to the instructions. Socratic dialogue techniques include counter-questioning children on their hypothesis, probing their assumptions, posing conceptual questions for conceptual clarifications and probing about implications and consequences etc. Brown and Palincsar (1989) have characterized Socratic dialogue as those discussions that are guided by teachers’ instructional priorities. Another technique is peer tutoring in various situations such as play and child care-giving and collaborative argumentation.

Computer scientists have also worked in the area of shared cognition using technology of *“distributed artificial intelligence”* (DAI) to implement a social model for learning. In the domain of computer science, a group forms a single cognitive system. In terms of research in CL, Pierre Dillenbourg (Dillenbourg, 1994) analysed various conceptions of learning (constructivist, socio-cultural and shared cognition) that can give foundation for a computational model. According to him, design of the computer system has an effect on the process of collaboration - it may support certain types of interactions that promote learning or may place explicit control over some aspects of collaboration. Dillenbourg et al. (1996), have described three settings in which computers have influenced collaboration, 1) where two humans collaborate on a computer based task; 2) where computers and humans collaborate (where computer and the human user share similar set of actions); 3) computer mediated communication (where computer is a medium between two or more humans). The research in these settings has indicated that dyadic work at computer may enhance the benefit derived from CL situation. The idea of human-computer collaborative learning has been applied to educational software.

Differences in the approaches to CL

The constructivist approach focuses largely on the individual plane, the socio-cultural approaches are concerned mainly with the inter-individual plane while the shared cognition approach focuses on the larger social plane. The differences in approaches of studying cognition are depicted in Figure 2.4.

Figure 2.4: Approaches to studying collaboration a) Constructivist, b) Socio-cultural, c) Shared cognition (adapted from Rogoff, 1998)

Different theoretical positions outlined in this section employ different research paradigms. The experiments (research) in the constructivist approach usually concerns two subjects of nearly the same age and learning occurs by virtue of conflict. In the socio-cultural approach, adult-child pairs are involved in research and learning occurs by appropriation and focus is on the processes involved in social interactions. In the shared-cognition approach focus on the larger social plane where the individual and the process involved in collaboration (also called interactions paradigm) are highlighted.

In this study, we mainly followed the socio-cultural and the shared cognition approaches to CL. Students worked in a group and shared a goal and all the members of the group worked together on common tasks to achieve the goal.

2.4.3 Research studies on CL in educational contexts

The benefits to learning by working in groups have been known for some time. In 1981 meta-analysis by Johnson et al. of over 120 research studies indicated that group work in learning situations was more effective than competitive or individualistic goal structures. Good et al. (1992, p. 167) describe 'clear and compelling evidence that small group work can facilitate student achievement as well as more favourable attitudes towards peers and subject matter'. Other researchers have suggested that the composition of the groups and the form of tasks the groups tackle are important in determining the quality of learning achieved through such group work (Barnes and Todd, 1977; Cohen, 1994).

CL could take place in formal classroom contexts or informal learning outside classrooms. According to Rogoff (1998), necessities for collaboration include face-to-face mutual involvements such as routine conversation, tutoring, teaching and cooperative learning; side-by-side engagements and participation in shared endeavours even without physical co-presence such as virtual environments.

Learning by collaboration occurs in many domains of life and is followed un/consciously. However in the formal education systems, the idea that learning is a social activity remains to be internalized. Attempts to emulate CL in formal teaching environments are often not very successful due to time constraints and lack of knowledge and skills amongst the teachers and administrators. In conventional classrooms teachers continue to emphasize on what a tutor can do rather than what students can do to initiate their own learning through collaborating with others. In short, in most formal education systems, individual learning is emphasized and encouraged to the extent that at times in classrooms there is prohibition on students helping or even speaking with each other without teacher's permission (Wells, 1992 in Edwards and Westgate, 1994).

Benefits of CL

Workers in different domains of education have enumerated the benefits of collaboration on learning and students' understanding. An experiment on Constructive Interaction by Naomi Miyake (1986) confirms that in the learning process the bulk of constructive criticisms occur while learning in collaboration. In an experiment she studied pairs of individuals whose task was to understand the working of a sewing machine. She found that the working of the machine was better understood when individuals interacted collaboratively. The experiment showed that about 80% of self-critiquing (reflection) took place during CL compared to 20% that took place when students were learning alone. Self-critiquing was one of the major contributors to the effectiveness of learning. This experiment showed that learners might miss the opportunity for better understanding if they do not collaborate.

In the context of history education, Van Boxtel (2002), carried out a study, which involved a comparison of students working in dyads versus those taught in teacher-guided groups. The subjects in the study were one history teacher and two of his classes who studied the topics on the Middle ages (Church and Knights). It was a pre-test/post-test design research. The analysis of the interactions focused on the participation of the students (12 years old), the quality of historical reasoning, the amount of co-construction and the role of available resources. The results of the study showed that both methods of collaborative work (small group as well as teacher-guided discussions) provided an opportunity for students to develop and improve ways of historical reasoning. CL represents a shift from regular teacher-centered classrooms to a classroom environment where the teacher is a facilitator of learning rather than a transmitter of knowledge. Similar studies have been carried out in the domain of geography (Lyle, 1996), science (Carter et al., 1999) and mathematics (Good et al., 1992).

The fields of psychology, computer science and artificial intelligence have used the basic framework and assumptions of CL. In psychology, researchers have focused on classroom learning in groups, apprenticeship learning, community participation (Lave, Wenger, Rogoff, Matusov, Chavajay, etc) and the researchers working in the area of

CL in computer science/ artificial intelligence have made their contribution in the domain of computer supported collaborative learning (Dillenbourg, Baker, O'Malley, Hansen, etc). It is to be noted here that the field of artificial intelligence focuses more on cooperative problem solving than CL.

Research on CL in small groups has focused not only on aspects of peer interaction that contribute to learning but also on physical arrangements in the group, its settings, group size and composition, learning tasks, which also have a bearing on learning (Rogoff, 1990; Webb, 1991; Dillenbourg et al., 1996; Barak et al., 1999; etc.). CL also aids in development/acquisition of soft-skills, which include skills of communication, effective presentation, negotiation, teamwork, social-esteem and self-management, which are increasingly being required by the industry. Educationists as well as employers have emphasized the need to train students in these skills as part of general education (Thangamuthu, 2007; Karnik, 2007).

In short, the value of group work in educational contexts is known but in practice, group work is discouraged. At the anecdotal level, collaboration is seen as a something that is good. The ability to work together has been emphasized for quite sometime but studies in the education contexts have shown that the ability to work in team decreases as students progress through the school (Stables, 2000). Considering the importance of CL and attempting to inculcate it in the formal education system, we planned this research project that encouraged collaboration between students and also between students and researchers.

2.4.4 CL in the context of technology education

Technology education has utilized the models of learning, ranging from considering learning to be a solo activity to viewing learning as a social process. The behaviourist considers learning in technology education to be a solo activity. It views learning as a one-way process of transmission of information from an expert/teacher to a student/novice. This, according to Dakers (2005, p. 79), connotes a 'technology education paradigm, which serves to commodify technological skills as a transaction in which skills are transferred from expert to recipient.' In this model, the person who acquires (receives) the skills is passive and the expert is active. The skills are considered external to the learner and internal to the expert and through the process of transfer, the learner acquires the skills.

Another model, which considers learning in technology as a social activity but in a restricted sense has been influenced by Vygotsky (1978). This model views learning as a process of internalization that occurs through socialization. Development occurs by ‘the mediation of socially distributed signs, external to the learner, which take the form of tools which are both semiotic and artefactual in nature, and which come together to form the culture and society into which the learning is evolving’ (Dakers, 2005, p. 79). This model takes into account some of the social factors responsible for learning but still separates the external from the internal. This model has been criticized for considering the process of internalization as one-way, starting at the social plane and ending within the individual (Matusov, 1998).

The third model that draws from the shared cognition approach considers technology, people (society), tools and materials (resources) are active agents who form a community of practice (Wenger, 1998) and a constant interaction between these is desired. According to Olson (1993, p. 262), ‘social purposes are lived out through technology.’ Considering the social nature of technology, it becomes essential to ensure that technological activities, products are examined in their context, taking into account their implications on human lives and the environment. Thus living in and acting on the world cannot be separated. Technology education is not just about using technology, it concentrates more on generating ideas and acting on them, as well as in using and developing processes and products that satisfy human needs (Curriculum Corporation, 1994). Technology education by this definition reiterates the contextual and social nature of technology. So what is learned is specific to the situation in which it is learned. But this does not restrict learning into ‘a box’ instead it emphasizes the relationship between what is taught in the class and what is needed outside the class. Therefore in order to be able to understand technology in the real world and suitably engage students, technology educators make efforts to contextualize the tasks/activities in ‘authentic’ situations. Authenticity in technology tasks comes from the task contexts, which determine the link between students' knowledge and its relevance in a particular situation (Hennessy and Murphy, 1999). McCormick (2004) has argued that technological knowledge needs to be acquired in learning situations that are both meaningful to students (personal authenticity) and related to the technological world outside of the classroom (cultural authenticity).

In the context of providing authentic learning situation for students, Hill (1998) studied primary school children (5-7 years old) and their teacher in a technology education class in Ontario. The class worked on a problem that was embedded in a real-life context. The problem was of writing and producing a play. Teachers and students discussed the topic in detail and the teacher guided the students in sorting out ideas and helped in decision-making. Throughout the activities, all the students were involved in a variety of technological problem solving activities such as deciding on the topic of the play, writing the play, deciding its characters, making the characters, planning their movements (with hydraulic and pneumatic system), stage setting, making props etc. The teachers supported their activities and provided them conceptual inputs from time to time. Involvement of all students in the class in these activities, decision making and discussions during the class show that students were able to work on technological problems, talk about the technological concepts that they had learned and were capable of discussing issues that were close to them. By situating the activities in real-life contexts of the students, it was possible to enhance this learning and also foster children's thinking about human and environmental consequences of their design.

A study carried out with junior high school students in Israel, aimed to increase the understanding of pupils' teamwork behaviour within technological tasks (Barak and Maymon, 1998). Students were observed in a four and a half hour workshop that required them to design and construct an envelope for a hot air balloon from tissue paper. It was found that pupils, if given freedom, tend to form homogenous groups. Single-sex groups were more common than mixed sex groups and this often led to the exclusion of members with varied skills. Most groups began to function as teams during the planning or construction stage of the task (rather than the initial stages of the project). The decision-making pattern within the groups was mostly by consensus

(44%). There was competition between various groups in the class but members within a group cooperated. Teachers tended to the take the role of facilitators (clarifying technical issues), managers (assignment of duties and performing tasks) or foremen (prevented students from functioning autonomously) within the groups. This study was further extended to characterize teamwork in modern organizations and work places (Barak et al., 1999).

Many researchers have stressed the importance of collaboration in technology tasks, not only for developing soft skills suitable for the world of work but also for life in general. Hennessy and Murphy (1999) have discussed the potential of D&T as a platform for providing an environment for collaborative problem solving. In their study, they proposed a set of ideal conditions for productive collaboration in a classroom which are: teachers' commitment and understanding of collaboration, contextualization of tasks to aid joint understanding and decision making, school and classroom organization that supports group work, pedagogic strategies (such as selecting appropriate tasks, scaffolding students, dealing with alternative perceptions, addressing conflicts, monitoring individual understanding, encouraging feedback etc) and pupil's perspectives (such as shared frame of reference regarding tasks, personal authenticity and investment in outcome, social skills and cognitive strategies for collaboration). The empirical study by Murphy and Hennessy (2001), with 9-13 year old students in England, showed that there is little evidence for collaboration in D&T activities, despite it being a rich context to offer/support resources for collaboration. Though the need to impart skills of collaboration in technology education has been highlighted in the literature yet inculcating teamwork skills remains one of the unmet goals of technology and of late many research studies are being planned that lay emphasis on team work (Denton, 1994; Dyrenfurth 1996; Barak et al., 1999, Barak, 2006).

2.4.5 Roadblocks to implementation

One of the reasons given for failure of students to collaborate in the classrooms is that the institutions may constrain learning through the prescription of curricula, following strict timetables, and the setting of targets and timing of exams. Consequently, much of the interaction between teachers and students gets directed towards control and accountability. For Argyris (1992), the very structure of such institutions not only hampers collaboration and hence learning but also actually prevents it from taking place.

Another impediment to CL, are the teachers who find it difficult (challenging) to manage class situation in collaborative tasks. This is understandable since teachers themselves are the products of a system that encouraged individual learning – so either they are unfamiliar with strategies for encouraging CL or if trained, they tend to often return to the 'comfort zone' of their usual mode of teaching. McGrath (2002) offers the model of situated learning as one possible solution to helping teachers understand the meaning of 'collaboration' in technology education and also as a way to ensure appropriate engagement of students in technological practice.

Like teamwork, talking among students is also not encouraged by teachers in school. Though in school a variety of talks can be observed but the generally accepted 'official' talk in the classroom is that of Initiation-Response-Feedback between teachers and students (Edwards and Westgate, 1994). Teachers tend to dominate the conversations and there are asymmetries observed between them and the students (Edwards and Mercer, 1987) where students find themselves difficult to be heard. On the other hand, studies have shown that not all kinds of talk are known to have positive effects. Bennett and Cass (1989) found that students while working in groups mostly engaged in talks for 'procedural interactions' rather than learning to manage interaction or establishing directionality.

2.4.6 The way ahead

Head and Dakers (2005) suggest that technology education should aim for the development of technological literacy. Students should be able to '...apply considerable moral and ethical judgements in evaluating technologies,... …to consider[ing] the effects that proposed solutions may have on the well being of individuals, societies and the local or global environment (SCCC 1996, as cited in Head and Dakers, 2005, p. 6), that is, students must be able to develop critical awareness about the technological world and consequently be able to make informed choices.

Teachers on the other hand should become partners with students in fostering learning of technology rather than focussing only on learning of facts. Learning by changing participation in socio-cultural activity should be seen as a key conceptual tool for planning work in school rather than a series of lessons (Lave and Wenger 1991; Rogoff 1990). Students should be given a chance to work independently with their peers rather than depend wholly on a teacher. In other words consideration should be given to students for autonomy and opportunity for group work.

Further, a collaborative endeavour can be effective if its members communicate well with each other (Barak et al., 1999). Mercer, Wegerif, Fisher etc. discuss the beneficiary effects of ‘exploratory talk’ on students’ meaning making. In order to go beyond mere ‘cumulation’ of meanings, students need to get explicit instructions in engaging in exploratory kind of dialogues. The importance of talk and group-work in classrooms and the cognitive processes necessary for understanding can occur through interaction with others and these need to be encouraged in the classroom context.

2.4.7 Conclusion

Technology is a social process (collaborative endeavour) and not a solo activity. It involves users, designers and makers of products. It is shaped by and through social, material and discursive resources. If these views are to be represented in technology education then teachers and students need to play non-traditional roles. Existing *prescriptive* technology education paradigm needs to undergo a change to an *experiential* one. Students have to be actively involved in the learning process. One of the ways to involve students in culturally meaningful learning is to contextualize tasks that are authentic situations (Murphy and Hennessey, 2001; Kimbell et al., 1996). Students must have a sense of ownership of the situation/ideas/products and be provided opportunities for reflection. CL approach has cognitive benefits that can facilitate changes in technology education paradigm and help both teachers and students. In India where technology education needs an introduction at the school level, CL framework can be one of the plausible ways for introducing the subject.

2.5 Gender and Technology Education

Technology being a social endeavour involves both men and women differently. This difference is influenced by socialization. In society, science and technology (S&T) are more readily associated with males who are considered more ‘technologically able’ than females (Acker and Oatley, 1993). This section of the chapter reviews literature related to the relationship between gender, science, technology and the status of women and girls in the fields of S&T. Models explaining under-representation of women in the fields of S&T and feminists’ perspectives on technical work are presented as well as various efforts at making technology education more inclusive.

Though different, the terms sex and gender are often used interchangeably to describe the behaviours and identity of children and adults. Bhasin (2002) defines ‘sex’ as biological or anatomical differences between males and females, which are constant and ‘gender’ as a term that refers to the socio-cultural definition of man and woman. Thus distinction between the two terms emphasizes physiological features on one hand while stressing cultural constructs or a set of learned behaviour patterns on the other.

Throughout history and across cultures women have played an integral role in development of technology. They have created or improved many of the products and practices that support our quality of life. Women have contributed in many ways to technical advancements. Since ancient times women have been the main gatherers, processors, and keepers of food and have been associated with nurturance, child rearing and house-keeping. Historically many cultures had heroines of technology as cultural icons. For example, the Greek culture held the goddess Athena as the original inventor of all mechanical arts (Stanley, 1995). More recently women have been credited with inventions like windshield wipers, Kevlar, computer language and others (Macdonald, 1992).

Despite involvement of women in various spheres of technology, there is a belief that what women do is not in any sense technological (Chunawala and Natarajan, 2004).

The contributions that women make are considered outside the ambit of technology. Women's use of machines is not seen as being competent with technology, unlike the male use of technology, as a mark of their skill (Wajcman, 1991). The popular portrayal of technology as being created by men paints a skewed picture of history and it perpetuates the stereotype that technology is a male endeavour (Zuga, 1999a).

2.5.1 Relationship between gender, science and technology

S&T encompasses many activities that are related to by women and men differently. In understanding gender, science and technology, it is imperative to understand the masculinity of S&T as a social product - what Harding (1986) describes as the 'gender symbolism' of S&T. S&T has similar ideological roots and its history helps us unravel the relationship of science and technology to gender. Both, S&T and males are described as hard, rational, objective, methodical, and as exerting mastery and control over nature. Conversely, 'femininity,' is soft, emotional, subjective, submissive and passive - everything S&T is not (Fox Keller, 1985).

Science is often equated with knowledge that is concerned with the physical world and the phenomena therein. The duality of logic as science and emotion as nature has been emphasised by natural philosophers like Plato who assigned gender characteristics to these concepts. Aristotle promoted the view that women were inferior to men and 'incapable of rational thought'. In the 16th century, Descartes, a philosopher, mathematician and a scientist, emphasised separation (of subject and object) and individuation (detachment), which provided rationale for attributing masculinity to S&T (Wyer et al., 2001). Francis Bacon (17th century), an English philosopher and proponent of scientific revolution, furthered duality by speaking of mind as knower (masculine) and nature (feminine) as the knowable. Man as the subject in control of female (object of observation /experimentation).

In the history of S&T, few women find a mention and those who do, belong to the upper classes of society. While women's participation in science was restricted to subordinate roles due to their presumed 'inferior biological status', women faced numerous barriers and achieved limited access to scientific institutions and technical knowledge (Wyer et al., 2001). In ancient times, women were not allowed to hold patents and publish scientific papers and therefore their contributions to S&T have remained invisible and contested. It must be kept in mind that no scientific contribution is ever the effort of a single individual and it requires work of many people. However the names of the contributors get lost during the course of research as Herring (1999), has commented that 'controversy over who was primarily responsible for inventions continues to run rampant, especially for the reaper, the cotton gin, and the sewing machine'. The participation of women in fields such as, astronomy, physics and natural sciences have also been largely unacknowledged.

The relationship between science, technology and gender is intertwined with language. Several researchers (e.g. Gurer and Camp; Cohn etc.) working in the area of gender, technology and language have pointed out that the language use in technology is gendered. Cohn (1987) analysed the language used in technology related teaching courses and found it laden with gendered imagery. For instance, in the field of defence technology words like 'coupling', 'marrying', 'delivery' are commonly used, while the field of computer science use words like 'abort', 'kill', 'bomb' etc. The use of 'hard' and 'soft' to describe skill sets is a common notion. This kind of talk/language used to characterize technological work acts as a gate-keeper to keep women out of technology. According to Brickhouse (1994), women and minorities are still considered 'outsiders' to the White-European male culture of science (and technology).

2.5.2 Under-representation of women in Science and Technology

The relationship between gender and technology has not been an equal one. Women have always been at the periphery of technology. Studies around the world have shown that there are great disparities in the number of women entering the field of S&T (Cronin and Roger, 1999). With regards to employment of women in the fields of S&T, even today, the roles that women take in relation to men are subordinate. Not only in S&T related occupations, but also in classrooms, there is difference in the number of male and female students opting for S&T as compared to their composition in humanities.

A survey conducted by the Scottish Higher Education institutions in 1995-1996 found that women accounted for only 32% of the population studying university level engineering, science and technology. This ranged from 14% in engineering and technology, to 62% in biological sciences (Howe, 1997). According to National Science Foundation report (NSF, 2004), in the United States, women accounted for 22% of graduate students in engineering and 27% of graduate students in computer engineering and 27% of graduate students in computer sciences, and approximately 30 - 45% of the graduate in most other science fields but these percentages did not necessarily translate into jobs.

In the European Union (25 countries), although women received about 40% of all the PhD’s engineering contributed to only 20% of this 40%. In Germany, women account for 49.9 % of all technicians, but only 12 % of academics in the relevant fields. The statistics from the Mauritius Examination Syndicate indicates that around 12% of girls take up S&T at higher levels, although most of them do so at the lower levels in secondary schools (Ainuddin et al., 2005).

In India, the participation of women in engineering has been negligible. The University Grants Commission (UGC) has estimated that women’s enrolment for engineering courses is around 16% (1999-2000). According to Parikh and Sukhatme (2002) women comprised about 15 % of the total graduates from major engineering institutes of India. The employment statistics also show that very few women in India take up careers in engineering and related services. In this regard, Sangeeta Gupta (2007), Vice President, NASSCOM (National Association of Software and Services Co.) has said that the male to female ratio is 76:24 in the Indian software industry but it was likely to improve in future.

Wajcman and Lobb (2007) carried out a survey in two cities of Vietnam to find out the nature and quality of jobs for men and women in the IT sector in Vietnam. A combination of qualitative and quantitative methodologies was used to explore the question of gendered division of labour in software industry. The data was collected through two questionnaires: one for workers and the other one for managers. To get the data on the nature of software work, interviews were carried out with a sub-sample. The study showed that in Vietnam women comprised 25% of the entire software workforce, and there was strong gender segregation of work tasks. Most women were concentrated in less skilled and routine jobs such as software testing while there were few women in designing software and writing specifications.

Several barriers have been documented that prevent entry of women in S&T, one being women's experience with technology. Many studies have shown that boys get more opportunities to handle technology at home while girls are discouraged from handling technical artefacts (Zuga, 1997). Even young boys and girls are given different kinds of toys to play. Girls do not use construction and mechanical toys as often as boys do (Browne and Ross, 1991). APU in UK has reiterated the notion that girls lack exposure to technological play.

According to Gannon (2007), the environment of work places has an effect on the kinds of people entering the profession. For example, the features of technology-oriented workplaces are not friendly to women. Girls imagine that IT professionals live in solitary, anti-social, sedentary worlds and they 'do not recognise themselves in the culture of computing' (AAUW, 2000, p. 7).

Differential pay structures are also responsible for keeping women away from S&T related careers. Women are poorly paid relative to men even in the same job. According to a report by American Association of University Women (Dey and Hill, 2007), in USA women earn 69% of what men earn for the same job. The official classification systems label the jobs in which women are concentrated as unskilled or semi-skilled. Women are employed in jobs that do not offer them much room for career and advancement of skills or high earnings. Cockburn (1985) points out, sex divisions nearly always break along the line of skill, with jobs classified as skilled done by men, and jobs considered unskilled and semi-skilled done by women. In addition, females with technical skills have traditionally been given lower evaluation than their male counterparts.

However, Wajcman (2004) in her book 'Technofeminism' has said that of late there has been more gender equity in the use of technologies as compared to 20 years ago.

Technofeminism, ‘fuses the insights of cyborg feminism with those of the social shaping, or constructivist, theory of technology.’ (p. 8). According to Wajcman, women are now more confident in using technology than the earlier generations and the key is to engage with technology at design stage. Both men and women are changing their practices and entering new relationships with each other and their environment. Thus the relation between gender and technology and work is being constantly reconstructed.

2.5.3 Factors in school that effect enrolment of girls in science and technology related courses

Perusal of the literature on school performance from around the world reveals that, throughout the last decade, girls have consistently outperformed boys in a wide range of standard public examinations. They perform equally or better than boys not only in traditionally ‘female’ subjects such as English and modern languages but also in traditionally ‘male’ subjects such as mathematics and science (Warrington et al., 2000; Press Trust of India, 2008). Despite these trends at the school level, evidence suggests that the early academic advantages accrued by females are short lived and rarely get transferred to the workplace. For example, an examination of the career aspirations of school leavers showed that, irrespective of their academic achievements, girls generally held lower career aspirations than boys and expressed a greater preference for traditionally stereotyped occupations (Brickhouse, 2007; Knipe et al., 2002).

With regards to specific academic fields, engineering is seen as a masculine one. Studies dealing with women’s decision on higher education show that choice of the subject, specializations within the subject and preference for institutions to study and so on are decided by multiple factors (Mukhopadhyay and Seymour, 1994).

One such factor is the school curriculum that reinforces sex stereotyping in which girls and women are invisible. Kalia (1986) carried out a survey of 41 Indian school language textbooks in Hindi and English prescribed and prepared by the National Council of Educational Research and Training (NCERT) for various states and found that not only was the language of the text highly sexist but also its pictures. Women were portrayed in very few of the lessons as compared to men, (the ratio of women to men being 1:3), and the depictions showed women as passive and inferior to men. Of the large number of occupations depicted in the textbooks, women were excluded from a majority of the occupations and the few occupations in which women were shown were lower in income and prestige as compared to those in which men were portrayed. Rao et al. (2001) have reported results similar to Kalia's study, with their study of Central Board of Secondary Education high school English textbooks. In another study illustrations in S&T books prepared by (NCERT) were analysed. It was observed that the pictures shown in the textbooks were gender biased. Most illustrations showed men more often involved in physical or intellectual tasks while women were shown either passive or involved in some non-remunerative tasks (Mehrotra and Chunawala, 2004). The range of occupations in which men were shown were wide and varied as compared to women who were shown in a limited number of occupations.

In technology education curriculum, it has been observed that the curriculum in many countries is disproportionately attentive to male perspectives on technology. Technology education is not just about using technology, it concentrates more on generating ideas and acting on them, as well as in using and developing processes and products that satisfy human needs.

In addition to curricular issues, classroom interactions also affect the attitudes of boys and girls towards technology. Classrooms interactions have been a topic of study for the past 20 years and have been thoroughly analyzed at all levels of education. In the 1980s and early 1990s, research showed that in public schools and post-secondary institutions, males dominated the use of computer time and hands-on projects in laboratories (AAUW, 1992), and they received more (and higher quality) attention from instructors (Sadker and Sadker, 1990). In another large-scale study by Jones and Wheatley (1989), which involved 60 teachers and over 1,300 students, it was demonstrated that boys were more likely than girls to conduct demonstrations in science classes. These studies show that boys are more likely to create situations where their contributions will be sought in the classroom. This disproportionate attention by teachers has long-term consequences for gender divisions (Howe, 1997). Girls in the class might feel that their contributions are not being valued or overlooked and they might develop a feeling of incompetence in the subject and keep away from it.

With reference to the local classroom climate during technology education classes, it has been found that the climate is not appreciated by both the sexes. According to Welty and Puck (2001, p. 14) ‘the physical environment found in technology education classrooms and laboratories can either welcome or turn off girls and young women.’ Females tend to avoid technology education classrooms and related careers because they find them to be ‘…dirty, cluttered, rough, and stressful environments. The physical strength that has been required to operate equipment can also be intimidating.’

Teachers have also been identified as key agents in maintaining or contesting gender order of the classroom (Muito, 2004). In the UK, where technology education has its roots in Crafts and Design, Paechter and Head (1996) found that teachers’ professional identities were affected by the relationship they shared with their students. Teachers of Craft and Design technology felt that their identities were formed when students (boys, working class) made some artifact and showed it to their parents. The teachers felt that this was a reflection of the importance of physical work to working-class masculinity. The findings of the study show that gender and identity are constructed in social interactions between teachers and students.

Along with curricular issues, interactions in the classroom and classroom climate, it is also accepted that children make important decisions based on the roles that they see women and men playing in society (Baulch, 2003; Pendergast, 1995). The predominance of men at all levels of technological activity creates the common perception that doing technology is a male gender role (Welty, 1996). There is a dearth of female role models that students are exposed to in their S&T classes. Research has also shown that role models and mentors, especially family members influence the career decision-making of children (Jepson and Perl, 2002). Exposing children, both boys and girls to successful women in technology can provide inspiration to girls to follow non-traditional career paths (Dorman, 1998).

Silverman and Pritchard (1996) undertook a comprehensive study on females and technology education. This study was reported in a paper titled ‘Building Their Future:

Girls and Technology Education in Connecticut'. The study suggested that girls in the middle school enjoyed technology education and had confidence in their abilities but this positive attitude did not necessarily translate into them opting for the subject at high school. Girls reported being discouraged to take technology education classes far more than boys. They however did not feel that boys made it difficult for them, but were concerned that teachers would treat them differently. Other factors that kept girls away from technology education were the lack of knowledge of technological careers, the failure to connect what students were doing in class with future careers and the lack of sense of economic realities. These factors specifically discouraged girls because they had less information about technology from experiences outside of school.

Rasinen et al. (2006) studied the evolution of technology education and craft education curriculum in Finland and have pointed out changes in the curriculum from 1970's till recently in terms of gender, pedagogy, teacher education, society and concept of learning. Technology education in Finland is mainly seen under the objectives and contents of craft curriculum. These researchers acknowledge that though there have been attempts to include and interest girls in technical studies, these attempts have been only at the secondary level and are often inadequate, as students' attitudes are formed at early stages of education.

Haynie (2003) carried out a quasi-ethnographic interview survey to find out how professionals in technology education felt about certain issues, concerning cross-gender interaction in technology education. In this study, he interviewed 12 women in the USA in the age range in 25 to 30 years to over 50 years. All of them had worked in the area of technology education from less than 5 years to over 25 years. He found that most women who were interviewed felt that they were well accepted and comfortable in the technology education profession, but there were some problems that made them feel isolated and uncomfortable. These included attitudes and actions of a few men within profession who held outdated views. They felt that these problems could be eliminated if more women were encouraged to enter the profession and were advanced to positions of leadership in which they could serve as role models.

2.5.4 Feminist perspective explaining the lack of women in science and technology

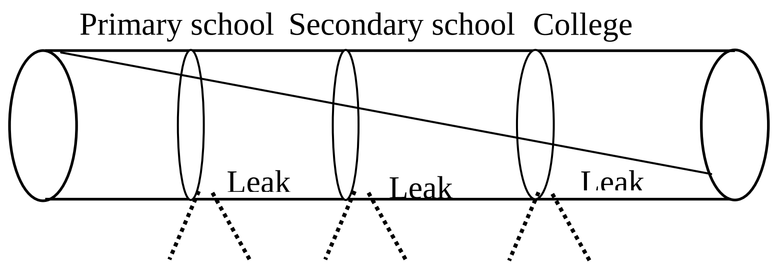
The feminist perspective provides explanation for women's invisibility in the fields of S&T. Some feminists believe that ideology of patriarchy oppresses women simply due to their sex, and prevents them to participate fully in human endeavours. There are a variety of feminist theories that aim to understand the nature of inequalities and promote women's rights, issues and interests. For instance, *liberal feminists* draw attention to the inequality in society and consider it due to socio-cultural factors not biological factors. They are concerned with addressing the issue of women's limited access to S&T. *Radical feminists* view patriarchy as the basis of male domination. *Cultural feminists* emphasise the 'essential' differences between men and women. Notions that women are "inherently kinder and gentler" are the foundations of cultural feminism.

Feminist standpoint theory tries to explain why views of women/oppressed are not included in technology. According to this theory science is not as objective and as value-neutral as it is portrayed to be. Harding (1986, p. 82) argues that 'masculine bias is evident in both the definition of what counts as a scientific problem and in the concepts, theories, methods, and interpretations of research'. According to Harding (1991), a standpoint is a place from which to view the world and determines what we focus on as well as what is hidden from us. Science tries to provide an objective view of reality but a perspective, from the lives of the less powerful, can provide a more objective view of reality than the perspective from the lives of the more powerful. The feminist standpoint theory posits that women are a weaker social group and therefore inquiry should start from the lives of women. It is important to value women's speech as well as their experiences. This theory helps to understand and explain the world from the vantage point of women's lives and has helped to legitimize women's contributions as well as contributions that benefit women.

The above theories have provided various causes for under-representation of women in 'male dominated' fields of study. However, no single theory can explain this phenomenon, as it is a complex web of interdependent factors. In addition, reasons for women's attrition from specific subjects differs at various levels of education as well as career progression and various academic departments need to address these issues (Cronin and Roger, 1999). Some theoretical models have been proposed that explain the shortage of women in certain professions and these are described below:

Leaky pipeline: It is a concept that is used to refer to the steady attrition of girls and women throughout formal S&T related fields, from primary education to tertiary education up to the decision making stage (Huyer, 2002). The percentage of females in the relevant pool declines at every stage (from primary school to secondary school to college to doctoral degree to postdoctoral fellowship to University professor appointment) as represented in Figure 2.5.

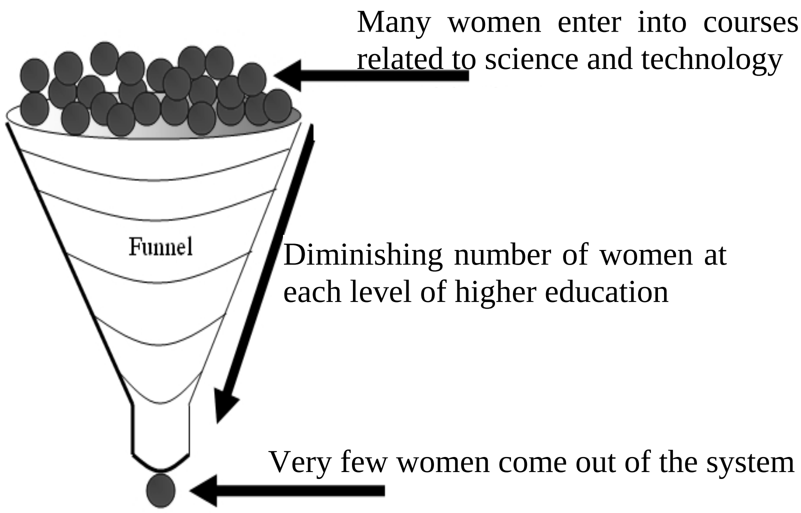
Figure 2.5: The leaky pipeline model



Funnel model: This model shows the progressive under-representation of women between and within three stages - access, participation and progression - and is similar to the pipeline metaphor (Matyas and Dix, 1992). In this model, the proportion of women is reduced at every stage of the funnel when, for a wide variety of reasons, women opt out of pursuing S&T education or career any further. Increasing access to these subjects in higher education will permit more women to enter these fields.

Figure 2.6 shows that the total number of girl/women who are qualified to enter and who enter S&T courses diminishes because they are filtered out at various stages. Of those who do complete these courses, relatively few progress to postgraduate level or beyond, to lectureships and chairs.

Figure 2.6: Funnel model to show the diminishing representation of women in science and technology



Glass ceiling: It is a term that was coined by the Wall Street Journal in mid 1980's to describe the barriers that prevent women from reaching the top of the corporate hierarchy (Shukla, 2004). Morrison et al. (1987, p.13) have described the glass ceiling as a 'transparent barrier that [keeps] women from rising above a certain level in corporations'. It is considered a barrier for women (as a group) not because they lack the ability to handle jobs at higher levels but because they are women. This phenomenon is especially true for women who choose non-traditional jobs such as law, information and communication technology (ICT), computer science, and engineering etc. They face constraints in the workplace such as isolation, limited access to mentoring and lack of female role models, and sexual harassment that inhibits their progress in the organization. So in principle women are given opportunities in non-traditional fields but in practice they face a lot of hurdles (such as glass ceiling) that impedes their upward movement.

To conclude, feminists have broadly focused on the following issues in the areas of S&T: (1) the composition of scientific institutions and the treatment of women and minorities in it, (2) investigation of the problems of concern of women and minorities,

(3) the victimization of women and minorities by S&T (Cynthia Cockburn), (4) language of S&T that incorporates sexist and racist theories (Evelyn FoxKeller), and (5) an androcentric epistemology (Sandra Harding, Judy Wajcman).

2.5.5 Efforts being made to include women in technology education

It is now a generally agreed upon fact that women are at the periphery of careers in S&T and that their contributions are often forgotten. According to Zuga (1997), there has been a strong and persistent practice of diminution of women's voices in industrial arts profession. In a later study (Zuga, 1999b) titled 'Thoughts on Technology Education Research', she also made the case that the discipline's database was limited and weak. This was her third review of Technology Education related research and her conclusions remained unchanged from the first and second.

Several efforts have been made at integrating women's perspectives into the S&T curriculum (Baker and Scantlebury, 1994). Classroom practices as well as research in these areas should include multiple perspectives, which would take care of the voices of women and minority. Efforts could also be made to highlight the contributions and perspectives of women in the study of technology. Some of these efforts have been successful in getting girls/women involved in technology while others have not been very successful and have been criticized for their weaknesses. This section attempts to explain a few such efforts.

a) *Add women and stir*: One of the major approaches concerned with dealing with the problem of under-representation of women in S&T has been to try to "add women" to S&T programs and workplaces or/ and as beneficiaries of scientific and technological products. It is a culinary metaphor that is used to explain the efforts (which are mere token efforts) that aim to include women as a mere formality. Such efforts have been valuable but have failed to achieve significant equality for women. Rothschild (1988, p.30) has critiqued this kind of effort and says that 'if one adds a new ingredient to the beef stew without changing the basic recipe, the flavour or consistency might change somewhat, but we still have only a variation on the same beef stew'. The problem is much deeper than socializing girls and women into the existing hierarchy and may perhaps require rethinking about the content and practice of technology education (Zuga, 1999a). According to Harding (1995), adding women to S&T development has all too often meant that only a few elite women join the high-prestige areas of S&T which otherwise recruits women for low-skilled and low-paying jobs.

If technology education has to significantly change then mere addition of women to courses will not help. The whole technology education community should strive to be gender fair- in their use of language, media, and role models etc. Thus removing gender bias from the technology education curriculum will require systemic change (Welty, 1996).

b) Peggy McIntosh's (1984) model for technology education curriculum development: This is a 5 phase holistic model as shown in Figure 2.7 for including women in S&T curriculum.

In the model, phase 1 is called *Womanless technology,* where women are absent from course content and instructional materials. The curriculum is presented solely from a male point of view and fails to explore women's concerns about the ways in which technological activities are conducted.

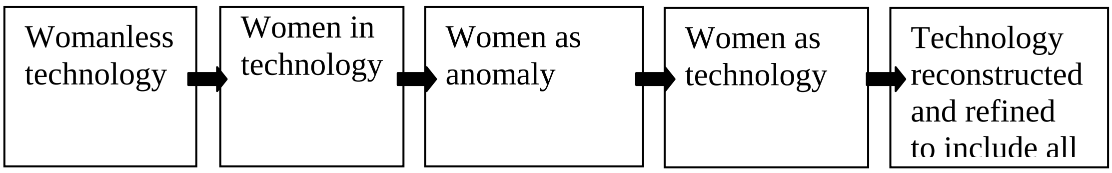
The second phase of the model is *women in technology.* During this phase, famous women in technology are featured in technology education curricula and instruction. The curriculum presents the perspectives and contributions of exceptional or elite women in technology. However, the fundamental definitions, assumptions, methodologies, and values underlying the study of technology remain essentially the same. This phase puts women at the periphery of technology.

The third phase of the model is called *women as a problem, anomaly, or absent from technology*. During this phase, women are studied in the context of being overshadowed by men. Questions are raised regarding the ways in which women have been left out of the structure of technological knowledge and, subsequently, the school curriculum. In this phase although the absence of women is recognized in the field but women are still not treated as an integral part of mainstream technology.

The fourth phase is called *women as technology*. During this phase, the curriculum acknowledges women and the intellectual resources available to humankind (Rosser, 1986). In this phase the curriculum often takes a proactive stance toward women by including the topics, learning activities, and examples that are consistent with the experiences, interests, concerns, and learning styles of women. Phase 4 requires a systemic re-conceptualisation of the technology education curriculum.

The fifth phase in the model is called *technology reconstructed and refined to include all*. At this level, women are considered an intrinsic and integral part of the enterprise of technology. Attention is given to the contributions, perspectives, and potential of women in the previous phases and would result in a new epistemology for the study of technology (Rothschild, 1988).

Figure 2.7: Five phases of inclusion of women in technology



c) Understanding 'women's ways of knowing': This position, usually taken by cultural feminists, recognizes the differences between men and women and makes attempts to create an alternate theory and methodology based on these differences. Women and girls develop their identity through social interactions, by connecting and communication with others, more than boys (Gilligan, 1982). They tend to value and perceive technology as a means of facilitating collaboration, communication, and linkages between people while men see technology as a means of extending their control over their physical environment and identifying strongly with the technical details associated with a given technology (Brunner et al., 1990).

Understanding the differences in the ways of knowing can lead to efforts that will help continue the evolution of S&T and not destroy it (Fox Keller, 1985). One of the efforts in this direction is to create a new S&T. The new subject will be characterized as 'one in which no rigid boundary separates the subject of knowledge (the knower) and the natural object of that knowledge; where the subject/object split is not used to legitimize the domination of nature' (Fee, 1986, p. 47). For cultural feminists '…the scientist is not seen as an impersonal authority standing outside and above nature and human concerns, but simply a person whose thoughts and feelings, logical capacities, and intuitions are all relevant and involved in the process of discovery' (Fee, 1986, p. 47).

According to Zuga (1999a) this alternative form of S&T is not considered to be an exclusive domain of women but of both sexes. Harding (1986) believes that 'new science' will have experiences of women, new purposes for social science, and new subject matter for inquiry by locating researcher and subject in the same plane.

The descriptions of women's ways of knowing have multiple meanings for technology educators. Zuga in her paper 'Addressing Women's Ways of Knowing to Improve the Technology Education Environment for All Students' (1999a) suggests several ways to include women's ways of knowing in technology education and these include:

<u>Restructuring the subject matter- A critical and revised view of technology</u>: This method calls for redefining technology that is prescriptive, dependent upon compliance, isolationist and control based to take into account nature and people first. Zuga suggests incorporating feminist critiques (also critiques based upon race and class) of technology into the curriculum of technology education.

<u>Revising language- Paying closer attention to explanation and context:</u> Technology teachers can provide students with a context in which problems are posed to them and then allow them to come up with explanations. Revising one's vocabulary would help to make it inclusive. She suggests that technology education teachers must encourage all students to share their knowledge and expertise and should avoid terse comments and include adequate explanations.

<u>Creating humane classroom environment- Recognizing women's ways of knowing:</u> Technology educators need to think about how women use technology. This will help them to bring in women's values to the study and development of technology and they will find their ways of using the technology for their own priorities.

Integrating cognitive and affective learning- Discussing values related to technology: Values are a part of the curriculum. Educators should incorporate broader knowledge base and values associated with technology in their curriculum through study, discussions, critiques, activities to avoid hegemony and unconscious reproduction of values.

2.5.6 Conclusion

Gender and technology interactions are complex and mediated by students' self-concept in relation to technology and their perception of future possible selves (Murphy, 2006). There is an inherent masculinity associated with S&T that needs to be changed in order to accommodate views of females. The current 'image of science and technology proves both to be inaccurate and to be a critical filter; a filter not only to most girls but also to the androgynous boys of whom fewer enrol in science in each generation' (Byrne, 1993 p. 13).

Biological and sociological reasons have been given for under-representation of women from S&T. Feminists have pointed out that language of technology is symbolic of its masculine nature and various barriers keep females away from technology. These include discrimination in social attitudes, girls' education and employment policies. The nature of S&T that favours males has been criticized by feminists and has been suggested along with other factors as reasons for females keeping away from these careers.

Technology by its very nature is diverse and provides possibilities for students to engage in a variety of tasks depending on their aptitudes. However, technology education curriculum needs to be restructured. Brickhouse (1994) suggests that we can make S&T more inclusive if we educate students not only *in* science (technology), but also inform them *about* science (technology). Feminists have pointed out the need to link technology with its social implications and thus give it a human face.

CHAPTER 3

USING PICTURES AND INTERVIEWS TO ELICIT INDIAN STUDENTS' UNDERSTANDING OF TECHNOLOGY

3.1 Introduction

Technology is embedded in culture and is reflected in a spectrum of artefacts and processes. The term is used variously to convey the modification of environment, design, and the social, cognitive, affective and material interactions involved in the process (Natarajan, 2004). The lay understanding of the word 'technology' is mostly associated with 'hi-tech' artefacts such as, computers, satellites etc. (Rennie and Jarvis, 1995c; de Klerk Wolters, 1989).

In schools where technology education is presented formally as a school subject, the curricula present technology as a problem solving activity that focuses on skills of investigation, designing, planning, evaluating and making or as the science, technology and society approaches that focus on creating awareness of technology and emphasize its historical, social and philosophical dimensions (Kimbell et al., 1996). With these multiple approaches and views on technology, students and teachers may have difficulty in reconciling the lay views of technology with those presented by curricula.

Besides, teachers need to know students' conceptions to provide suitable learning environments (Driver et a1., 1994). Teaching technology from an adult point of view may not be the best way to respond to children's interests, abilities and their stock of knowledge (Senesi, 2000). It is very helpful to understand their conceptions in order to determine what they can learn, how and when.

Gender and experiences in school and at home (MacKenzie and Wajcman, 1999) and interactions with technological artefacts influence attitudes of individuals towards technology (Volk et al., 2003). To explore these aspects, there have been numerous PATT studies conducted across the globe (Bame et al.; 1993, Correard, 2001) and results of which have been discussed in the previous chapter.

This survey served as a precursor and input to the research and development of D&T units at the Homi Bhabha Centre for Science Education, Mumbai for introducing technology education at the middle school in India. We aimed to see how ideas about technology among Indian students from urban and rural areas, from different media (languages) of learning and girls and boys compared with those of students from other parts of the world. Most of the results presented in this chapter have been published earlier (Mehrotra et al., 2007 a).

3.2 Objectives of the survey

This study aimed to address the following questions:

- What kinds of objects, artifacts do students associate with technology?
- What activities are considered technological?
- Are there gender differences in students' perceptions of objects and activities as technology?
- Are there gender stereotypes in the way students perceive occupation suitability?
- Are there gender differences in the way work is distributed between a boy and a girl in a given situation?
- Are there differences in the career aspirations of boys and girls?

3.3 Methodology

The survey questionnaires inspired by the PATT instrument aimed at measuring students' attitudes towards technology. While attitude is a complex psychological concept having interrelated components of affect, behaviour and cognition indicative of underlying belief or value (Shrigley et al., 1988), in this work we have aimed at knowing the overall concept that students have of technology.

For this study we developed 2 pictorial questionnaires for use with Grade 6 (11-14 years) students. In both the questionnaires, students were given written and verbal instruction to circle the pictures that they felt had something to do with technology.

One questionnaire focused on *technology-as-objects (TAO)* (Appendix A) and the other on *technology-as-activities (TAA)* (Appendix B-Form A and Appendix C- Form B). The questionnaires were initially prepared in English and later translated to Marathi (vernacular language of the State of Maharashtra) for use in Marathi medium schools.

The responses to the questionnaires suggested some patterns in students' conceptions of technology. Interviews of some students followed the questionnaires and were aimed at a detailed exploration of the reasons for associating objects and activities to technology. The interviews usually began with the researchers asking the interviewees some general questions about their school and their family background. This was followed with questions that focused on aspects covered in the questionnaires, such as, users/creators of technology, temporal aspects of technology, locales of technology, gender and technology, what is 'not technology', and words, objects and activities associated with technology. The interview schedule is appended in Appendix D. In all, there were 3 tools used for the survey: 2 questionnaires and an interview schedule.

3.3.1 Tools used for the survey

a) Technology-as-objects (TAO): This questionnaire consisted of 30 pictures of objects associated with ten categories: sports, agriculture, school, music, household, workplace, transport, communication, warfare and natural objects. Our selection of categories and the pictures in the categories was guided by the fact that our sample would have rural and urban students as well as girls and boys. In an earlier study involving students' drawings of 'image of science/technology' we found that students often drew images of science or technology as related to communication, transport and warfare, in locations outside the classroom (Mehrotra et al., 2003). To focus on locations we included categories such as, school, household and workplace. For the rural context we included agriculture. Sports and music were included for their familiarity in both school and outside school contexts.

Each category had pictures that focused on aspects of 'time' or tradition/modernity. For example, in the transport category, there were pictures of bullock-cart, and airplane, while in the warfare category there were pictures of bow and arrow, tank and gun.

Additionally, we had a category that could be termed ‘natural objects’ or ‘no technology’ (flower, sun), as we were interested in knowing how students would deal with this category of objects. The *TAO* sub-part was used in our earlier work with Grade 8 students and a reliability score 0.9 (Correlation coefficient) had been established (Khunyakari et al., 2008).

The TAO questionnaire had 3 open-ended questions. The first question was, “*What would you like to become when you grow up*?” The other two questions were situational. In both the questions a situation was put before the respondents and they were asked to respond to the questions with reference to this situation provided. This was done so as to help students focus on a particular issue rather than make general comments. The first situational question was, *“Two of your friends, a boy and a girl, come to you for your advice on which occupation they should choose. Which occupation would you advise them to choose?”* This question was followed by a list of occupations and the respondents were required to put a tick in the column of either boy or girl according to what they thought was suitable for them. The aim of this question was to see how stereotypical students’ thinking was with respect to career choices for boys and girls. The second situational question was framed in the following way, *“Meeta (girl) and Suresh (boy) are friends. They have a set of jobs to be completed before they can go out to play. They distribute the jobs so that they can finish them quickly. Who would you suggest should do the following jobs?”* A list of jobs followed this section and the respondents were required to tick in the column Meeta or Suresh. The objective of this question was to elicit students’ ideas of job distribution given time constraints.

*b) Technology-as-activities (TAA)**:*** This questionnaire depicted activities related to categories in the *TAO* questionnaire. Most pictures showed humans involved in an activity and there were a few pictures without humans (waterfall, spider making its web, sunflower turning towards sun). Two alternate forms (A and B) were developed, with 24 pictures each. Both forms had some activities being done by males and some by females. If an activity in form A was shown as being done by a male then in the alternate form it was depicted as being done by a female. Students were asked to write “T”, if they thought that a picture was related to technology, and “N”, if they thought that the picture was not related to technology. This questionnaire was aimed at eliciting students' ideas about technology in activities and gender stereotypes, if any.

Establishing Validity and Reliability of TAA: The validity of these alternate forms of TAA was checked in terms of whether the pictures were clearly identifiable. For establishing validity, we administered TAA to colleagues (13) at the Centre, and asked them to write whether the pictures given in the forms were clear and also identify whether the picture was that of a male, female or appeared ambiguous. Based on this feedback we incorporated changes and prepared a final questionnaire for administration to students. The changes suggested were for improving the clarity of pictures and using line drawings wherever possible. For example: we had put a picture of a female scientist, most of the reviewers could not identify her sex and we had to replace that drawing with a line drawing, similar was the case with male sitarist, archer. In some pictures where there were two humans shown, it was suggested that we remove one. Example in the picture of rickshaw, it was suggested that we remove the passenger. In all there were about 14 changes that were suggested in the questionnaire most of which were incorporated.

Reliability of the instrument was tested by test-retest method. Form A of the questionnaire was administered to one section of grade sixth of an English medium school, and at the same time Form B was administered to another section of grade sixth of the same school. The same forms were given to the same sections of students after a gap of 10 days. Both the two forms showed high test-retest reliability. Test-retest reliability was established separately for Form A and Form B of TAA and the reliability for Form A was found to be 0.70 and 0.84 for Form B (Equal-length Spearman-Brown).

c) *Interviews:* We believed that interviews would deepen our understanding of the children's responses to the questionnaires. A semi-structured interview schedule was constructed as a supplement to the questionnaires. Interviews were conducted with some students, who had already responded to the questionnaires from both the rural and urban settings. The interviews focused on student's responses to the object and activity questionnaires and tried to explore their ideas further and test their consistency of responses in all the instruments. The interview schedule also aimed to get information about the students' socio-economic background. Each interview took about an hour (or more). Care was taken to have an equal representation of boys and girls. Responses of the students were audio-recorded and detailed notes were also taken.

3.3.2 Sample

There were about 9 sample clusters that were identified for the study. The criteria being to have a representative data of urban and rural/tribal population, a fair and balanced representation of boys and girls in the target population and a reasonable physical proximity of the sample clusters to our institute for effective co-ordination with the authorities. The rural schools were situated about 60 kilometres from our research institute in the adjoining Thane district.

There were 3 rural schools (*Aashramshala*) in which the questionnaires were administered and these were under the Ministry of Tribal Welfare Department, Government of India. Two of these schools were mixed-sex while one was a single-sex girls' school. All the 3 schools catered to students from modest family background. The families of most of the students were involved in agriculture around the area or in some small business. Most students belonged to the scheduled tribes of Maharashtra and were from: Mahadeo Koli, Katkari, Warli, Malhar Koli, Agari, Mahadeo Thakur tribes. Table 3.1 gives the distribution of sample in according to schools in rural and urban settings.

Table 3.1: Number and kind of schools in the urban and rural settings in the sample

Types of school	English medium	Marathi medium
Rural/Tribal	0	3 (2 mixed sex+ 1 single-sex girls)
Urban	3 (All mixed sex)	3 (All mixed sex)

The urban samples were taken from 6 schools in Mumbai. These schools were either Marathi medium or English medium schools and catered to students that belonged to middle class families. All the urban schools were mixed-sex schools.

The *TAO* questionnaire was administered to 343 students studying in Grade 6 from 9 schools in and around Mumbai, India. The details of the sample are given in Table 3.2. The two forms of the *TAA* questionnaires were administered to 201 students of Grade 6 in 4 of the schools with an interval of 5 days. On an average, students took 20-25 minutes to complete each questionnaire.

Table 3.2: Sample composition

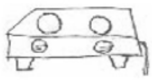
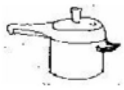
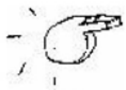
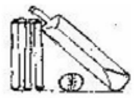
Technology-as-objects (TAO)	**Urban**	**Rural**	**Total**
Girls	88	73	161
Boys	126	56	182
Total	214	129	343
Technology-as-activities (TAA)			
Girls	65	49	114
Boys	60	27	87
Total	125	76	201
Interviews			
Girls	5	5	10
Boys	6	2	8
Total	11	7	18

3.4 Results

3.4.1 Technology-as-objects

In response to the *TAO* questionnaire we observed that students related all pictures, in all categories to technology. There was no picture that was not related to technology by even one student i.e. all students related all pictures to technology (30 out of 30). The average number of pictures circled was 14 (out of 30 pictures). Table 3.3 presents the objects within each category and the percentage of students stating the objects were related to technology.

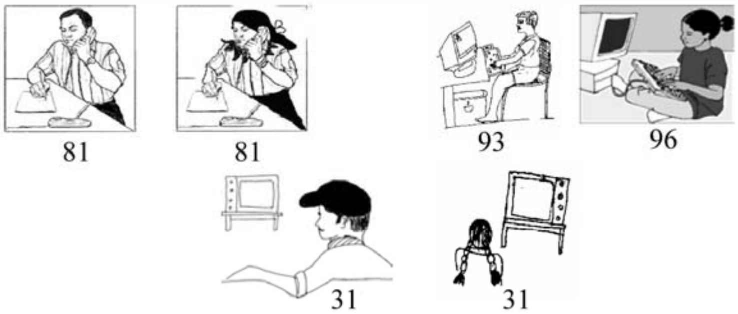
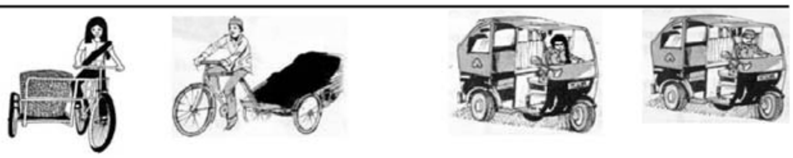
Table 3.3: Percentage of students relating objects to technology

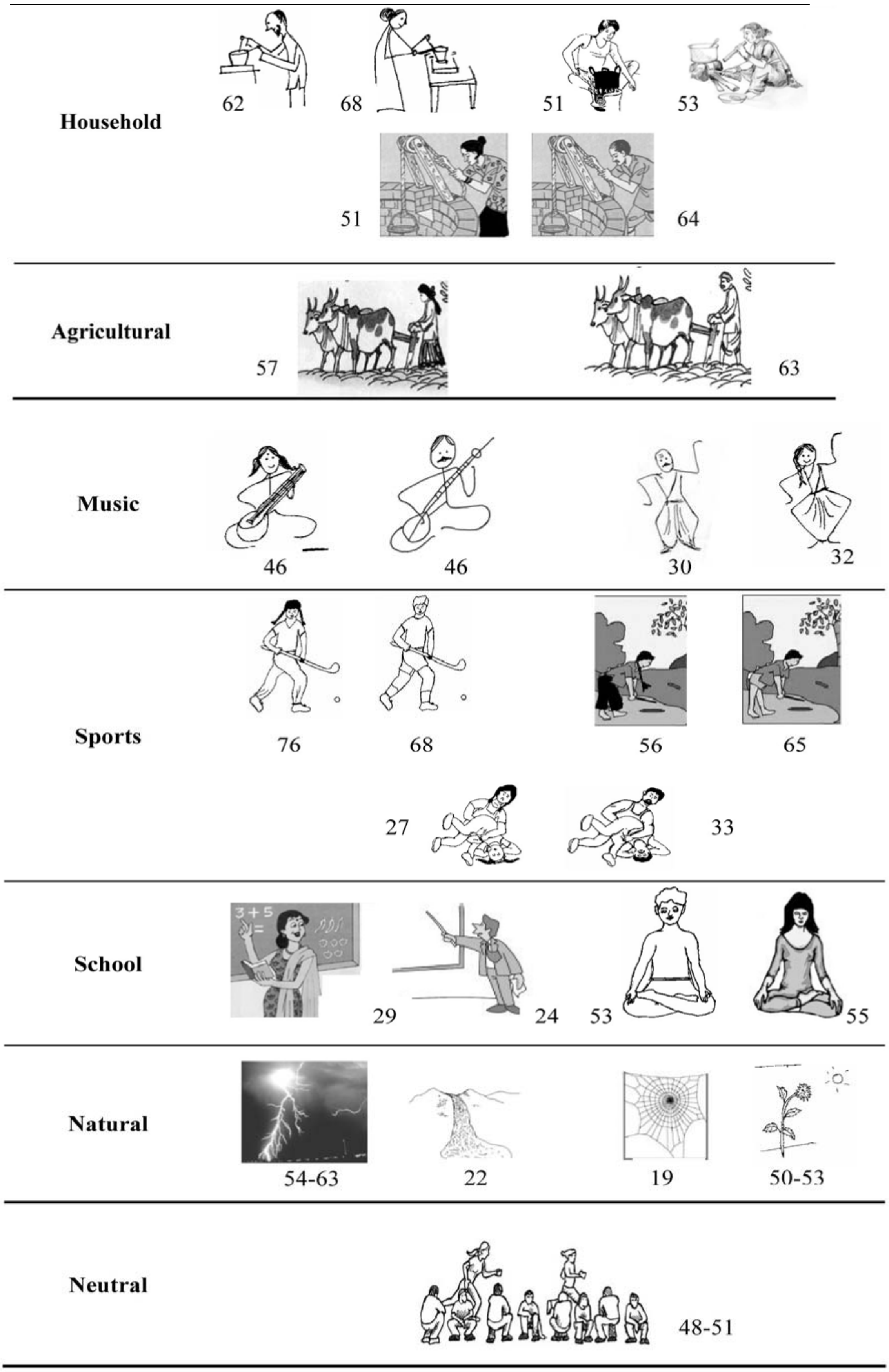
Category	Percentage			
Communication	 89	 84		
Transport	 87	 83	 61	 27
Workplace	 59	 70	 55	 79
School	 55	 31	 64	
Household	 73	 36	 55	 24
Warfare	 65	 49	 29	
Music	 35	 33	 43	
Natural objects	 23	 42		
Sports	 29	 35	 26	
Agriculture	 23	 40		

3.4.2 Technology-as-activities:

Table 3.4 presents students' responses to the two alternate forms of the *TAA* questionnaires. The table shows the percentage of students associating pictures in Form A and B with technology. The average number of activities related to technology was 27 (out of 48 pictures in both the forms). For each category the pictures from the alternate forms have been presented in Table 3.4.

Table 3.4: Percentage of students relating activities to technology

Category	Percentage
Communication	 81, 81, 93, 96, 31, 31
Warfare	 69, 66, 78, 64
Transport	 69, 56, 61, 65
Workplace	 96, 88


Household
62
68
51
53
51
64
Agricultural
57
63
Music
46
46
30
32
Sports
76
68
56
65
27
33
School
29
24
53
55
Natural
54-63
22
19
50-53
Neutral
48-51

3.5 Analysis

The responses to the questionnaires are complemented by the results from the interview and these are discussed below. The questions in the interviews served as a framework for our analysis.

Objects, activities and words associated with technology

The responses of the students to the *TAO* and *TAA* questionnaires indicate that some objects and activities were more often associated with technology than others. More students related objects and activities in the categories of *communication, transport* and *workplace* to technology. In addition in the activity questionnaire, the *warfare* category was considered related to technology by a large number of students. The four most often chosen pictures were the computer (89%), followed by the airplane (87%), television (85%) and tractor (83%). Less proportion of students considered *agriculture*, *sports* and *music* as technological. It is interesting that in an agricultural economy like India, only a minority of students considered agricultural objects (plough, bullock-cart) as technological. This aspect is discussed further in later questions on traditional/modern and rural-urban differences.

Natural objects and *activities in nature* were considered technological by a larger percentage of students than even objects in the category of agriculture and sports. When we probed this in the interviews, one reason given by students for considering natural objects or activities to be technological was that they had read about these objects and activities in their science books. A girl from the urban Marathi setting reasoned that *'Anything that has life and grows and respires is technology',* while another student (boy) from urban Marathi group related sun to technology using a knowledge-laden argument; *'It uses hydrogen and produces heat and light'.*

Not all objects within a category elicited similar responses. For example, fewer students (27%) considered a bullock-cart (transport category), to be technological as compared to an airplane (87%). In the interviews, students were shown their earlier responses on questionnaire and were asked to support their answers.

Some of the reasons for considering an object to be technology related were; it is human-made, is used for speeding and easing activities, is composed of simple and/or complex machines and tools, and is useful. Some responses from both boys and girls from urban as well as rural settings suggested that some components of an object could 'have' technology while other may not 'have' *('Tube-light has technology only if the switch is on').*

Comparison between boys and girls' choice of objects shows significant difference (chi-square-test) in the following pictures: drum, flower, gas, stapler, tank and computer. Least differences between boys and girls were found in the following pictures- blackboard, lemon squeezer, fountain pen, airplane, gun, microscope, scarecrow and bicycle. All/most of these pictures did not belong to any one category. It can also be seen that 'traditional technology' is less frequently considered to be technology. On the other hand, gadgets that run on electricity and are perceived 'complicated' are more frequently considered to be related to technology. Similar findings have been reported by Rennie and Jarvis (1995 a,c), de klerk Wolters (1989).

Figure 3.1: Percentage of students choosing each category of objects as related to technology

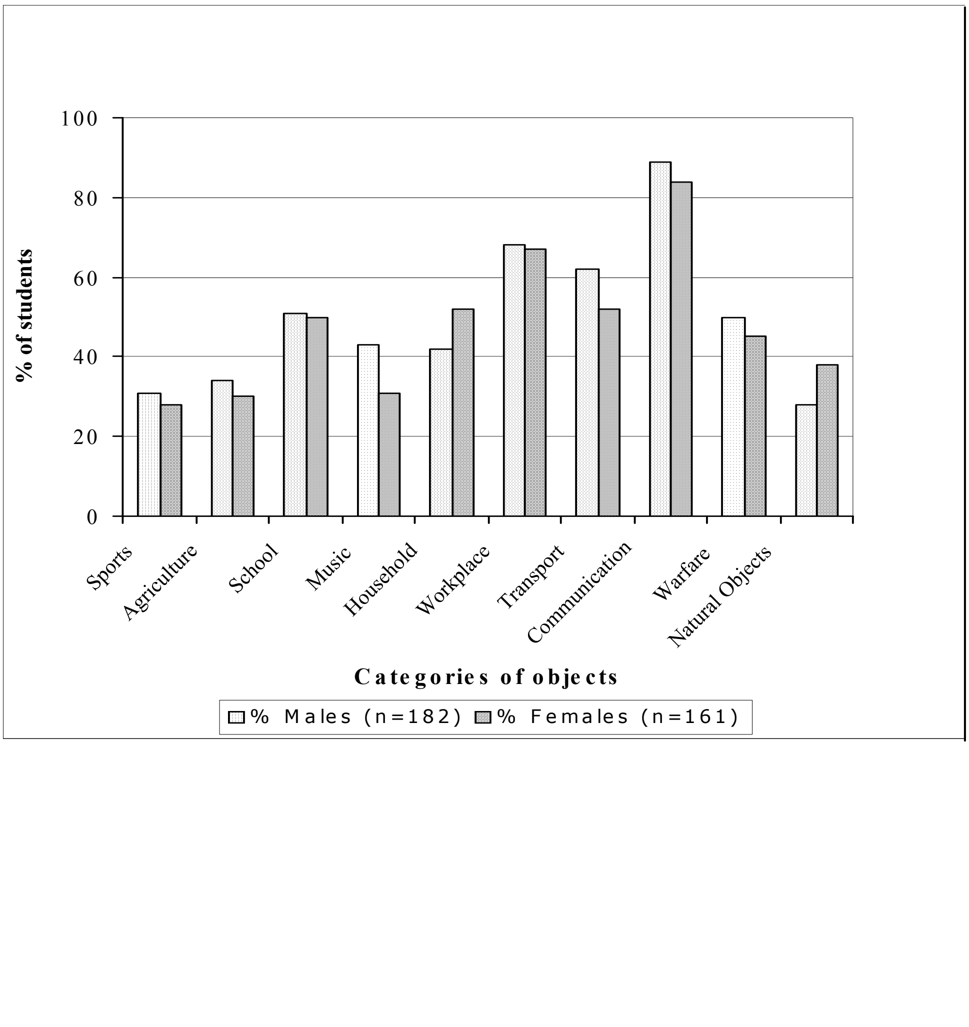


Figure 3.1 shows the comparison between boys and girls for each category of objects. As can be seen in the graph that most males and females consider objects in the category of communication as related to technology. More females than males consider objects in the ‘natural’ and ‘household’ categories to be related to technology.

During the interviews, students were asked to write words that came to their mind when the word ‘technology’ was mentioned. Objects such as *gun, electronic items, vehicles, computers,* were most often listed. Other commonly associated words were school subjects *(science)* activities *(driving)* and knowledge or research related words *(inventions, knowledge of complex machine, discovery)*, as well as professions *(doctor, engineer),* and famous personalities (*Homi Bhabha, Alexander Graham Bell*).

A point to be noted here is that in *TAO* questionnaire as well as in the interviews electronic objects (computer and television in *TAO*) were most often related to technology. But since there were only 2 objects in the questionnaires that needed electricity to function, we cannot say that there were differences between boys and girls or between rural and urban students on this variable.

Activities like *working on computer*, *talking on phone* and a *scientist in laboratory* were related to technology by most students. On the other hand, activities perceived as more dependent on skills than equipment, like *wrestling* (male picture 33%, female picture 27%), *teaching* (male picture 24%, female picture 29%) and *dancing* (male picture 30%, female picture 32%) were considered as technological least often. An exception was ‘yoga’ which was associated with technology by over half the students.

The activities in which humans were shown actively involved *(working on a computer)* were considered technological by more students than those in which humans were passive *(watching TV).* Students’ response patterns differed between an object shown alone and an object as part of an activity. In general it was observed that when objects and humans were shown together, more students related it to technology than when the objects were shown by themselves: *sitar* – a musical instrument – as object (35%) versus *playing a sitar* (46%); bow and arrow as object (29%) and archery as an activity (>60%) and plough as object (40%) and as an implement in farming (~60%). This reiterates that the use of human skill in association with an object increases its perception as being related to technology. In this context, it was interesting to note that teaching activity using objects (~29%) was associated to technology by almost the same number of students as the object blackboard (31%).

People who use/ create technology

Most students said that all people use technology *(we all use some or the other technology like phone)*. A few students stated that children or those staying at home do not use technology. This is consistent with household objects being related to technology only by half the students in the survey.

Regarding who creates technology, most students believed that scientists and researchers working in laboratories or special centers created technology as they *'engaged in experiments'*. About 90% of the students surveyed related the laboratory activity to technology. Only two students stated that their teachers could create technology. Very few students thought that human beings other than scientists and researchers could create technology, even if they had knowledge. One girl from the rural Marathi setting articulated that God created technology.

Is technology something new (modern) or old?

Objects like bullock-cart, plough and wood-stove were considered technological less often as compared to their more modern counterparts (plane, tractor and cooking range). In the interviews, we probed aspects related to traditional and recent objects: the temporality of technology. All the students interviewed thought that technology involved something new and that it came into existence in the recent past, rather than in ancient times. Some students stated that technology began before or after some specific event: 'discovery' of light / fire /steam engine/ life/ electricity/Indian Independence. One student said that *'science was discovered before technology'* and other students specified in years when technology came to being, example: 'B.C.', '100 years', '1000000 years'.

A gradation in technology level was also seen; some students stated that in ancient times there was less technology as compared to now. The ideas of progress (evolution) were exemplified by a boy's (from urban English medium setting) response about various objects: *('Airplane, we can fly and it has developed over age. Earlier we used to walk barefoot. Pressure cooker is related to technology, as it is a new way of cooking. Earlier we used open vessels. Flower does not have technology because from the starting it is like this. This is no new thing.')*

Is technology found more in urban or in rural areas?

Gradation of technology was mentioned with respect to locales too. All interviewees believed that technology existed more in urban areas. Some of them even had a clear idea about gradations in various places, such as, highest amount of technology in cities, followed by districts (towns) and lastly in villages. The reasons for such answers were that towns have more transport and communication facilities, factories, laboratories and regular power (electricity) supply.

Career aspirations

In the questionnaires students were asked to write what they would like to be when they grow up? Most students gave some response (Only about 7% of students left it blank). Many students did not write only one professional aspiration but 2 or more choices. Of the choices stated most of the students had opted for careers related to medicine (36%), which included doctor and nurse this was followed by a career in teaching (22%). These details can be seen in Table 3.5.

The three most preferred options for boys were medicine (29%), defence services (18%), pilot (18%), and for girls it was medicine (36%), teaching (32%), scientist/researcher (7%). None of the girls wanted to take up a career in sports or be a driver or opt for a career in administrative services. Very few of them, 3 of them wanted to be in defence services, 1 girl wanted to be a Chartered accountant and another 1 wanted to take painting as her career. Three girls (2%) wanted to be a pilot as opposed to 33 boys (18%). Another striking difference that was observed between the career choices of boys and girls was in teaching and defence services - 32% girls wanted to get into teaching career where as only 13% boys wanted to be teachers. Thirty-three boys (18%) wanted to get into defence services where as only 3 girls (2%) wanted to opt for that career. The percentage of boys and girls who wanted to be astronomers was 12% and 6% respectively. These results suggest that these students had narrow choice regarding careers and that most of the students wanted to either opt for medicine or teaching with none wanting to choose careers in agriculture, architecture, carpentry etc. This may be due to lack of knowledge of careers and vocational opportunities available to them. It was also observed that very few students wanted to be engineers and lawyers.

Table 3.5: Occupational preference of boys and girls

Profession	%Girls (n=161)	%Boys (n=182)
Doctor/Nurse/ Medicine	37	29
Teacher	32	14
Scientist/ Researcher	7	13
Astronomer	6	12
Engineer	6	8
Any job/service	3	1
Hospitality industry	2	1
Pilot	2	18
Defence forces	2	18
Lawyer	1	0
Higher studies	1	1
Painter	1	1
Chartered accountant	1	1
Sports	0	5
Driver	0	1
Administrative services	0	2

It was also observed from the data (Table 3.5) that boys wanted to opt for wider range of professions and the number of professions that they did not want to get into was also less as compared to the girls. Alma Lantz (1985) found that stereotypes about subjects that have traditionally been identified as "masculine" operates to discourage girls from pursuing non-traditional careers. These aspirations could be indicative of what they see around them, availability of role models, what they hear from their parents and teachers, peers. It mirrors to some extent the kind of stereotypes prevalent in the society. Another reason for girls having a narrower choice of careers than boys is that they lack ‘basic information about careers, including any sense of salaries, promotion prospects or the amount of education and training needed to pursue different occupations. While boys and girls may share this lack of information, for girls it is combined with stereotypes about technology as a male occupation, which reinforces their reluctance to consider non-traditional occupations.’ (Silverman and Pritchard, 1996, p. 46).

We observed that none of the students, either in rural or urban area, reported that they wanted any career related to agriculture. India, being mainly an agricultural economy does not seem to attract young students in careers related to it or they do not think that technology related career is feasible in agriculture. This also corresponds to the fact that fewer students think of agriculture related equipments (plough and scarecrow) to be related to technology as seen in the previous question.

3.5.1 Gender and technology

The *TAA* questionnaire had 19 activities being done by males or females. Significant differences (paired t-test) were found for 5 activities: archery (male picture- 64%, female picture-78%), pulling rickshaw (male picture- 56%, female picture- 69%), scientist (male picture- 88%, female picture- 96%), playing hockey (male picture- 68%, female picture- 76%) and wrestling (male picture- 33%, female picture- 27%). Of these activities, the activity when depicted by a female was considered technological by more students than when depicted by a male, except for wrestling.

To the question, *‘Who uses more technology – boys or girls?’* most students (9/15) said that both used technology equally. Two boys said that boys used more technology while two girls stated that girls used more technology. Regarding the use of technology by their parents, most students said that both parents used technology, but related their mother’s use of technology to the household while their father’s use extended both at work and at home. Only one student specifically said that his mother did not use technology because *‘she stayed at home’*.

In contrast to the above responses, when asked, 'If there is a space shuttle on which only one person could go then who should be sent – a boy or a girl?' most students (13) gave non-egalitarian answers. Three girls and 7 boys said that a boy should be sent and gave several reasons: *'it needs courage, which only boys have', 'till now most astronauts have been boys', 'boys can act faster if there is in any trouble', 'boys are able to do difficult work', 'have better observational powers'.* Three girls who were of the opinion that a girl should be sent, reasoned that *'girls should be given a chance to go to space'*.

When students were asked *'What do you think is 'not technology'?* In response to this question in the questionnaires, several objects and activities were not related to technology by a majority of students: especially in the categories agriculture, sports and teaching. Several reasons were given for not relating some activity/object to technology, such as: '*not human-made'* – a natural phenomenon, '*it grows on its own like trees'* or '*it does not move -like a clock without battery',* '*it does not involve tools', or' is not related to science'.* Students' answers to the question 'What is not technology?' focused on natural phenomena such as *'stone', 'blowing winds, sun rays falling on earth', 'walking' 'nature and living organisms'*, absence of electricity *'when you switch off light'*, or something not related to science *'weaving, dancing, etc'* or mechanical objects, example *'objects on which no action has been done'*.

The issue related to gender and technology was also addressed in the 2 open-ended questions in *TAO* questionnaire. The first question concerned advising a friend on various career opportunities and the other question pertained to division of chores between a boy and a girl (Meeta and Suresh).

Advising another on career opportunities

In the first situational open-ended question, students were asked if they had to give an advice to a boy and a girl about the career they should choose, then what advice would they give? After the question, 10 career choices were provided and students were asked to write against each choice whether it was suitable for a male or female or both.

Table 3.6 presents the results of students' responses on the suitability of careers for males and females. For all the ten choices, at least a few students said that they were suitable for both male and females but the number of students that agreed to 'both' varied for each career option. Maximum number (68%) students agreed that teaching was a profession that was suitable for both boys and girls, this was followed by doctor (66%) and at the third position were professions of dancer and scientist (48%) that were considered suitable for both boys and girls. The careers that were *least advised for boys* by students were cook (2%), nurse and dancer (4%) and *the most recommended* ones for boys were soldier (74%), pilot (56%) and farmer (54%).

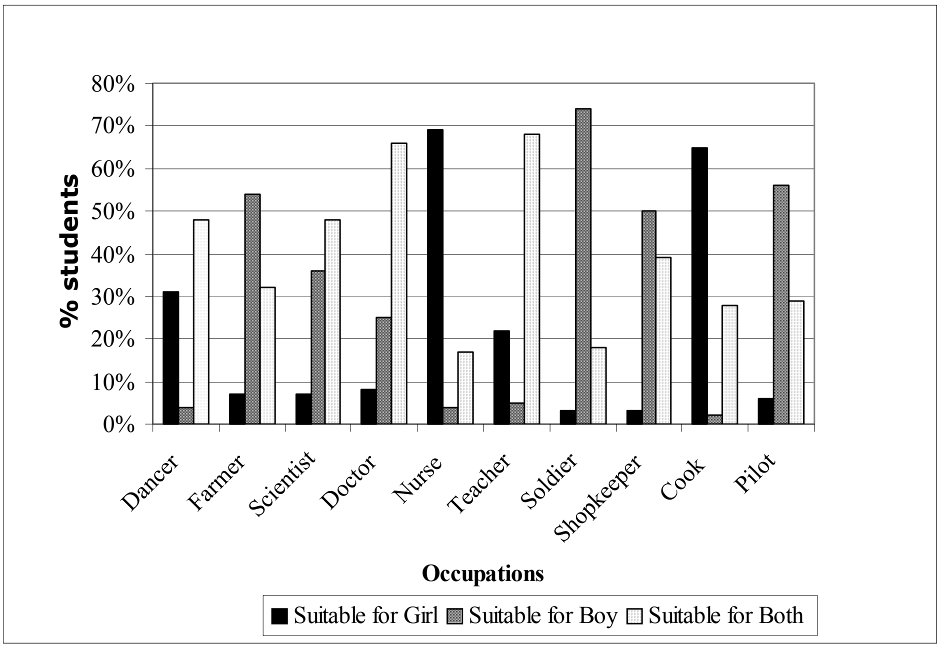
Table 3.6: Advising another person on suitable career opportunities

Occupations	Suitable for Girl (%)	Suitable for Boy (%)	Suitable for Both (%)
Dancer	31	4	48
Farmer	7	54	32
Scientist	7	36	48
Doctor	8	25	66
Nurse	69	4	17
Teacher	22	5	68
Soldier	3	74	18
Shopkeeper	3	50	39
Cook	65	2	28
Pilot	6	56	29

On the other hand careers that were *most advised for the girls* by students (both boys and girls) were nurse (69%) and cook (65%) and the *least advised for girls* were shopkeeper, soldier (3% each) and pilot (6%). Looking at the graph (Table 3.6 and Figure 3.2), we notice that women appear in fewer numbers in most of the careers except nurse, cook and dancer, which clearly demonstrates the stereotypes held by the students.

When the occupation of farming was explicitly mentioned, about 185 (54%) students said that farming was suitable for boys - meaning that boys alone can take it as one of their professions, 23 (7%) students said that it was suitable for girls alone and 110 (32%) students said that it was suitable for both. It is to be noted here that historically farming/agriculture was a female dominated activity where women looked after plants around their houses and grew vegetables but once the tools/equipments started being put to use, men began to dominate it (Wajcman, 1991) and now gradually, it seems that not many students think it suitable for females. Phillips and Taylor (1980) have argued that “skill definitions are saturated with sexual bias” and so this idea even holds true for children. Being a soldier or a pilot for a girl was also not suitable, according to the students.

Figure 3.2: Suitability of occupations for boys and girls



We observed from the data that most boys thought that being a nurse was almost exclusively a profession for females while soldier was for males. However, they thought that doctor and teacher professions were suitable for both males and females. For the females, similar preferences were found in the suitability of occupations for females and males but there seemed to be lesser difference in the number of girls choosing a particular occupation as exclusively for either of the sexes.

It was observed that those occupations that were considered more suitable for males, generally involved those objects that were considered related to technology by a high percentage of students. Example, the careers considered most suitable for boys were soldier, pilot and farmer and objects related to these occupations such as a gun (65%), tank (49%), airplane (87%) and plough (40%) were related to technology by a large number of students.

Similar trends were seen when the same question was posed to the students during the interviews. Students who were interviewed considered nurse, cook and dancer to be suitable for females while farmer, soldier and pilot were considered exclusively suitable for boys. Most students based their decision on the roles that they had seen women and men playing in society. As one of the students commented, "….all pilots, soldiers and farmers are boys…" and another one said … "I have not seen a girl soldier anywhere". Silverman and Pritchard (1996) have observed in a study in the US (Connecticut) that both girls and boys have a positive attitude towards technology but traditional stereotypes about male/female occupations operate strongly and outweigh girls' positive feelings about their experience in technology education classes. It seems that due to lack of role models, both in the public and private sectors, girls and boys are reluctant to consider non-traditional occupations as career options for males and females. Family also plays a very influential role in shaping a child's thinking about potential occupations. As researchers have pointed out that throughout the formative years, children are bombarded with indirect messages about what kind of work is thought to be most appropriate for men and women (Morgison, 1995).

Work division between a boy and a girl

In the second open-ended question, respondents were asked who (boy or a girl) would do which job faster, given a time constraint. Then a list of 10 common chores were provided and students were asked to put a tick in either Meeta's column or Suresh's column. The results of students' responses on this item are presented in Table 3.7. Most of the students (80%) said that Suresh (boy) should replace a fused bulb while 90% of the students said that the job that can be done by Meeta (girl) fast was arranging utensils (vessels) on the shelf. Other jobs that the students said that could be done suitably by Suresh were repairing a torn book (69%), recording songs on a cassette (59%), sorting a tool-box (57%). The jobs that would be more appropriate for Meeta other than arranging utensils on the shelf were dusting the house (85%), watering the plants (55%). The jobs that were not appropriate for Suresh, according to both girls and boys were arranging vessels (4%) on the shelf and dusting the house (3%). The jobs that Meeta would not be able to do fast were replacing a fused bulb (11%), sorting a tool-box (33%).

Table 3.7: Percentage of work divided between Meeta and Suresh

Jobs	Suresh (%)	Meeta (%)
Dusting the house	4	85
Repairing a torn book	69	20
Ironing the clothes	46	42
Collecting grocery from the store	48	40
Recording songs on a cassette	59	29
Replacing a fused bulb	80	11
Sorting the tool box	57	33
Bringing firewood	48	42
Arranging utensils on a shelf	3	90
Watering the plants	30	55

There was a significant difference between boys and girls for the job ‘sorting tool box’. Most students’ assigned the work in a typical way- the jobs that required dealing with appliances or tools and the outdoor jobs were thought to be more suitable for a boy. This is again indicative of certain stereotypes that are prevalent since time immemorial. As Lerman (2003, p. 516) has pointed that in the history of technology “….being female meant learning and performing ‘housewifery’….which included cooking, sewing, cleaning and laundry.” Kitchen is thought of a place that is exclusively for females. There seems to be gendering of places/locations within the house also- kitchen being the territory of women and garage of men.

In the interviews students were asked to comment on why they had thought that Meeta or Suresh would do a particular work faster. Most of them thought that work within the house or kitchen could be done faster by Meeta whereas those jobs that required going out of the house or involved the use of tools or was perceived as dangerous were thought to be done more efficiently by Suresh. This was clear from one of the student’s remark *“Meeta only can do it very nicely and Suresh has many other jobs to do.”* The same student said this, “*Meeta cannot replace a fused bulb. She doesn’t know how to do it. Boys learn it from fathers. Girls can learn but girls are fearful.”*

Another reason why some jobs were assigned to Suresh and some others to Meeta was that students held gender stereotypes about certain jobs. For example one student from the English medium cluster commented, *"watering is appropriate for Suresh because gardeners are mostly boys."* At times there were instances of students taking pride in telling why a particular job was suitable or not suitable for a particular sex. In one instance, one the rural Marathi medium boy justified that Suresh should not arrange the vessels on the shelf because, *"boys can drop the vessels and break them while girls do it properly."* And boys should sort the tool-box because *"if girls do it, they might hurt themselves and then they will cry whereas if boys cut themselves, they will not tell anyone and will continue to work."* The same student says that boys should get grocery from the store because, "*boys are good at Maths and can do addition and Maths quickly while girls have to be taught to do it".*

Interviews gave us some insights into the way students' assigned jobs to different sexes. We observed that students based their responses on what they had come across or experienced in their daily lives, or the gender roles they associated with each sex. There is evidence that shows that both the parents react favourably to their children when they engaged in behaviours/ tasks that were perceived to be gender-appropriate (Welty and Puck, 2001).

3.6 Conclusions and Implications

This study is one of the first attempts in India that aims to understand students' ideas about technology through pictures and interviews. Broadly our purpose for this study was to explore the way children perceive their technical world. It appears from the survey results that Indian middle school students have associated technology mostly with objects and activities depicting modern appliances used for speeding work and easing life, usually seen in the urban areas. The product-oriented view of technology is consistent with earlier studies (Raat and de Vries, 1986; de Klerk Wolters, 1989 and Rennie and Jarvis, 1995c) where students associated products, particularly computers, transport, domestic appliances and modern electronic gadgets with technology.

Students in our sample also associated school subjects, research, discoveries and inventions with technology. This idea may be due to the fact that technology is introduced in Indian schools as application of science. Students viewed technology as a human endeavour and credited scientists/ researchers for technological inventions but considered most other humans as mere users of technology. Indian students thought that technology essentially had an evolving nature, was present in the ancient periods in limited ways and is now used by everyone. They also thought that there was more technology in urban than in rural areas.

Students gave consistent reasons for associating a particular object or an activity to technology. These were mostly to do with the benefits derived from using technological artifacts such as having to use less physical strength, doing work faster, being made by humans and being dynamic. Students who related technology to natural categories stated that plants, waterfall, thunder and lightening had motion and life and therefore were related to technology and also they had studied these in their science books. Reasons for considering something as ‘not technology’ were; it did not have a machine, was not related to science, or was something found in nature.

Students seem to be a little unsure at this stage of their career choices- this was evident in the number and varieties and combinations of occupations that they gave. Students have stereotypic ideas about the occupations and jobs/chores for boys and girls. Students stereotype a significant number of occupations along gendered lines. In addition, their choices of occupations are strongly gender-biased. Given the culture and social conditions prevalent in India, it is clear that these stereotypes get reinforced.

This survey indicates that objects along with humans get associated with technology more often than humans presented in an activity without equipment, or when objects are presented alone. This finding is in contrast with de Klerk Wolters (1989) and Rennie and Jarvis (1995b) studies where pupil’s drawing on technology were mostly without humans indicating that humans are not an essential element of technology.

According to Mammes (2004), the interest of girls in dealing with technology can be encouraged through interventions that reduce gender differences in experiences about technology. Gender biases surfaced in the survey, in the following ways. Pictures showing women involved in activities were considered by more students as technological, than the same activities by men (playing hockey, a working scientist). Perhaps women in these roles as well as the activities were unfamiliar to students. Considering an activity technological differs from considering it suitable for a person and therefore, most students said that a boy more than a girl should be selected for space travel.

The results from this study can be used for planning technology education curriculum in India and can help teachers/ planners equip themselves with the ideas that children hold of technology. Our findings suggest that Indian students' ideas of technology though varied, lacked depth. Their view of technology was rooted in science either as its applications or as its object of study. There is a need to introduce the study of technology at the school level as a subject with distinct knowledge and skill requirements. Teachers and educators need to be conversant with the multiple perspectives of technology so that in their classrooms they may be able to make appropriate linkages of technology with science and society as well as with other school subjects.

CHAPTER 4

METHODOLOGY: DEVELOPMENT AND TRIALS OF D&T EDUCATION UNITS

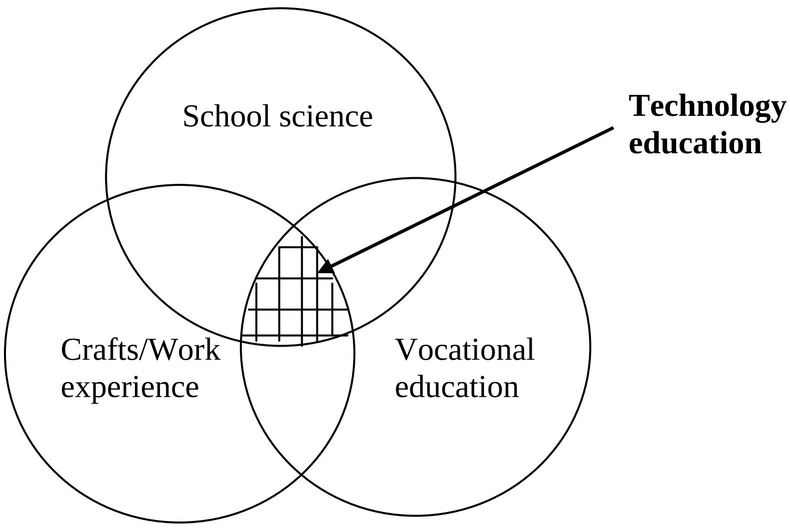
4.1 Introduction and Rationale

This chapter will discuss the development and implementation of three D&T education units among Indian middle school students (Grade 6, age 11-14 years) in three different socio-cultural settings. In most Indian schools, students are passive receivers of information. Facts are provided by teachers from textbooks and received by students without much thought or discussion. In the existing school subjects there is very little room for peer communication or collaborative work among students. In our view, technology education is one subject, which if introduced at the school level, has scope for creating a space for collaboration in the existing system.

Technology is a collaborative endeavour between users, designers and makers of products, besides the people involved in marketing the products. The view of technology as a social process shaped by and through social, material, and discursive resources has been endorsed by Vygotsky (1978), Wertsch (1991) and others. Technology education needs to involve multidisciplinary perspective and multiple skills right from the school level. Since technology derives its needs from community, it is therefore an inclusive collaborative activity. We believe that if these views are to be represented in technology education, teachers and students are required to play non-traditional roles to make the subject meaningful.

In India technology education does not exist as a separate school subject. The skills and knowledge emphasized in technology education curriculum elsewhere in the world find their place in the Indian curriculum in subjects like science, work-experience and vocational education. It is at the interface of these three subjects that education in and about technology resides in India (Figure 4.1). School science is seldom experienced as a collaborative activity and work experience is envisaged as mere making of socially useful objects in large numbers and thus gaining skills. It has less to do with designing new objects or changing existing situations. In work education too, individual efforts are valued over collaborative design. Vocational education in India is solely geared towards developing skills for employment as technicians on shop floors.

Figure 4.1 Placing technology education in the Indian school system



Technology education as we see it transcends all the boundaries created by science, work-experience and vocational education. Technology makes linkages with craft, the natural sciences, indigenous knowledge and also the social sciences. Our idea of technology education shifts the emphasis from the view of technology education as applied science and the use of digital technologies to collaborative participation of students in design and evaluation of need-based artifacts and systems (Choksi et al., 2006).

To turn our idea of technology education into reality, we designed 3 D&T education units with the following theoretical basis – (a) Building a collaborative working environment in the classroom, (b) situating the goals in the context of students/authenticity, (c) teaching technology with design at its core and (d) making the activity gender sensitive. Inputs from all these theoretical backgrounds formed the basis of our development of technology education “units” for the middle school level. We envisaged a unit as a set of activities leading to a useful product, which may be for individual users or a user community; may be an object, an assembly or a system, static or dynamic. In this, we also recognize the slippery boundaries defining technology. Each of following theoretical base forms a rationale for our units.

(a) *Building a collaborative working environment in the classroom* - The theory of collaborative learning has been dealt with in detail in one of the sections (4.2) of the review of literature chapter. While collaboration simply refers to the fact that people are working together on a task, the term can have variety of meanings - a situation can be characterized as collaborative, interactions taking place between group members can be collaborative, learning mechanisms/processes can be collaborative. Collaborative learning basically involves construction of meaning through interaction with others and a joint commitment to a shared goal.

In our units collaboration was introduced by having groups of 3-5 members each within a setting. The task to be performed or the problem to be solved was given to the entire setting and then each group within that setting had to engage independently in the task and solve it. They could of course interact with members from other groups but had to make a product/artefact in their own group. While working in groups, students set common goals and all the members in the group were mutually aware of the shared goals, talked to each other, reasoned, negotiated on issues, took up activities, appropriated which are the processes involved in collaborative interactions (Dillenbourg, 1999).

At another level collaboration was also envisaged as working together of researchers and students. In a regular classroom, the relationship between teachers and students is generally not symmetrical (teacher gives instructions and students have to follow them) (Sadker and Sadker, 1990). In the trials of our units we tried to consciously reduce this asymmetry of relationship and knowledge. To do so we often sat with groups and solved the problems with them, instead of giving them the answer right away. Many a times it used to be a learning experience for us working with students. Though we were always there while the units were in progress, we tried not to dominate students' discussions and were only facilitators.

(b) *Situating goals in the context of students/Authenticity* - The term 'authenticity' has been used for real-life situations in a variety of contexts. 'Authenticity' has been thought of differently by various researches. Some researchers conceive of a generic kind of authenticity. Activities achieve authenticity in this sense because they reflect the nature of real problems as being complex, ill-structured, collaborative, containing multiple perspectives and offering multiple paths and solutions (Young, 1993; Squires, 1999). Jonassen (1999) suggests that an authentic activity may simply be one that is personally meaningful to the learner - that is engaging and relevant in a way that assists them in their own meaning making.

Authenticity has been used with learning, classrooms, situations, problems, activities, assessment etc. In all these cases, real-life (natural and meaningful as opposed to made-up) remains at its crux. Many theorists (Hill, McCormick, Lave, Wenger etc.) argue the importance of providing students with authentic experiences that reflect real-world ways of knowing and doing. It is thought that such experiences allow learners to transfer knowledge from formal education to practice, and so provide opportunities for meaningful learning.

Other researchers argue that emphasis should be placed on engaging students in cognitive processes that reflect the real-world counterpart (Anderson et al., 1996). This would involve learners in the same types of cognitive challenges as are present in the work environment, but not necessarily in exactly the same tasks an expert practitioner would perform (Savery and Duffy, 1996).

Honebein et al. (1993) argue that an activity is not inherently authentic, but authentic in relation to some other activity. The level and nature of authenticity presented to learners depends upon many factors. Some situations may require a high level of precision in their representation so that practical skills may be developed. Other learning situations may focus more upon developing or applying conceptual knowledge or skills, such as critical thinking or problem solving while in some others social interaction and negotiation may be crucial.

Real-life contexts or authentic situations help students understand concepts in context rather than as isolated facts. Problems set in real-life contexts are termed as ‘authentic problems’ and the learning that results from solving authentic problems is called ‘authentic learning’ (Murphy and McCormick, 1997). Such learning is a social process in which the conversation and tasks enable learners to encounter real-life situations from a variety of perspectives as they are exposed to the range of opinions and attitudes of others (Radloff, 1999).

Lave has used the word ‘situated’ to characterize similar kind of contexts. In her work, she emphasizes the importance of community in the learning process and argues that students learn contextually from others. According to her, learning takes place in a ‘participation context’ and not in the individual mind. So according to Lave it is much easier to learn from natural settings as compared to un-natural activities.

Technology education also has an element of real-life learning as Hill (1998) defines technology education, ‘as the study of technology…. where students are provided the opportunity to use a variety of materials and processes to solve real-life technological problems…(p. 204)’. In order to engage students in meaningful learning, technological tasks should be embedded in real-world contexts. According to Jones (1997) students tended to show greater indications of technological capability when they were engaged in authentic technological activities.

Hill and Smith (1998) showed that involving students in genuine projects derived from community needs, such as garden tables for a retirement home and a spool rewind system for a major tyre manufacturer, provided specific contexts for active student learning. However, for McCormick (2004) this does not mean that learning in the classroom should be the same as in the world outside rather it should be ‘coherent, meaningful and purposeful within a social framework that is within the ordinary practices of the culture of technological activity (p. 164).’

In our D&T education units, the element of authenticity was included in the tasks that were set to the students. All the 3 units were situated in real-life contexts. We tried to make the units personally authentic to the participating students. Along with personal authenticity, cultural authenticity of the units was also considered during their planning. This was done to ensure that students from both rural and urban areas and boys as well as girls could connect themselves to the tasks at hand. We also tried to contextualize each of the units in such a way that the skills gained during the units could be transferred out of the ‘laboratory’ to classroom and real-world. The specific ways in which each of the three units have been contextualized will be discussed with the description of the units.

(c) *Teaching technology with design at its core* - 'Design' is a difficult term to define. It is used both as a noun and a verb and can refer to either a process or an end product Designing involves thinking creatively and begins with hazy, speculative ideas that become clearer and better formulated as they are refined and shared with others (Ritchie, 2001).

Designing involves 'imaging' in the mind's eye and then externalizing the ideas in a concrete form. It involves the use of oral, graphic and other communication skills to clarify ideas. In D&T activities, designing involves the process of generating, developing and communicating ideas relating to outcomes. For Murphy and McCormick (1997) 'design' is a central kind of procedural knowledge, but this is often characterized in similar terms to problem solving.

Design is one of the ways by which technology can be situated in an authentic, real-life context. According to Hill (1998), one of the ways to do so is to understand how the design process operates at the centre of the technology education process. Design process is not a linear, one-way process, instead it is an iterative process and produces some 'order from disorder' and shares some features with creativity. Design has an element of open-ended problem solving as opposed to closed-ended design briefs provided by the teachers.

In the context of technology, designing includes keeping in mind the user and also issues related to making. By keeping in mind the user one is referring to those design issues that relate to the way in which the final product interacts with the users. Issues related to making refer to those design issues that are concerned with actual making of the product being designed. So for tasks to be set in context, one needs to have a balance between the user need and making. According to Williams (2000) children adopt inventive and flexible approaches while designing in technology and the process that they follow for designing varies with the situation.

Design forms a major part of the procedural knowledge of any technological activity. Designing involves skills that are complex and some teaching is required for imparting skills that are difficult to acquire by mere observation or experience. Keeping this in mind we held a session on teaching elementary techniques of technical drawing, representation of dimensions, folds and cuts on a drawing. We tried to consciously minimize the separation of theory and practice by having students practice drawings of simple and familiar objects such as lantern, boat etc.

Each of our units was roughly divided in phases (such as investigation, planning, designing, making, communication, evaluating) and design pervaded through all the phases. We tried to incorporate design in all our units in a ‘vernacular way’ (as opposed to modern way), where the designer and maker of the product were the same unlike a modern designer who may design the product without having to make it. Each phase in our units was sufficiently open-ended to allow for flow of creativity. Design-briefs that were provided to the students were largely open ended and students could conceptualize the problem in a variety of ways. For the 3 products - bag, windmill and puppet- the nature of their use as well as their users were different. Bag was a commodity of common personal use; windmill and puppet did not have a personal use attached to them. Windmill had to lift some weight while the puppet had to be used in a play. The design of the products had to vary keeping in mind the various uses of the product.

Drawing/sketching was another important aspect of designing. Students were free to draw their design or make models or prototypes of the products/artifacts. To help them visualize the procedure better, steps like making procedural maps (step-by-step procedure of making) and listing materials and tools required for making the artefact were incorporated in various phases of the units. Students could revise and rework on these details, incorporating inputs from peers, before making the actual product. Apart from drawings and sketching, students had to design the character of the puppet (dialogues, dress etc.) in the puppetry unit. Thus, in our units designing was at the core of all the technology units and its process was continuous through all the phases.

Another important feature of the design process is to have students justify their solutions at several points along the way. In selecting a solution, the goal is to have students indicate why that particular solution is the best based on the knowledge they gained by discussing it with their teammates and other sources. In our units, students would present their findings to the class after designing and engage in discourse with other students and the researchers. Interrogating students for their critical thinking at these points helps them reflect on what they are learning, embedding knowledge and skills more deeply (Kimbell et al., 1996). Reflecting on what they have learned is an important part of D&T activity. Reflection comes at multiple times in the process and students become accustomed to thinking this way.

(d) *Making the activity gender sensitive* – One of our motivations was that the three units should be gender sensitive or ‘girl-friendly’. Various researchers (Mark, Taber, Rosser etc.) have used the term ‘girl-friendly’ in variety of contexts. But irrespective of the context, the term aims at including women and girls in mainstream S&T. This often means increasing access and retention of women and girls in S&T, by encouraging them in these fields and making the practices conducive for women and girls to participate in. Some researchers have defined girl-friendly in terms of pedagogical techniques that need to be undertaken to make technology more interesting for females, while others have used it to create an environment that encourages women to participate actively in S&T endeavours.

Sue Rosser (1990) has defined female-friendly in terms of pedagogical techniques that need to be practiced in S&T classrooms that take into account women’s ways of learning and encourage them to remain in the field. These pedagogical techniques include practices where:

- There is increase in the numbers of observations, which provides students more hands-on experience with various equipments
- There is scope to incorporate and validate personal experiences of women
- Fewer experiments are likely to have applications of direct benefit to the military and have more experiments to explore problems of social concern
- Hypothesis is formulated focusing on gender as a crucial part of the question asked

- A combination of qualitative and quantitative methods in data gathering is used
- Females are also included as subjects in experimental designs
- More interactive methods are used, thereby shortening the distance between the observer and the object being studied
- Precise and gender-neutral language is used in describing data and presenting theories
- Development of theories and hypotheses that are relational, interdependent, and multicausal is encouraged rather than hierarchical, reductionistic, and dualisitic
- Less competitive models in the practice of S&T are used
- Practical uses of science and engineering in their social contexts are discussed

Taber (1991) has taken views like that of Rosser and has stressed the need to make physics 'girl-friendly' in the UK National curriculum. Taber points out a range of practices pertaining to a physics classroom that are found to be gender biased and also suggests ways of overcoming these problems through redesigning curriculum and change in attitudes of the educators. These gender-biased practices include:

- Allowing boys to dominate the classroom exchanges or the teacher interacting with boys and girls in different ways
- Teachers preferring to work with boys rather than girls or find boys more interesting
- Teachers believing that some scientific and technical subjects are more appropriate for boys than girls
- Teachers making sexist and stereotyped assumptions about the future and present lives of their pupils
- Teachers who award higher marks to work they believe to be from boys
- Teaching and assessment materials that use illustrations and examples involving mostly males, or distinguish between the roles of the two genders, making females only observers or assistants, or materials that predominantly relate to the experiences of males
- Boys who monopolize apparatus in practical work

Armstrong and Leder (1995) have suggested ways to make engineering education curriculum more gender inclusive. They suggest that most girls who choose to do science do so because they are interested in the social-context of science. Many girls feel that ‘science is related to their real-life experiences, to human needs, to environmental issues etc’. They also observed that girls tend to work more collaboratively.

Assessments in subject can also be girl-friendly. Harding (as quoted in Armstrong and Leder, 1995) suggests that ‘multiple choice or so called objective tests favour boys’ and therefore to encourage girls to participate in technology tasks, open-ended and informal rather than objective type questions are helpful.

Mary Gatta and Mary Trigg (2002) have discussed female-friendly technology in terms of creating/providing an environment that retains females in mathematics, S&T domains. According to Sherman (1999), female-friendly technologies are those technologies that realize the importance of women in technology and provide opportunities for women in hi-tech and new-media tools.

The term female-friendly has also been used to mean planning special programs (eg. Techbridge, Geek Chick) that prepare girls to participate in mainstream technology. One could also think of it in terms of including values in technology tasks that favour girls that is, taking affirmative action. These include allowing group work and encouraging communication and interaction among all group members, allowing for discussion and participation that is harassment free, informal assessments and open-ended tasks. According to Industrial Design Society of America, developing female-friendly technologies means ‘bringing in female sensitivity to products historically shaped by masculine tastes, habits and requirements’. They need to go beyond ‘cute’ and ‘pink’ (New York Times, June, 2007). Girl-friendly technology also means making gadgets that appeal to women. Volvo has come up with cars that have ‘girl-friendly’ designs - the seats, the car-doors have been modified that allow the head rest - to accommodate women’s head with pony tail etc, the car is equipped with a personal communicator.

How did we make our units girl-friendly?

We designed our units to be girl-friendly by including/ taking into account the following issues:

- All our units were contextualized in real-life situations instead of abstract situations. Real-life situations helped the students in contextualizing the problem in a better way
- Students were made to work in groups and discussions/debates among group members was allowed
- Care was taken by the researchers to use sex-equitable language in the class
- The tasks in all the units were open-ended and the assessments not very formal
- All the units required students to not only collaborate among their group members also across group collaboration was encouraged
- All the units had scope for using skills that were appealing/possessed by both boys and girls
- We also ensured that the number of boys and girls participating in the units were about the same

4.2 Design and Technology project

In order to introduce D&T to middle-school students in India, a project was initiated at the Homi Bhabha Centre for Science Education (HBCSE) in the year 2002-2003 that involved the development and trials of D&T units for Indian middle school students. Three units were undertaken in the trials: *making a bag, making a working model of a windmill and making a puppet and putting up a puppet show*. All the units were designed within the frame of collaborative learning, wherein groups of students shared a goal and were held together with a common sense of purpose. To achieve their goals and solve problems set to them in real world contexts, students worked as teams, employed common practices, used the same tools and expressed themselves in a common language. The units were selected on the basis of increasing order of complexity of tasks and intra and inter group collaboration.

The *bag-making* unit viewed technology as a product (artefact) and could be done by an individual, though a group was involved in the process. The *windmill* unit required students to make a working model of a windmill to lift weights and test it. This activity was more complex, having many sub-parts and needing more mental and physical work. The third unit on *puppet making and putting up a puppet show* was based on a systems approach of technology. Each group had to make a puppet and all the puppets made by them were needed to put up the show, so a second level of collaboration (with the entire cluster collaborating) was introduced.

For each D&T unit, students worked together for about 15 hours in 5 sessions. These units were tried with 20-26 grade 6th (11-14 years of age) students in three settings. It was ensured that the number of boys and girls participating in the trials were about the same. These settings were: English medium students from urban schools, Marathi medium students from urban schools, and the third cluster was from a government run residential Marathi medium school for tribal students *(ashramshala)*. This *ashramshala* was located at a distance of about 60 Kilometres from the city of Mumbai.

The overall approach in all the units was a modified form of design-make-appraise (DMA) approach suggested by Kimbell (1994). The modified approach is presented in a model put forward by Choksi et al. (2006). As we can see in the Figure 4.2, that collaboration and communication are the central aspects of our model. The other stages / phases, which include: motivation, exploration of design, making technical drawing, planning, making and evaluating products of self and others. In each of the phases there is communication and collaboration within and across groups. None of the phases stand-alone or are strict within themselves, instead one phase leads into the other and there is constant interaction between the phases.

Figure 4.2: Collaboration and communication centered D&T education model for the Indian school context

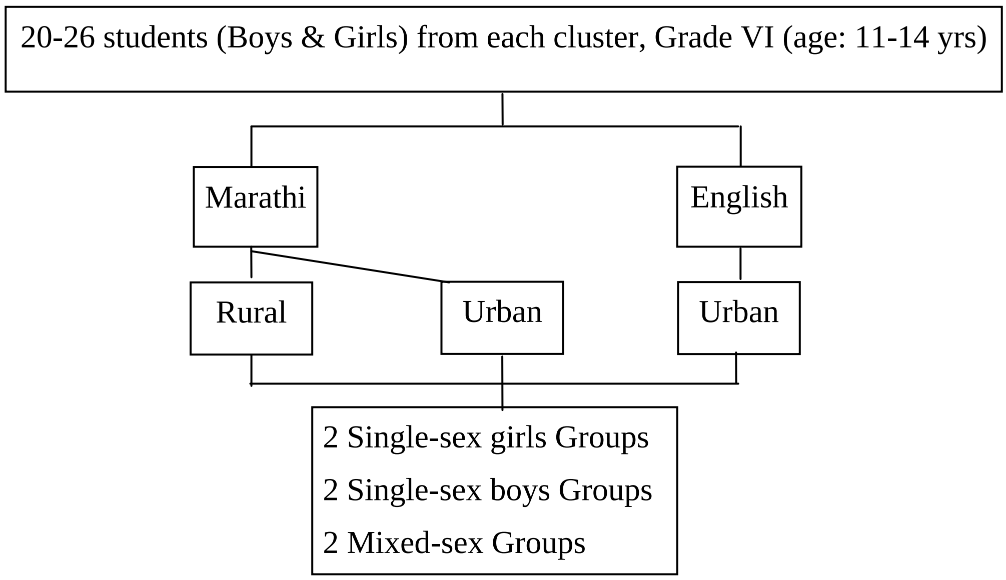
All the three units were structured around the communication and collaboration centered D&T model. Each unit involved several tasks with fuzzy boundaries, which were adapted for each of the three socio-cultural settings, though maintaining the overall structure of the units. The idea of taking students through the three units was not to make them perfect in making the output/product but was rather to take them through the ‘process of design’ and make them aware of the underlying concepts. We hoped that through these activities that students would be able to figure out the entire activity as a single continuous process towards making a product.

Volk (2007) commenting on the methodology followed by us in the unit on puppetry said that making students work in groups helped in creating a collaborative learning environment. Students could communicate their ideas to others in a non-threatening environment.

4.3 Sample description

Each unit was tried with students from 3 different socio-cultural settings and these were: the urban Marathi, the urban English and the rural Marathi students. The trials with students from urban settings were carried out at the Centre while we (researchers) went to the rural school for the trials. The students who formed the sample were studying in Grade 6/7 (age 11-14 years) and the research trials were carried out at separate timings in different settings. Figure 4.3 gives the diagram for sample description.

Figure 4.3: Sample description



In the *urban English setting*, the trials of all the 3 units were conducted in 3 consecutive weeks in the first 3 weeks of May 2004 (bag-making in 3^{rd} - 7^{th} May, windmill in 10^{th} -14^{th} May and puppetry 17^{th} - 22^{nd} May, 2004). The students who participated in the trials in all the 3 units were the same (except for a girl who dropped out after the bag-making unit). The total number of students who participated in the bag-making activity was 19 (10 girls and 9 boys). Initially there were 5 groups of students (2 single-sex girls groups with 3 members each, 2 mixed-sex groups with 4 members each and 1 single-sex boys group with 5 members). On the second day of the bag-making activity, another boy volunteered to join and there was some reorganization. The single-sex boys' group with 5 members and the addition of the new boy to this group was divided into 2 groups with 3 members each. Thus in all, there were 6 groups. For the unit on windmill and puppet, all the members and groups remained the same (except for 1 drop out in one of the single-sex girls' group, which remained with only 2 members). The details of group composition and group names of the 6 groups that were formed in urban English setting are as follows:

- 2 single-sex boys groups (Team Evolution, Team Science)
- 2 single-sex girls groups (Nature, Science Kingdom)
- 2 mixed-sex groups (Velocity, Fantastic Four)

In the *urban Marathi setting*, the trials of the bag-making unit were carried out from 18th August - 27th August 2003, wherein students came to HBCSE every alternate day. For this unit, 21 students (10 boys +11 girls) participated in all the trials. There were 6 groups formed:

- 2 single-sex boys' groups (Dr. Homi Bhabha, Sanshodhok)
- 2 single-sex girls' groups (Sadaphuli, Gulab)
- 2 mixed-sex groups (Swatantra Vir Sarvakar, Thomas Edison)

The windmill unit was tried with this setting after a gap of about 8 months of the bag-making trials, in the 2nd week of April 2004. In the consecutive week puppetry unit was tried with students from this setting. The month of April being the summer vacation period, students were able to participate everyday of the week for 5 days per unit. Since there was a gap of 8 months between the two units some changes occurred in the sample - 3 new female students and 1 boy joined the sample and there was 1 dropout of a female. The new girls formed a single-sex girls' group and the boy joined one of the existing single-sex boys' group. In all 24 students participated for the trials of this unit. So for the windmill unit there were 2 mixed-sex groups, 2 single-sex boys' group and 3 single-sex girls' groups. The constitution of the groups in the urban Marathi setting for windmill unit was as follows:

- 2 single-sex boys' group (Homi Bhabha, Sanshodhok)
- 3 single-sex girls' groups (Sadaphuli, Gulab, Nishigandha)
- 2 mixed-sex groups (Thomas Edison, Swatantra Vir Savarkar)

For puppetry unit, there was reorgainsation of groups once again, through the participating students remained the same. A mixed-sex group and a single-sex girls' group were combined (Thomas Edison and Sadaphuli groups) to form a mixed-sex group that had 2 boys and 3 girls. The combined group changed their group name (to Raatrani) in order to get a new identity for the group. Therefore for puppetry activity we had the following 6 groups:

- 2 single-sex boys' groups (Homi Bhabha, changed their name to Kusumagraj, Sanshodhok)
- 2 single-sex girls' groups (Gulab changed their name to Gulmohar, Nishigandha changed their name to Rabindra Nath Tagore)
- 2 mixed-sex groups (SwatantraVir Sarvarkar, Raatrani)

In the *rural Marathi setting* for bag-making unit trials were carried out during the 2nd week of October 2003 (6th October 2003). 20 students (10 boys + 10 girls) participated in the bag-making trials. There were 6 groups that were as follows:

- 2 single-sex boys' groups (Suryadev, Ganapati).
- 2 single-sex girls' groups (Jeevdani Mata, Sri Rama)
- 2 mixed-sex groups (Saraswati, Shri. Santoshi Mata)

The trials of the windmill unit were carried out with rural Marathi setting from 15th July -19th July 2004. By this time the students who had participated in the bag-making trials had come to Grade 7. Twenty-four students volunteered to participate in our trials. Out of these 8 students were common who had participated in bag-making trials. The reason for this large dropout was that many of these students has not passed from the previous grade and some had left the school. So for the windmill unit in all 24 students (12 girls and 12 boys) participated in the trials. There were 6 groups in this setting also and the details about the groups as follows:

- 2 single-sex boys' groups (Indian, Ma Tujhe Salam)
- 2 single-sex girls' groups (Shri Rama, Omkar)
- 2 mixed-sex groups (Aashirwad, Shri Shankar)

For the puppetry unit, there were two newcomer girls. Each of them was asked to join the existing single-sex girls' groups. So for puppetry unit each of the single-sex girls' group had 5 members. Hence the number of participants was 26 (14 girls and 12 boys) for this unit. The group names unit were maintained. The puppetry trials took place in this setting in the 2nd week of August 2004.

Group naming was done to encourage team spirit and for ease of identifying. We saw interesting differences in the settings even in the selection of names. In the rural setting, group names had a religious touch and tended to be names of gods or goddesses (e.g. *Sri Shankar, Sri Ram*), while in the Urban Marathi setting the groups were named mostly after famous personalities (e.g. *Swatantra Vir Sarvarkar* - a freedom fighter, *Rabindranath Tagore* - a Nobel laureate in literature). The names selected by groups in the Urban English setting were influenced by S&T (e.g. Science Kingdom, Velocity). In both the urban settings, some group names were influenced by nature (e.g. *Gulmohar* - a flower)

4.3.1 Socio- economic background of students from the urban setting

The sample from the urban setting comprised of 2 schools from Mumbai. Both these schools were located within the radius of 1 kilometre from our centre. One school was an English medium school that catered to a wide spectrum of students from different education and economic backgrounds. The parents of these students worked for the Atomic energy plant in various capacities from a scientist to clerk. Parents of all the students were educated and in almost 50% of the cases both the parents were employed. Most students spoke in their mother tongue at home. The school was within walking distance from their house and was coeducational. Academic tracking was practiced in the school. For our study we had specifically asked the school principal to give us average students from each of their 3 sections. Students had access to computers at school and some of them even had computers at home. The school had a fairly decent library and outdoor sports activities were even included in their regular class timetable.

The second school from the urban setting was a Marathi medium coeducational, government aided school. The school catered to students from middle income or lower income groups. The mothers of most of the students included in our sample were housewives and fathers were generally involved in the service sector or small business. Students did have access to computers in school but not at their homes. The mother tongue of most of the students was Marathi (which was the same as their medium of instruction). The school had a small library and outdoor sports activities were scheduled in their timetable. Academic tracking was also practiced in this school but average students from each of the class sections were taken for the study. The general upkeep and the facilities in the school were not adequate.

4.3.2 Socio- economic background of students from the rural setting

Students from the rural setting studied in a Marathi medium, coeducational residential school that was run by the Tribal welfare department of the Government of India. The school was located about 60 kilometres from Mumbai in Thane district. Most people in the village were farmers or labourers. Women and girls of the village were mostly involved in farming and household activities. The school was located about 1.5 kilometres from the main highway.

Most students in our sample belonged to poor income group families whose parents were either totally illiterate or were minimally educated. There was only one section for each class and therefore there was no practice of academic tracking. Students' mother tongue and the language of instruction at school were the same. The schools were minimally furnished and the classrooms were well ventilated. Students sat on the floor while the teacher taught from a desk in front of the class. The school had computers but students had never had an opportunity to work on them, as the electric power supply to the school was erratic. The information on socio-economic background of the students was collected on the first day of trials of the units. The students needed to fill in a self-information form (Appendix H). For the rural Marathi students, apart from students filling in the self-information form, the headmaster of the school was also contacted to give more details about academic and social background of each child who participated in our study. Based on this information, we found some differences across the settings and these differences are being listed below.

Differences in the rural and urban settings

- Rural students were more likely to come from lower socio-economic status families as compared to urban students
- Most parents of rural children either had no jobs or had jobs of lower occupational status (as well as earning), on average, than did the parents of urban students

- Parents of rural students had lower level of education than most parents of urban students
- Rural students were at a relative disadvantage as compared to urban students with respect to exposure to ICT
- Dialects of urban and rural Marathi students were different

In all the 3 settings, before the unit began, we asked the students to form groups of 3-4 members each. We instructed them to form 2 all girls, 2 all boys and 2 mixed-sex groups. In all the 3 settings, it was observed that students formed single-sex groups spontaneously. However they did not volunteer to form the mixed-sex groups, and at times they had to be forced to be members of a mixed-sex group

4.4 General overview of the structure and implementation of D&T units

The aim of structuring the units was not to produce, 'uniform work across the class.' But, it also '… allow[s] students to concentrate on developing their own ideas to the full, not in isolation but as part of a class in which there is a culture of sharing and cooperation to everyone's benefit' (Welch, 2001). The general structure of the tasks that took place over a period of 5 days for each of the unit is given in Table 4.1.

Each unit roughly remained same in its structure across the three settings nevertheless, they had to be adapted for each setting in terms of some of its sub-parts. Besides, adapting the units for each of the settings, the units also evolved over the course of time from one setting to another, incorporating our learning experiences into the trials with the subsequent groups.

We observed in the bag-making unit that students from the rural school were very shy and did not open up much to us. Most of them also had not had any opportunity to speak in front of the entire class. So in order to make them feel comfortable with the 'environment of the units', we carried out two sessions of ice-breaking activities with this group of students. During these sessions, we played games that required them to speak/talk and involved active participation from all the students. These games included '*antakshari*', dumb charades and some basic classification activities with leaves from their school campus. However in all the 3 settings we found that there were some fluent oral communicators and these were more so from the urban groups. The rural students took longer to complete written and oral activities, and their oral communication was more often inaudible. They also took time to open up even to the researchers. The details of implementation of each of the units are given in the sections that follow.

Table 4.1: General structure of D&T units: Elaboration of activities in each step

Stages	Elaboration of activities
Day 1 **Investigation & Motivation**	Introduction of various kinds of bags/windmills/ puppets by researchers Writing words for the artefact/ system in various languages by students
Day 2 **Designing**	Technical/academic inputs related to the units provided by researchers Designing the artefacts to be made by students Technical drawing of the artefacts by students
Day 3 **Planning & Communicating**	Procedural map of the artefact by students Materials needed for making and their quantities listed by students Work distribution within groups listed by students Communication of design to the entire cluster by students
Day 4 **Making**	Actual making of the artefact by students
Day 5 **Evaluation & communication**	Students critically evaluate own products as well as those made by others Students formally communicate their evaluation to the entire cluster

With the structure and implementation of the units in the 3 settings we had a few assumptions and these included:

- Language is a powerful tool to promote collective and individual learning
- Education should provide opportunities for children to develop competent use of language
- Educational experiences may not be adequate to develop language for reasoning

4.5 Unit 1: Bag-making

4.5.1 Learning objectives of the bag-making unit

The bag-making was the first of the three units tried out with students. It was the simplest of the three units that were tried with students and it viewed technology as an artifact. According to Mitcham (1994, p. 161), 'objects/[artifacts] are the most immediate mode in which technology is found to manifest'. A bag is an object of daily use and a common artifact made by students at the school level in the craft classes in the Indian classrooms.

Besides being an object of common use, bag-making also has an advantage in allowing the use of a variety of materials and has relatively less complex sub-tasks involved in it. The pre-requisites of making a bag were less - students needed to have some knowledge of materials, joints, folds, measurements, knowledge of handles/fasteners and strengthening agents. While considering collaboration aspects in the tasks, since making a bag was a relatively simple activity that is, there were relatively less sub-tasks involved in it. The aims and objectives of this unit on bag-making were:

- Exploration of a variety of materials, their properties and functions
- Understanding of joints and folds
- Representation of ideas through drawings and other symbols
- Development of skills of measurement
- Depiction of measurements accurately on drawings
- Calculating the cost price of a product
- Ability to critique their own designs and take appropriate measures to modify or refine their ideas
- Critiquing other's ideas and products

4.5.2 Structure and Implementation

The activities within bag-making unit involved researchers setting a context in which the problem was situated. This context was adapted to suit the needs of rural as well as urban students and both boys and girls. The overall structure of bag-making unit has been given earlier in Table 4.1. The medium of interaction of researchers with the students was same as their medium of school. Table 4.2 sketches out the differences in conducting trials on bag-making across the three settings. This unit was first tried with Urban Marathi students, followed by Rural Marathi students and then finally with students from the Urban English school.

Table 4.2: Bag-making unit across the three socio-cultural settings

Characteristics	Urban Marathi	Rural Marathi	Urban English
Context	Carry 5 given books to a friend's place for a month's time	Carry 5 books and a slate to school everyday	Carry 5 given books to a friend's place for a month's time
Writing exercises	Student were asked to write the types of bags they had come across in their daily lives	The exercise of listing types of bags was done on the blackboard	Student were asked to write the types of bags
Inputs on drawing	Lecture/talk on perspective drawing	Teaching/talk on perspective drawing	Teaching of technical drawing
Teaching measurements	Not planned within the unit but was taken up impromptu on finding out that students were not comfortable with measurements	Measurements planned in the unit and but no exercises taken on it	Measurements planned in the unit and exercises taken on it
Teaching the estimation of cost-price of an artefact	Not taught	Given a basic talk on cost estimation of an article	Not taught
Model making	Practice making paper boats	Model making dropped	Model making dropped
Teaching procedural map making	Explicitly taught to make procedural maps (example tea)	Explicitly taught to make procedural maps (example lantern, with poster/chart of procedural map displayed in the classroom)	Explicitly taught to make procedural maps (example lemon water and chart of procedural map of pinwheel was displayed in the classroom)

Motivation and Investigation

Generally in each of the settings, the unit started with researchers asking questions about familiar events/objects to initiate a discussion and break the ice. In the case of bag-making unit, all students were asked how they usually carried things from one place to another. Students in the 3 settings came up with various words such as: Baskets, purse, suitcase, sack, cargo, trolley, ships, trains, teleporting, *pishvi*, *thaila*, *batwa*, horizontal bags, bags that can be carried on shoulders, cloth bags, leather bags, paper bags, jute bags etc….

We observed that in the Urban English school, students suggested 'modern' ways of transporting things, which seemed to be highly influenced by the media (e.g.: teleporting, trolley). While in both the Marathi medium schools, students came up with 'traditional/conventional' ways of transporting things (such as, sack, jute bags). Apart from ways of transportation, the alternative terms used for 'bag' by Marathi medium students were often traditional such as '*batwa*', '*thaila*'.

The contextualisation of the bag-making unit was through the following design brief: *"If you are to carry 5 books to your friend's house to study for a month, how would you carry them?"*

Students were given time to deliberate within their groups about the best ways of carrying the books. Most groups found bags as solution to the problem given to them but some groups came up with other ideas such as, "leave a set of books at your friend's place", "use the internet to work on [instead of books]" but when another constraint of cost was added, all students thought of bag as the most economic way to carry books.

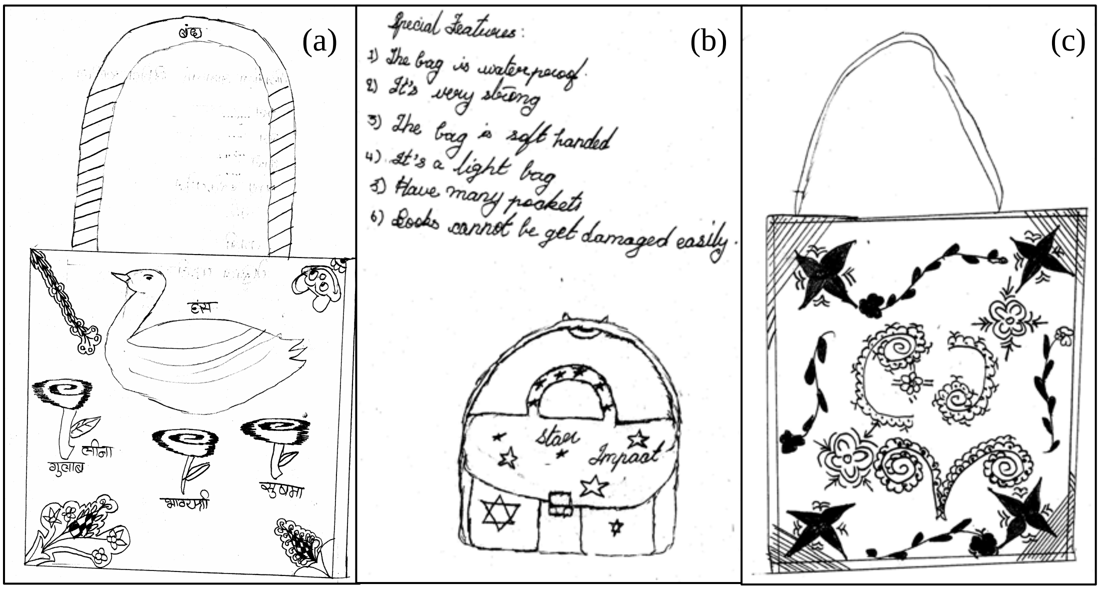
After students in a setting agreed to a solution, each student was asked to list the qualities of an ideal bag and make a drawing. Students had to bear in mind the specifications/constraint of carrying 5 books for a period of one month while making the drawing of their ideal bag. Some of the qualities that emerged from their lists are given in Figure 4.4 and drawings of ideal bags are given in Figure 4.5.

Figure 4.4: Qualities of an ideal bag given by students

Strength (should not tear easily)
Big (must carry those 5 books)
Should be Waterproof
Inner side must have wool (in winter the books do not become cold)
Must be Good to see
Must have a handle (easy to carry)
Should be soft
Should be bad conductor (else would become hot in summer)
Must be light
Should have a good zip (in rains when we walk near puddles water should not splash in to our bag)
Should have pockets (to keep things in place)

During the investigation phase, a variety of bags and pictures of bags were made available to the students to handle. Each student had to even observe bags available in the market and their homes and the specific purposes of those bags, if any. Some of the features of the bag such as how handles were attached, how joints were reinforced, mechanism of support were also pointed out to the students.

Figure 4.5: Drawings of ideal bag by students from (a) Urban Marathi (b) Urban English (c) Rural Marathi settings

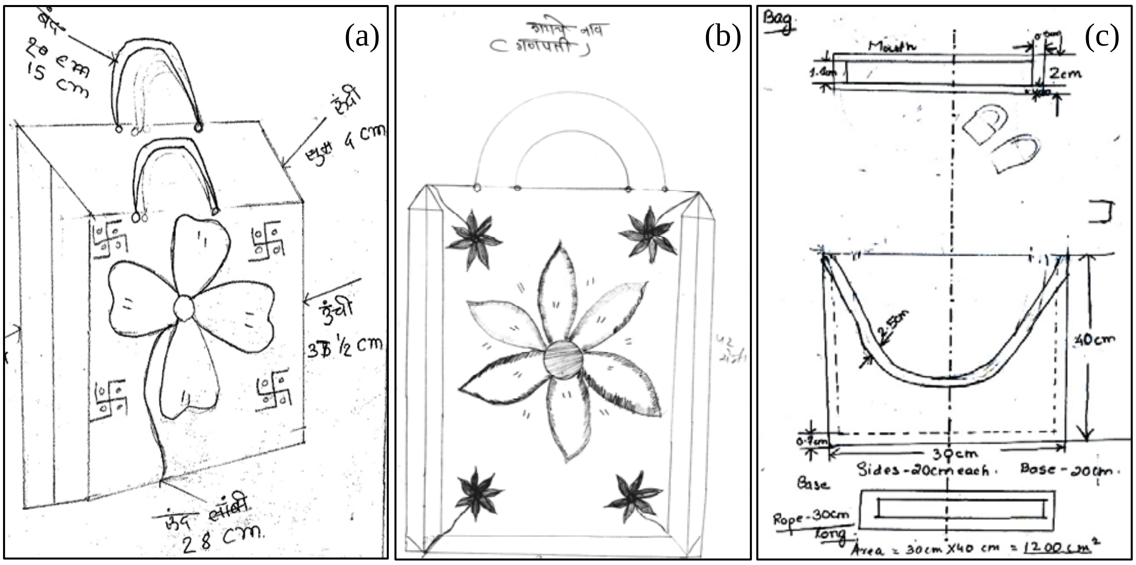


Planning

This phase began by each group choosing one drawing from the 3-4 drawings of ideal bags made by members of the group. The group members negotiated the drawing and made modifications in the chosen drawing to suit the purpose of carrying 5 books for a period of one month. Then the students were asked to show the front-side and back views of their bag in the drawings.

Planning phase included, researchers or experts giving formal training and practice to the students in making technical drawings, taking measurements, marking measurements on drawings and drawing objects from various angles. Once the students had had some practice, we asked them to make a drawing of their group's bag with its measurements. We observed that only groups from the Urban English setting who were taught to make technical drawings were able to make drawings with measurements using the conventions of leads, arrows and end points (Figure 4.6 c), where as the groups from the Marathi medium settings could not show measurements following the conventions (Figure 4.6 a and b). However, depiction of perspective in their drawings seemed difficult even for Marathi medium groups (both urban as well as rural) where it was formally taught, as can be seen in Figure 4.6 (a).

Figure 4.6: Examples of Technical drawings made by students from (a) Urban Marathi (b) Rural Marathi (c) Urban English settings



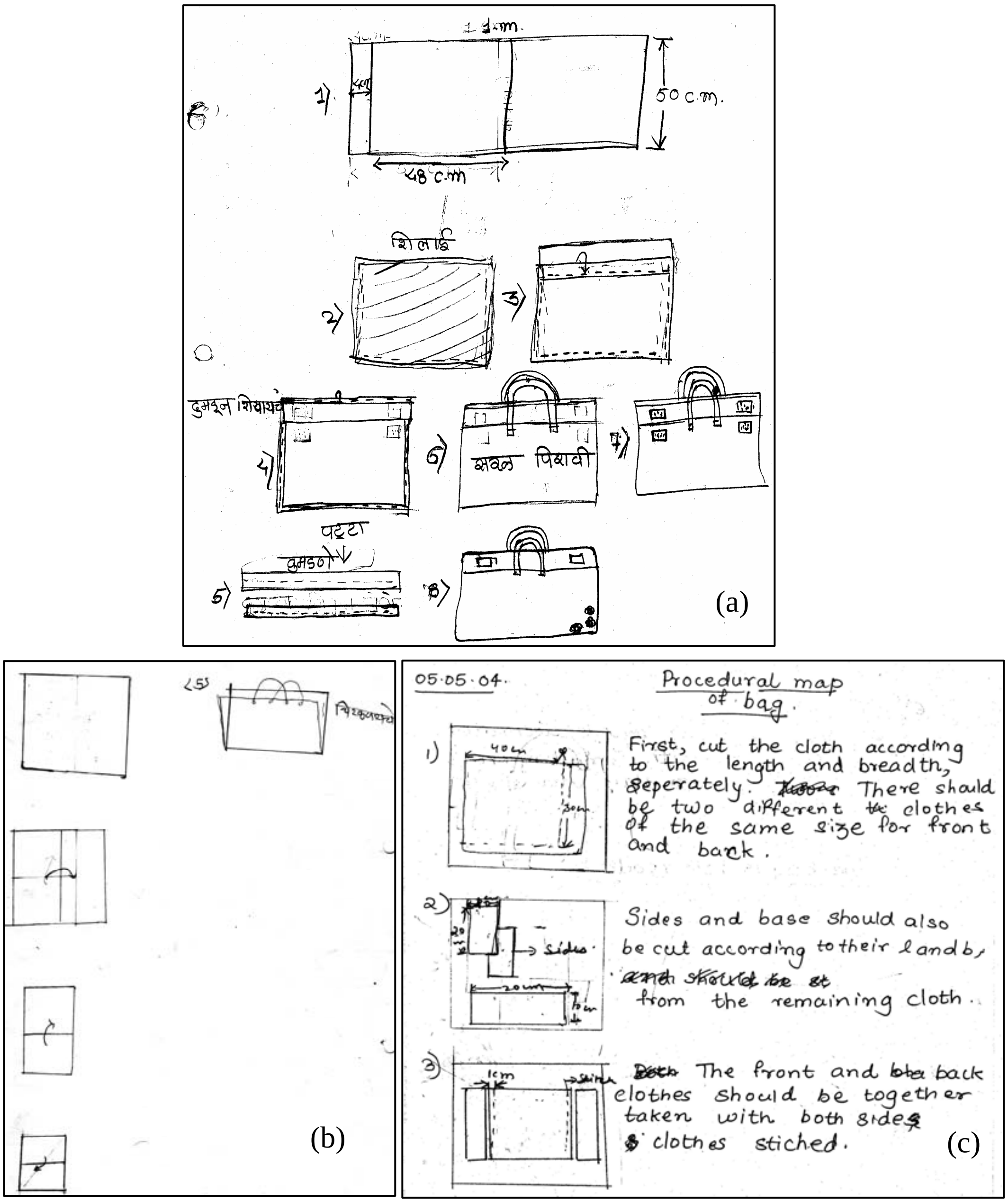
Designing and communication

According to Ritchie (2001, p. 65) ‘designing requires students to be reflective about their ideas and those of others, apply their previous experience and knowledge and suggest achievable ways forward.’ It is not necessary that the designing phase of the activity comes before making, rather it pervades through the entire unit and involves ‘imaging’ or seeing in the mind’s eye and then constructing it concretely (Archer, 1980). Communication - oral, written, graphic- forms an important part of this phase.

Designing, in our bag-making unit predominantly came in /happened on the third day of the trial. During this phase some formal inputs were given to the students and these included how to make a ‘procedural map’ (step-by-step procedure). Examples of steps involved in preparing tea/ lemon-juice/lantern were used to explain how a procedural map is made. Students were encouraged to use both writing as well as drawing to show various stages of making.

After having explained them how to make a procedural map, groups were asked to make a procedural map for their bags, which required them to anticipate the steps of making. A variety was seen in students’ procedural maps also. Some groups made drawing as well as wrote the steps involved in making the bag (Figure 4.7 c), whereas in some groups students preferred to show the procedural map by drawing that were marked (Figure 4.7 a). In rural Marathi setting, most groups did not make well-annotated drawings and were often incomplete (Figure 4.7 b).

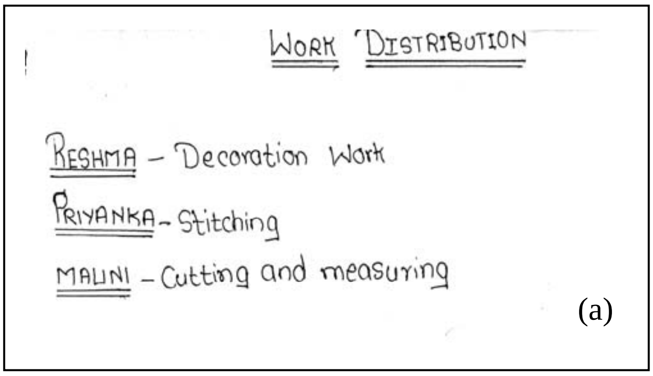
Figure 4.7: Procedural maps by students from: (a) Urban Marathi (b) Rural Marathi (c) Urban English settings



After having made the procedural maps, students were asked to divide the work within their groups (work-distribution list) and also make a list of materials that they would need for making their artifact and their approximate cost (Figure 4.8). Work distribution written by groups was often very superficial, work was divided based on the steps involves such as, ….will do measurements, ……- stitching, …..-

cutting,……-decoration….” (Figure 4.8 a). But while actual working, students within groups took up tasks that were either given to them or what they chose to do depending on their skills. Students did not adhere to their material list very strictly and often asked for/took materials that were not mentioned in the list or did not use all materials that they had asked for- may be their reflection on problem solution made them rectify their design.

Figure 4.8: Bag-making unit (a) Students’ work distribution list (b) Group involved in making


WORK DISTRIBUTION

RESHMA – Decoration Work

PRIYANKA – Stitching

MALINI – Cutting and measuring

(a)


(b)

Groups after having designed their bags, presented their design to the entire class who could question them and ask for explanations and the group presenting had to defend their designs or give explanations or modify them. In some presentations, it appeared that for some students this was the first time that they were making a public/formal presentation. This was especially true for students from the rural school. Most of the communication was restricted to reading what the groups had written with lots of emphasis on aesthetics.

During the designing phase, we also tried to give some inputs on costing - how to include the cost of one-time use items and reusable items. But in their subsequent writings/communication, we observed that they had not understood the idea of costing and therefore had just given arbitrary numbers for the cost of their bags. The concept of profit and loss was also not well understood by most students, which was reflected in their evaluation sheets- students somehow contrived to get profits.

Making

'Making' is considered the final expression of the design solution (Kimbell et al., 1996) and leads to the production of an outcome or reality. Making provides an opportunity for students to engage with materials and manipulate them and thus learn about them. Once the groups had finalized their designs, we provided them the materials that they had listed in their work procedure. There were extra materials also available to the students that they could use. The making activity lasted for 2-3 hours.

During making we observed that most groups made paper bags and decorated them with either '*rakhis*' or sketched some deign on it and filled it with sketch pen colours. There were some groups that made cloth bags and only one group made a paper bag and lined it with cloth. Either mixed-sex groups or single-sex girl's groups generally made the cloth bags. Cloth bags were decorated by sticking laces and flowers or by making some patterns on it by sketch pens. We observed that students did not refer much to their designs and made their bags according to their convenience and availability of materials. Fleer (2000) and Hope (2000) have reported weak links between children's design plans and making and suggest insufficient technical knowledge and insufficient detail in plans as possible reasons for them not referring back to their designs.

There were often differences in the dimensions of their bag from the one that they had planned. Even the work distribution that was planned was not followed; ultimately the members were allotted/chose to do tasks according to their skills. In mixed-sex groups, often girls opted for sewing tasks while boys took measuring, cutting and pasting tasks and in the single sex groups also work was not divided equally- usually the person who dominated the group did the major tasks while others were his/her helpers.

There were differences in the quality of bags made across the settings. The cloth bags made by the rural students had better (stronger) and neater stitching as compared to bags made by urban students and the designs made on them were inspired by nature (of trees, flowers etc). In the bags made by urban groups, cellotape, fevicol, glue were used liberally, which at times substituted stitching. The variety of handles made by students were limited- most of them used '*nara*' drawstring for making the handles - some groups braided 3 strands of it to achieve strength, while others used pieces of cloth for making the handles.

During the making phase, we also observed that groups tended to spend a lot of time on decorating their bags, often at the cost of its intended functions, example: in some groups, the joints of the bag were weak while it was highly decorated. The bags made by students from the rural school were more decorated and glittery as compared to bags made by students from urban schools. In terms of durability and strength, the bags made by the rural students surpassed those made by the urban students.

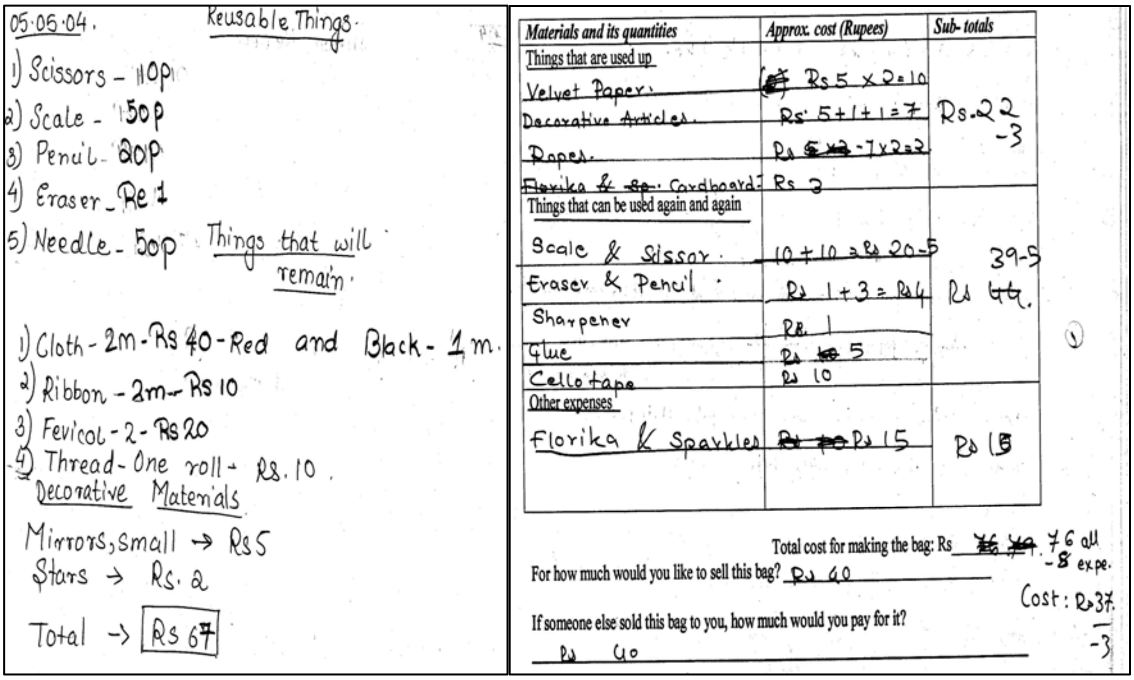
Evaluation and communication

Students often need to be encouraged to look critically at their work and also the work of their peers (Ritchie, 2001). This critical look or evaluation in D&T tasks allows students to make judgment about the product/artifact in front of them or reflect on the strengths and weakness of the product and the process of making it. Evaluation in our units was not just a summative one, instead it happened at various phases of the unit, but formal evaluation took place after making the bags. During formal evaluation groups evaluated their own group's product (attached in Appendix I) as well as product made by another group using a semi-structured evaluation sheet (attached in Appendix J- other group).

The semi-formal evaluation sheet had both open-ended and close-ended questions pertaining to physical aspects of the bag as well as its properties such as durability, strength, usefulness etc. The open-ended questions of the evaluation sheet expected students to reflect on the making process and compare their created products with the one planned by them along the following pointers: size, shape, weight it can carry, time it is expected to last, materials used for making it and its decoration. Other questions that were asked in the evaluation sheets related to students' ideas for improving their bags; issues related to its economics (costing) and the possible uses of their group's bags. The close-ended questions asked the students to rate their bags on strength, usefulness, durability, looks and the seasons in which it could be used. The evaluation sheet on which student had to evaluate other group's bag was also structured similarly.

There were open- ended questions on the use and costing of the bag (as can be seen in Figure 4.9) while the close-ended questions were similar to the ones in the self-evaluation sheets. Students were good at appreciating other's work as well as their own group's work during presentations. The groups presented the negative aspects of other groups' work in a very diplomatic way- shrouding them in many praises and often also suggested ways to correct the problem. The analysis of student's responses on these questionnaires is discussed in chapter 6.

Figure 4.9: Costing of bag by one of the Urban English groups

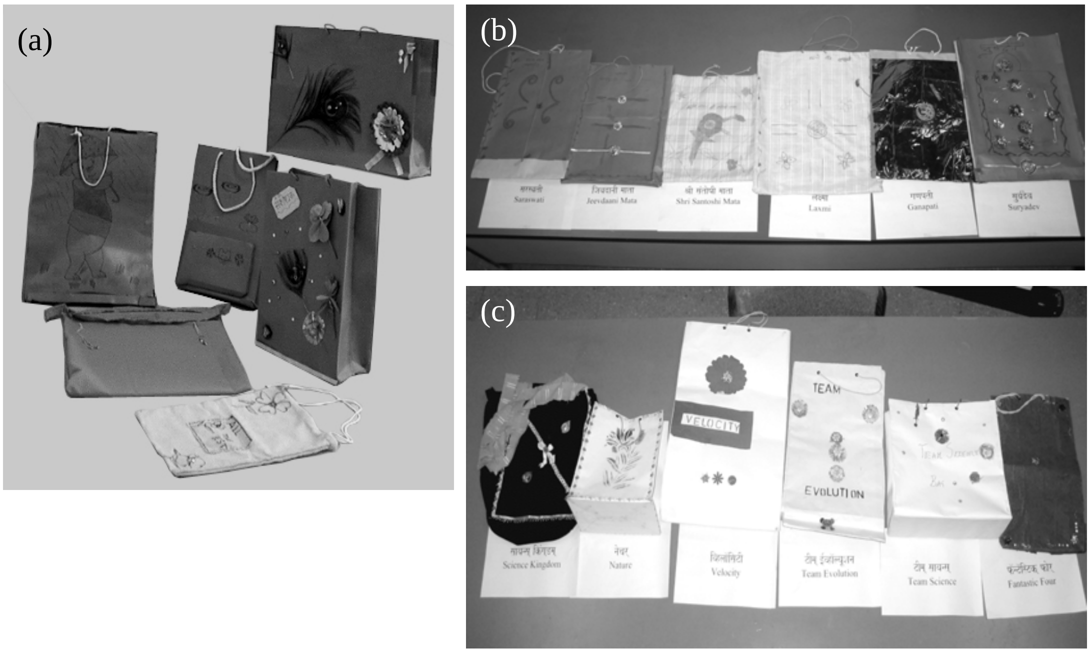

05·05·04. Reusable Things.
1) Scissors – 10p
2) Scale – 50p
3) Pencil – 20p
4) Eraser – Re 1
5) Needle – 50p
Things that will remain.
1) Cloth – 2m – Rs 40 – Red and Black – 1 m.
2) Ribbon – 2m – Rs 10
3) Fevicol – 2 – Rs 20
4) Thread – One roll – Rs. 10.
Decorative Materials
Mirrors, small → Rs 5
Stars → Rs. 2
Total → $\boxed{\text{Rs 67}}$

Materials and its quantities	Approx. cost (Rupees)	Sub- totals
Things that are used up		
Velvet Paper	Rs 5 x 2 = 10	Rs. 22 -3
Decorative Articles	Rs 5+1+1 = 7	
Paper	Rs ~~5x2~~ 1x2=2	
~~Florika & sp.~~ Cardboard	Rs 3	
Things that can be used again and again		
Scale & Sissor	10+10 = Rs 20-5	39-5 Rs 44.
Eraser & Pencil	Rs 1+3 = Rs 4	
Sharpener	Rs 1	
Glue	Rs ~~10~~ 5	
Cello tape	Rs 10	
Other expenses		
Florika & Sparkles	~~Rs 10~~ Rs 15	Rs 15

Total cost for making the bag: Rs ~~86~~ ~~49~~ 76 all -8 expe.
For how much would you like to sell this bag? Rs 40
Cost: Rs 37. -3
If someone else sold this bag to you, how much would you pay for it?
Rs 40

During communication of product, students once again were mainly critical about the aesthetic aspects of the bags but on some facilitation/guidance they could critique the products fairly well, in fact some of the points raised by them during the formal communication lead to rich discussions among the group members. Figure 4.10 is a picture of bags made by students from all the settings.

Figure 4.10: Bags made by students from the 3 settings - (a) Urban Marathi (b) Rural Marathi (c) Urban English



4.6 Unit 2: Making a working model of windmill that could lift given weights

4.6.1 Learning objectives of the windmill unit

The unit on windmill was the second unit that we tried with the students. Making a working model of windmill that could lift some weights had system's approach to technology. System's approach to technology involves looking at a set of objects/actions united by some form of interaction or interdependence to perform a specified function (Andrews, 2001). Making a working model of windmill, involved working on many of its sub-parts, which were complex and required more mental and physical labour by the participants than the previous unit on making a bag. Windmill is an object of social use rather than an individual one, as was the case in the previous unit on bag. Windmills, one of the early non-human sources of power were originally used for pumping water and grinding cereals (Kumar, 2004). It is a machine/object that we thought would be familiar to most students involved in the trials. Though, India did not pioneer in the use of windmills but of late there seem to be some concern about harnessing natural energy. Therefore this unit on windmill served as platform for making the students aware of some social issues as well as a few scientific principles involved in its working.

For the unit on windmill, the overall structure of the unit remained more or less the same as the previous unit but the differences lay in its aims and content. This unit had its theoretical base in the concepts of force, weight, environmental issues such as energy conservation that are usually taught in middle/upper primary school science and it differed from the previous unit in viewing technology as a process of making and using (testing). The main objectives of this unit were:

- Getting students to realize the potential of everyday technology
- Getting students aware of the types of windmills
- Exposure to the history of windmill and appreciation of its implications on society
- Functions of windmills
- Exposure to variety of materials, their properties and uses
- Exposure to variety of tools and their usage
- Evaluation of one's own product based on experiments and the criteria provided
- Evaluation of other's product.

4.6.2 Structure and Implementation

The general structure of the tasks over a period of 5 days for each of the unit is given in Table 4.1. The distinguishing feature of this unit was that it was contextualized in such a way that it started with a toy that children were familiar with and then was extended to a real windmill. The phases in the unit remained the same as the previous unit, viz: Motivation and investigation, planning, designing and communication, making and finally evaluation and communication. During the trial, student worked in groups of 3-4 members each. The unit was adapted slightly across the 3 socio-cultural settings and these changes have been enumerated as shown in Table 4.3.

Table: 4.3: Windmill unit across the three socio-cultural settings

Differences	Urban Marathi	Rural Marathi	Urban English
Language used in the class	Mainly Marathi	Marathi	Mainly English, but Hindi was used of informal communication among students
Inputs for technical drawing	Making technical drawings taught to them during the unit	Were taught to make technical drawings before the unit began	Were taught before the previous unit
Teaching the estimation of cost-price of object	Given a simple exposure on how to estimate the cost-price of an article	Given a simple exposure on how to estimate the cost-price of an article	Were taught before the previous unit
Making a small model such as a pinwheel	Was done before motivation phase	Was done after motivation phase	Was done before the motivation phase
Succession of this unit	Trials for this unit took place after a gap of about 8 months of bag-making unit	Trials for this unit took place after about a gap of 7-8 months	Trials for this unit took place immediately after bag-making unit
Testing	Done immediately following making	Done when the students visited our Centre in Mumbai as there was acute shortage of electric power supply in the school area	Done immediately following making

Motivation and Investigation

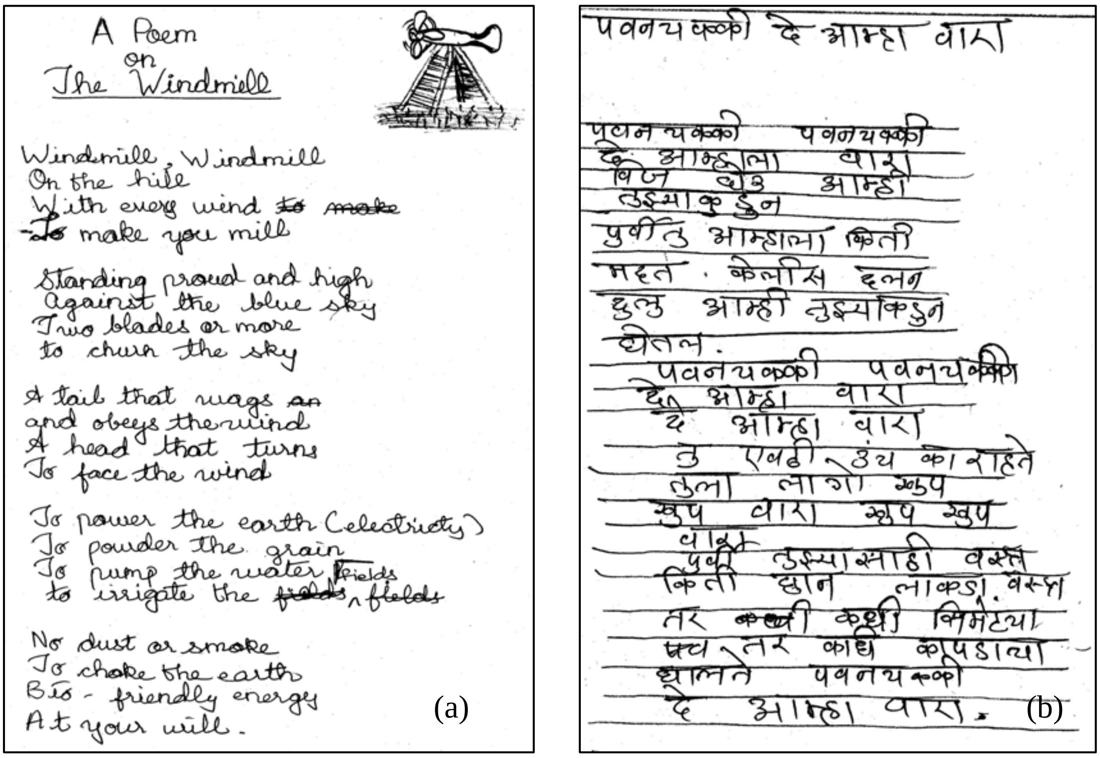
The unit started with researchers setting the context by asking the students if they had ever been to a fair and what all had they seen there. This got all the students in the class involved and they listed a number of things such as games, food stalls, rides, swings, *firki* (pinwheel) etc. This was something that was done orally with all the students and this helped us to ensure that all students were aware of the object that we were going to discuss- the pinwheel.

In order to take the discussions further, we asked each group to make a pinwheel for which a poster of procedural map was put up in the classroom for reference. We observed that most students knew how to make the pinwheel using paper, drinking straw and a common pin. After all the groups had made object, we asked each student to draw its front and side views. This exercise gave them a practice in making a perspective view of a familiar object as well as encouraging them to explore the object more carefully. After making the pinwheel students were asked to come up various words for a pinwheel, (what was a pinwheel known in their native language?). The words that students came up from the 3 setting were: *Hawai-chakra (*wind-wheel*), Gol-firnara chakra* (wheel that rotates), *Firnaari chandani (*moving star-like disc*), Rang chakra (*colour wheel*), Firki (*pinwheel), *Pambheri* (Punjabi), *Kataadi* (Malayalam), *Hawachakri* (Bengali).

The idea of a toy pinwheel was then used to contextualize the D&T task by narration of a story in which a pinwheel had picked up a feather accidentally and the characters of the story used the same analogy to solve the problem of lifting groundwater for which they needed to make a pinwheel-like arrangement that could raise water to the required height. Now the task put in front of our students was how to make a pinwheel strong enough to lift some weight.

During this phase, which lasted for about 3 hours, students were explained the structure and function of various parts of the windmill and were exposed to some historical information on windmills through photographs and video clips. Students were also encouraged to write poems/paragraphs on a windmill. Two poems written by students are given in Figure 4.11. The functional aspects of windmill have been highlighted in both the poems written shown in 4.11 (b), but in 4.11 (a) functions of the windmill have been described along with its structure.

Figure 4.11: Poems written by students of (a) Urban English (b) Rural Marathi schools on windmill



A Poem
on
The Windmill

Windmill, Windmill
On the hill
With every wind ~~to~~ ~~make~~
~~To~~ make you mill

Standing proud and high
Against the blue sky
Two blades or more
to churn the sky

A tail that wags on
and obeys the wind
A head that turns
To face the wind

To power the earth (electricity)
To powder the grain
To pump the water fields
to irrigate the ~~fields~~ fields

No dust or smoke
To choke the earth
Eco - friendly energy
At your will.

(a)

पवनचक्की दे आम्हा वारा

पवनचक्की पवनचक्की
दे आम्हाला वारा
विज घेऊ आम्ही
तुझ्याकडुन
पुर्वी तु आम्हाला किती
मदत केलीस दळन
दळु आम्ही तुझ्याकडुन
घेतलं.
पवनचक्की पवनचक्की
दे आम्हा वारा
दे आम्हा वारा
तु एवढी उंच का राहते
तुला लागो खुप
खुप वारा खुप खुप
वारा
पुर्वी तुझ्यासाठी वस्तु
किती छान लाकडी वस्तु
तर कधी कधी सिमेंटच्या
तर काही कापडाच्या
घालते पवनचक्की
दे आम्हा वारा.

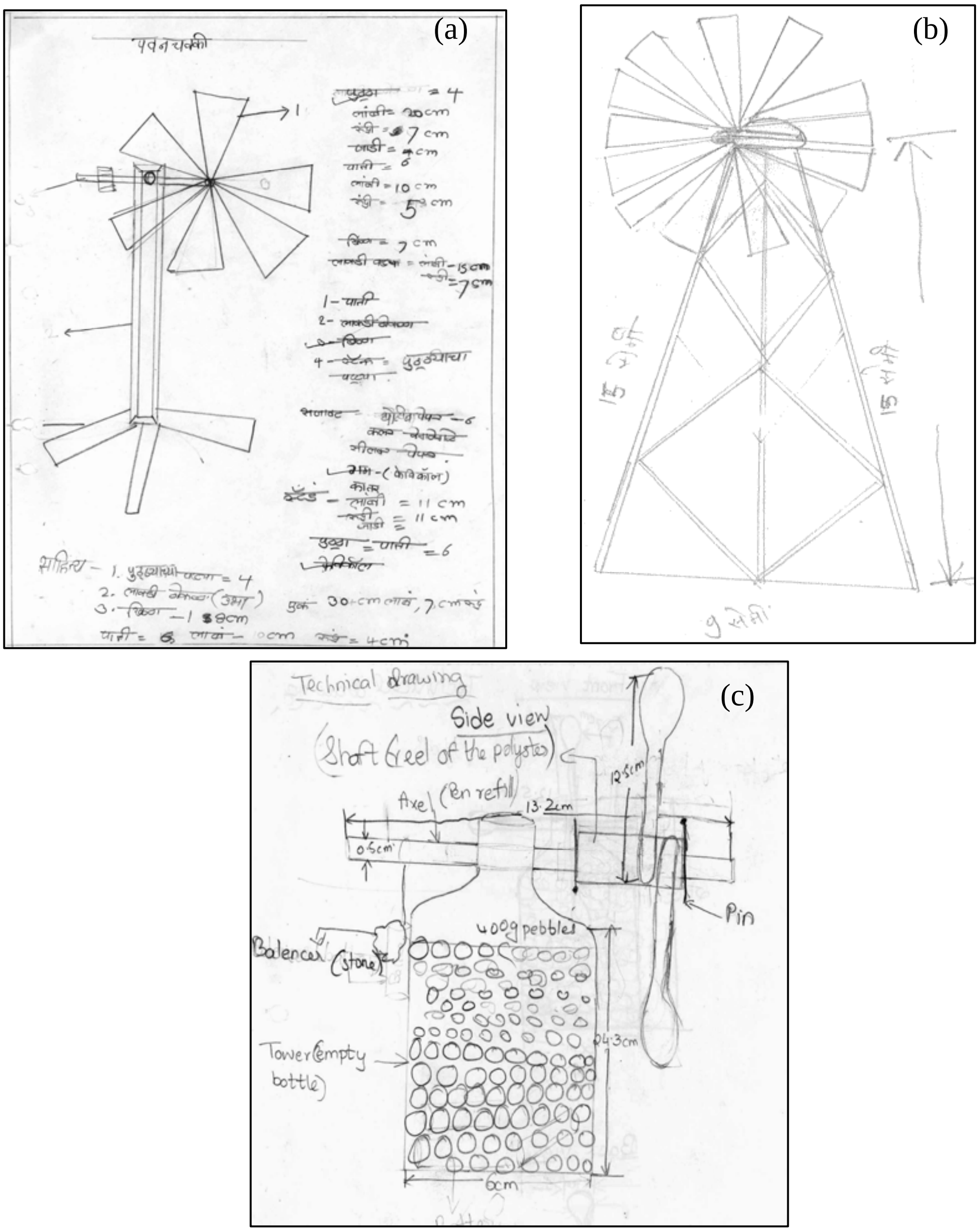
(b)

Planning

On the second day, the task was again told to the students and they were asked to draw a windmill that could actually lift some weights. This was a group task. After the groups had made their designs, they were asked to modify it, if they wanted and be sure that it could lift some weights. When groups were sure of their designs, they were asked to make technical drawing of the windmill that their group would make. At this stage, students from the Urban Marathi setting were exposed to the role and significance of technical drawings (the other groups had already been given this exposure). During this task, we observed that there were lots of interactions among group members in finalizing the design. For this unit, the technical drawings made by groups were more detailed as compared to the drawings made in the bag-making unit. In the technical drawings, students tried to show various components of the windmill along with their dimensions, such as tower, shaft, vanes, axle and its assembly.

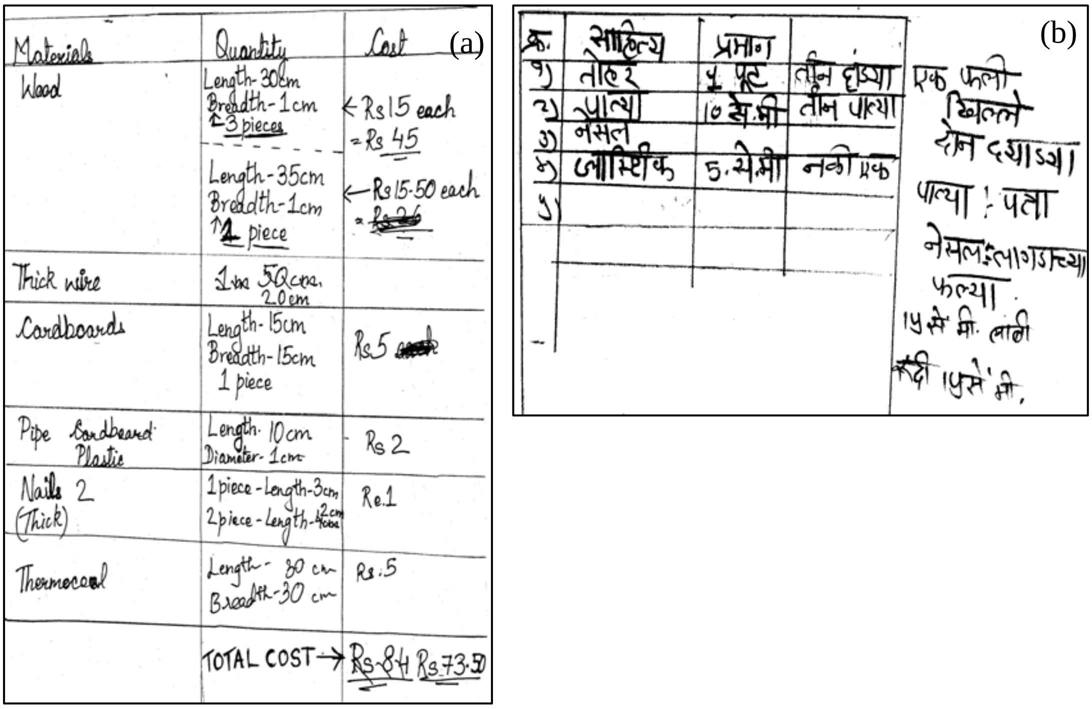
Examples of students' technical drawings are given in Figure 4.12. There was a variety in technical drawings that groups came up with- some groups showed both the front and the side views, while some groups drew only one view. While most groups, followed the conventions of leaders and arrows, but some drawings had more details on them as compared to others- example the technical drawing shown in figure 4.12 (c) has more details as compared to figure 4.12(b).

Figure 4.12: Examples of technical drawings of windmill made by students from (a) Urban Marathi (b) Rural Marathi (c) Urban English settings



Once the groups had finished making their technical drawings, they were asked to make a list of materials along with their quantities for making their windmills. This was done so that researchers could get an idea of the materials needed by the students and get them ready for making. Students were also asked to estimate the cost of making their windmill model. Figure 4.13 gives an example of a group's work on a material list and the estimated cost of their group's windmill.

Figure 4.13: List of materials required by groups for making windmill (a) Urban English (b) Rural Marathi setting



(a)

Materials	Quantity	Cost
Wood	Length-30cm Breadth-1cm 3 pieces	←Rs15 each = Rs 45
	Length-35cm Breadth-1cm 1 piece	←Rs15·50 each = ~~Rs 26~~
Thick wire	1 m 50 cm, 20 cm	
Cardboards	Length-15cm Breadth-15cm 1 piece	Rs5 ~~each~~
Pipe Cardboard Plastic	Length 10cm Diameter-1cm	Rs 2
Nails 2 (Thick)	1 piece - Length-3cm 2 piece - Length-2cm	Re.1
Thermocol	Length- 30 cm Breadth-30 cm	Rs.5
	TOTAL COST→	Rs 84 Rs 73.50

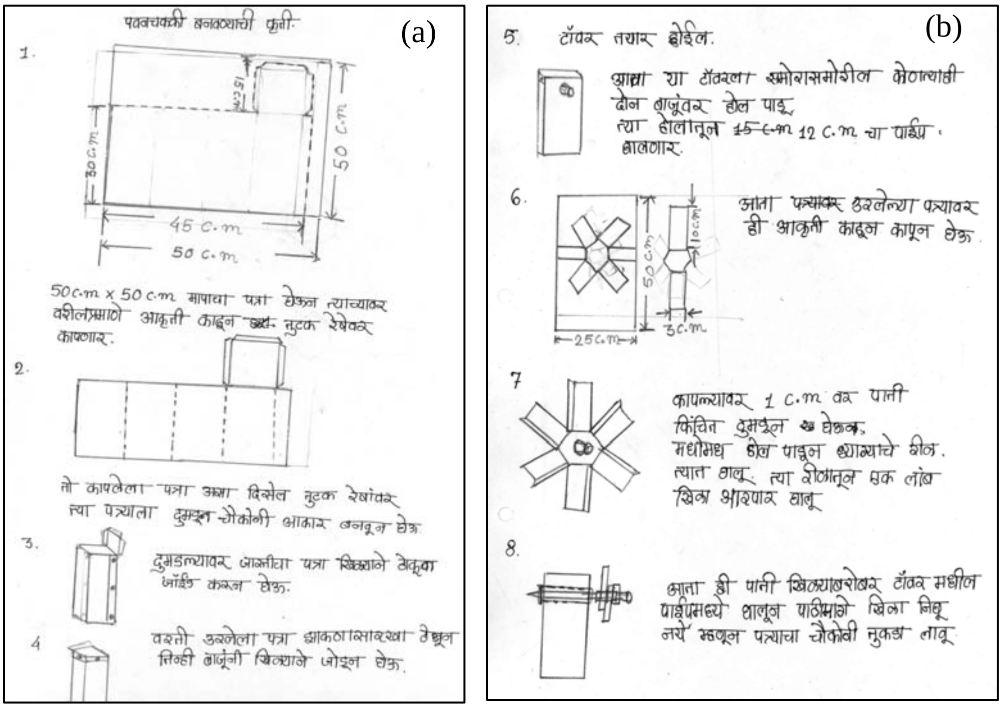
(b)

We observed that in most cases, all the materials asked for the groups were not used for making their model and also they often used materials that were not mentioned in their list. Preferences of materials asked by urban and rural groups were typical. Rural students mostly asked for wood and tin foil while in the list of urban students materials like Styrofoam, fevicol, plastic and metal containers etc were asked.

Designing

Once the students had made technical drawings of their products, they were asked to anticipate steps in making their working model of the windmill and make a procedural map of it (Figure 4.14). As in the previous unit, they were asked to think about and write down the work distribution within the group. This was done to ensure that all members of the groups were involved in the task and that no one person was dominating the making process. These sub-tasks provided an opportunity of task-analysis to the students at their level in a meaningful context. Once the students had finalized their designs, they communicated it to others in the setting, who could question them or provide them feedback, which the groups incorporated in their designs, if they were convinced about it.

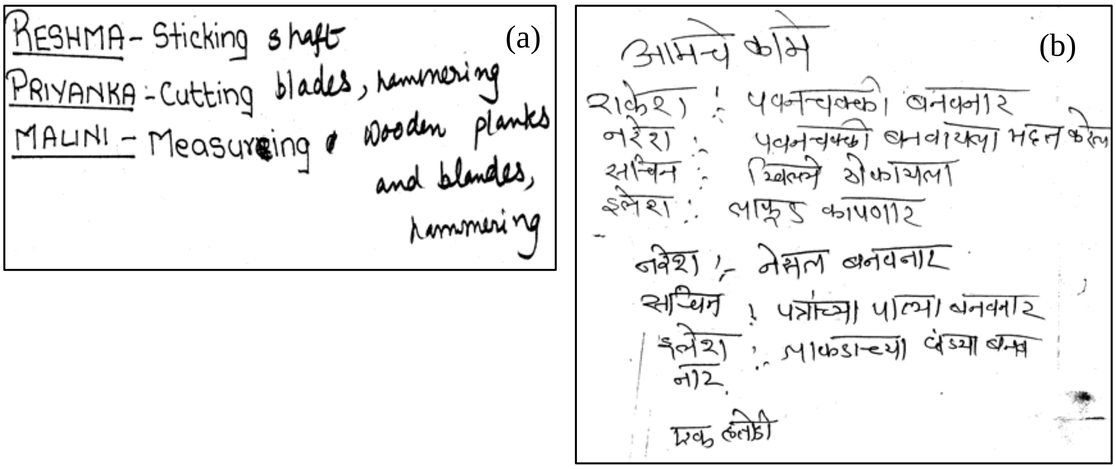
Figure 4.14: Example of a complete procedural map of windmill made by a group from the Urban Marathi setting



Our general observation was that drawings in the procedural maps drawn by the groups were sketchier as compared to their technical drawings, with fewer technical details (Khunyakari et al., 2007). A variety of icons such scissors, ruler, glue bottle etc, were used by groups to show the detailed actions of making in the procedural maps.

In most groups the work distribution lists indicated that the work was not equally divided between group members. Students tended to divide the work either in terms of specific tasks (such as sticking, cutting, decoration etc) (Figure 4.15 a) or in terms of making parts of the windmill (vanes, tower, axle) (Figure 4.15 b).

Figure 4.15: Work distribution according to (a) Specific tasks (b) Specific tasks + Parts of the windmill



Making

This phase actually involved students working on the model of the windmill. During this phase, students were involved in a lot of activities related to making their model. For most students, it was a first time exposure to various tools and equipments such as drill machines of various sizes, hacksaw, clamps, hammer. While the students were at the task we observed that the students were not strictly involved in doing only those tasks as were listed by them in the previous step. Also, students rarely referred to their designs while they were making the windmill and the end product often turned out to be quite different from what was planned. Figure 4.16 shows students involved in making their models.

In the rural Marathi setting, most groups made windmills with wooden towers that were about 10-12 inches high. Most of the tower structures were sturdy. The vane assembly was typically made using plastic (PVC) pipes, sketch pen body/cover while most groups made vane of tin foil or card paper. In the urban setting, there were variations in tower material and design- apart from towers made of wood, plastic bottles filled with pebbles, metal boxes filled with sand, metal foil with pebbles were also used for tower. The vanes were either made of tin foil or card paper or cardboard. In both the rural as well as urban settings, models were decorated with coloured paper.

Figure 4.16: Students involved in various stages of making windmill (a) Urban English (b) Urban Marathi (c) Rural Marathi settings

Evaluation and communication

After the groups had finished making their windmills, they tested their models' efficiency by placing it at various distances from an artificially created source of wind (blower) and then seeing the amount of weight that it could lift and the number of rotations made per minute. They recorded these observations on a semi-structured evaluation sheet (attached in Annexure K). Apart from the weight that the windmill could lift, there were other parameters on which groups had to rate their windmill such as its length, dimensions of its blades, its aesthetic aspects. Once the groups had evaluated their own products, they evaluated the products made by other groups and then communicated this evaluation to others in the class (evaluation sheet attached in Annexure L). Groups in the rural Marathi settings could not test their windmills because of the shortage of power supply in the school area. They tested their models when they came to our Centre for an exhibition and also to meet their peers in the urban setting.

The aim of these evaluations was not to create competition among groups but rather to help students learn the art of genuine critiquing and be able to see the positive and negative aspects of their group's model. Communication helped researchers and students to build a shared understanding with other students in the class through the freedom provided in expressing their thoughts in any language that they were comfortable with. Figure 4.17 shows the windmills made by students from the 3 settings.

Figure 4.17: Windmills made by students from the three settings

4.7 Unit 3: Making a puppet and collectively putting up a puppet show

The puppetry unit represents a systems approach to technology, with groups of students making puppets and putting up a puppet show using the puppets made by all the groups. We structured the units for students to work collaboratively, where students shared a goal and were held together with a common sense of purpose. This was the third and the final unit that we tried out with students from all the three settings.

We selected puppetry as a unit for technology education for various reasons. It introduces several levels of collaboration among students and teachers, most of whom are familiar with puppet shows. Puppetry draws on the experiences of both boys and girls, in rural and urban areas, and requires diverse skills to make a puppet and put up a show. Our initial ideas of a D&T unit on puppetry were strengthened by our visits to an exhibition on puppetry and to puppet shows.

Puppetry is one of the most ancient forms of entertainment in the world (Kamat, 2000). India also has a rich heritage of puppetry dating back to around the 5th century B.C. The early puppet shows in India mostly dealt with histories of great kings and heroes, political satire and events from mythological and historical epics. The various kinds of puppets across the country include shadow puppets, glove puppets, rod/stick puppets and marionettes.

Besides providing entertainment, this visual art form is also used for conveying meaningful messages. Over the years, puppetry has developed into a powerful media of communication. Puppetry is a form of art that unites craftsmanship and design with drama and is essentially a dramatic art, in which puppets are made to be actors (Contractor, 1984). Techniques such as rhythmic movement, pantomime and play making with dialogue and action can be combined with puppetry to make it a practical and expressive art in education.

Children engaged in puppetry can develop imagination and creative thinking and it can be of great help for teachers. Teachers could view puppetry and other forms of theatre as a classroom resource that is complementary to other pedagogies employed. It allows teachers to comprehend the sociological dynamics that operate within the classroom and their impact on learners' knowledge skills (Singh, 2004). The use of puppetry in education offers a method of 'learning by doing' wherein there is communication of ideas.

Puppet making is a suggested activity in the art and craft curriculum followed by most Indian schools. However, it is a recipe-based activity, with all students in a class making identical puppets without a context. In contrast, making puppets not only allows for exploration of materials, forms and colours, it has an inherent flexibility to place it in the context of the students, integrating local socio-cultural aspects. Its dependence on and richness of context could appeal to students from different strata of society and to both girls and boys. The unit allows students to innovate, stimulate and communicate ideas to others in an environment that is non-threatening. The details of methodology of puppetry unit have been published as a chapter of a book (Mehrotra and Khunyakari, 2007).

4.7.1 Learning objectives of the puppetry unit

Puppetry as a D&T unit is connected to other school subjects. Apart from the obvious link with theatre, dramatics and art/crafts, it involves developing linguistic skills through dialogue writing for the puppet show and the discussions on product designs, procedures and evaluations, while making as well as after completing the product. We discussed with students ideas about human body joints and movements, body symmetry and proportions, gestures, dress codes, etc., which are topics in biology and social-studies curricula. Students were encouraged to think about regional/geographical similarities and differences in dress, habits and speech patterns and their life-style (culture). Students needed to pay considerable attention to measurements while designing the puppet and this helped students learn to make estimates, learn about scale and representation of measurements in drawings. The unit was thus interdisciplinary and gave students an opportunity to apply their knowledge. Besides students had to use their social and personal skills while sharing resources and space. The objectives of this unit on puppet making for student learning of knowledge and skills can be summarized as follows:

- Familiarization with making human-like puppets
- Understanding how movements (of limbs and puppets) occur
- Understanding human symmetry and body proportions
- Developing a story with constraints of number of characters and depicting the characters
- Representing ideas through drawings
- Representing measurements using standard conventions
- Exploring different materials and evaluating their feasibility for use in making puppets
- Communicating through writing and speech
- Using critical thinking

- Working collaboratively to bring about productive outcomes
- Putting up a stage show
- Appreciating other people's work
- Evaluating one's own and others' activities and products

4.7.2 Structure and Implementation

The activities involved conceptualizing a story with 6 characters for 6 groups, writing the story, selecting a character, and developing its role in the story, designing a puppet for the character, making a glove puppet (constraint), and finally putting up a puppet show. It included finding out about various types of puppets, their movements, making the puppet look and speak in culturally appropriate ways and the overall presentation of the puppet. Students were responsible for all aspects of the puppet show, from making props, to setting up the stage, lighting arrangements, background music, script and dialogue writing as well as narration. This involved collaboration which, 'is a ubiquitous part of life, found in the laboratories, the military and the classroom' (Hausmann et al., 2004, p. 547), by the students and their taking complete responsibility for the final production.

We adapted the DMA approach to integrate opportunities for formal and informal communication, structured and unstructured paper and pencil productions and for collaborative working. The structure then included the following phases in the puppetry unit: (i) Motivation and student investigation, (ii) designing, planning to make and communicating the plan, (iii) making and (iv) product evaluation and communication and (v) designing the show and staging. Our experiences in conducting the five phases in the three socio-cultural settings are recounted below as a temporal presentation of our observations during the conduct of the unit. We do not intend to compare the classes or groups in the three settings.

Motivation and Investigation

In this phase, which took about 3 hours, the goal of the unit, namely making puppets and staging a show, was contextualized through discussions and investigations. We had a discussion with the students on different kinds of puppets, followed by students handling actual string, hand/ glove, and stick puppets in animal as well as human forms. The different groups then wrote a story each. After communicating the stories to the class, the groups chose one of the stories for the puppet show. Appendix O gives the stories selected for the show in each of the settings. Each group selected a character from this story, wrote its character sketch and also made a drawing of the chosen character. The drawing and the character sketch were communicated to other groups and modified based on feedback.

The investigation phase was initiated with a discussion on stage shows. Soon students themselves mentioned puppet shows. When students tended to digress, we helped to focus on the essentials of a stage show and the various words for puppets. In order to develop students' language skills through multiple terms and similar words, we asked students to provide us with different words for “puppet”. They came up with a variety of words such as: “*Kathputli* (string puppet), *Bahuli* (doll), *Haath bahuli* (glove puppet), *Cartooncha khel* (play of cartoons), *Halnarya bahuliya* (moving dolls), *Cell var chalnarya bahuliya* (battery operated dolls), Robotic puppets, Dummies….”

Students generally took turns at handling the puppets provided by us for investigation; but some groups attempted to grab each other’s puppets. Figure 4.18 is a picture from the urban English setting showing a student handling and investigating a puppet. The next task for the six groups was writing stories with 6 characters and presenting their stories to the class. We suggested that the selected stories should have a gender balance in the characters. Students unhesitatingly wrote and narrated their stories. Most groups wrote familiar stories, and some even rewrote stories from their textbooks. The stories were fairly detailed in terms of character and scene descriptions and some of them even had complex plots. After all the groups presented their stories, students were asked to select one, which they would stage as a puppet show. In both the Marathi medium settings, a consensus on the story was achieved almost immediately in the class; but the groups in the Urban English setting could not reach a consensus and each group wanted its story to be selected. We often had to intervene in resolving disputes among groups in this setting.

Figure 4.18: Students from Urban English setting handling a puppet during investigation phase

The story decided for the puppet-show by Urban English setting was an adapted version of the story, *Snow White and the three dwarfs*. The story chosen for the show by the Urban Marathi students was based on the theme of saving the environment. The story was of a queen who wanted to make a house wood, which could be procured from nearby forest. Then one day, the forest goddess appears in the dreams of the queen and explains her the value of trees and tells her not to cut trees for selfish motives. The story that was enacted for the puppet-show by the Rural Marathi students was a refashioned form of the popular story, *Wolf, Wolf!!* Students in this setting had replaced the wolf by a monster.

The students in the three settings then modified the selected stories. For example, in one case, bloodshed and death of a character was replaced with a milder form of 'punishment' ".... she should not die, she can fall sick" (Urban English). Despite our suggestions for gender balance, in all the three settings the selected stories had mostly male characters. We persuaded the students to convert one or two characters to females. Each group had to then choose a character to make a puppet. In this matter too, the groups in the Marathi medium settings made their choices amicably. In the Urban English setting, there were disputes between groups and the selection of characters was often gendered. The all boys' groups wanted to make male characters and girls' groups wanted to make female characters.

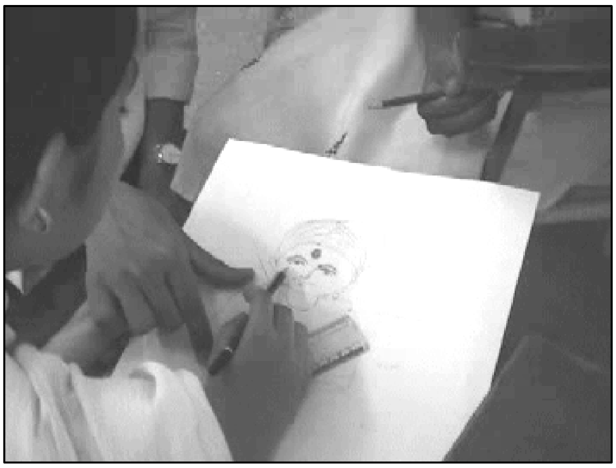
In order to provide the knowledge and skills needed for designing we used a number of simple games and audio-visual demonstrations to discuss human body symmetry, proportions and joints with their movements. Symmetry in body parts and relative body proportions were discussed through a number of examples (cartoons, toys etc.), where deviations from normal symmetry and proportions are strategies to draw attention to certain personality traits. Cultural aspects reflected in individuals' dress, accessories, speech, dialects, behaviours, etc. were also part of the discussion. We hoped that the students would integrate these ideas in designing their puppet character.

Each group filled a worksheet by exploring their own body movements, which encouraged collaborative learning combined with fun. Students moved parts of their body and discussed the directions and extent of movement. Most were aware of a few body joints such as 'shoulder joint, neck joint' but they were neither familiar with the formal names nor accurate about their possible movements. This activity at the close of the phase on investigation and motivation helped students get used to the formal vocabulary as well as relevant scientific information.

Designing, Planning to Make and Communicating

In this 3 to 4 hour phase, each student made exploratory drawings of the character selected by their group (Figure 4.19). The group negotiated the depiction that best represented their character and made a technical drawing showing precise measurements.

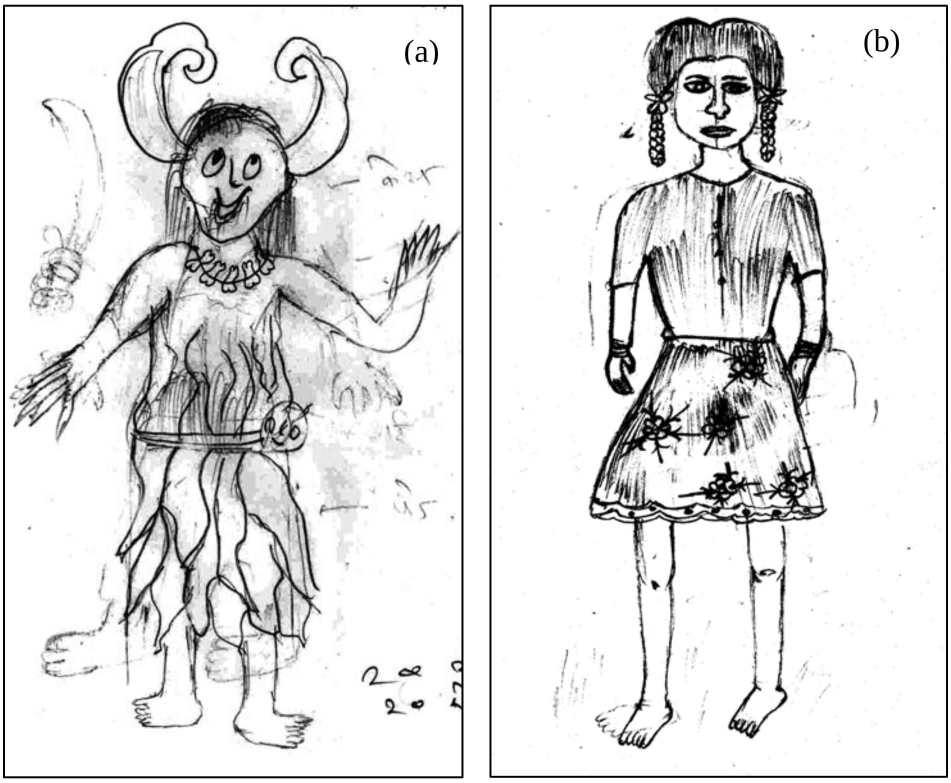
Figure 4.19: Student in Urban Marathi setting making an exploratory sketch of a puppet



During this phase students also listed estimated quantities of materials they would need and tools for making their puppets. Each group made a procedural map that included pictorial and written step-by-step explanation of how they would make their puppet and divided the work amongst the members of group. They communicated their design and plan to the class, following which they made paper templates of their puppet design guided by their technical drawings.

Figure 4.20 gives an idea of how students went about designing their character through exploratory sketches. There were more explorations for 'supernatural/fantasy' characters, such as, forest goddess and monster (Figure 4.20 a, drawing of monster in rural Marathi setting), whereas humans in the story seemed to need fewer explorations (Figure 4.20 b, drawing of a character Swati, in rural Marathi setting, shows few partly erased explorations around hands and feet). Students' exploratory sketches included very typical Indian features – such as turban, bangles, *bindi, dhoti,* etc.

Figure 4.20: Students' explorations of (a) Supernatural character (b) Human character



Groups were also asked to write about their selected puppet character. The written descriptions were brief in both the urban settings, being mostly a table of physical features or short descriptions. An example from an Urban English setting group is given here in Box 4.1.

Box 4.1: A short description of a puppet character in the Urban English setting

Our character is December – the month December. His age is 1586 years. His height is around 2 feet, actual height but the puppet will be about 0.75 feet. ....His language will be English. He is fond of roses and he also talks politely and behaves with respect....

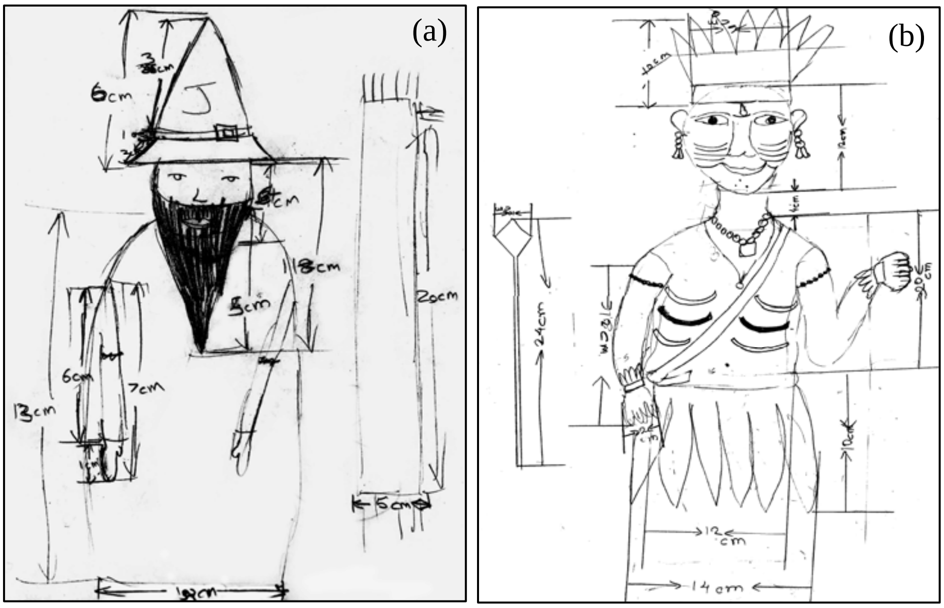
Groups in the rural setting gave long, repetitive and vivid descriptions, about the characters' habits, occupation, physical characteristics, dress and accessories as can be seen by students' description of their puppet character given in Box 4.2.

Box 4.2: Description of puppet character by Rural Marathi students

This woman has worn a red saree. Her name is Meher. Her occupation is farming. This woman has a daughter. This woman wears bangles in her hands. She has farming as her occupation. She lives in Alkhivli village. She is young. Her hair is black. The bangles that she wears are red and yellow. Her nature is good. She has mehendi [henna] on her hands, her eyes have kajal [kohl] and her feet have payals [anklets]. She is 30 years old. She has a loud voice. She speaks in Marathi. Her behaviour is good. She speaks slowly and does not rush while speaking. She speaks pure [Marathi] (Translated from Marathi).

Following the description activity, groups made technical drawings of their selected character. Students had been taught the basics of technical drawings, including use of conventions for depicting units and measurements in an earlier D&T unit. These technical drawings were detailed and helped students advance in their character visualization. The technical drawings of the students in the Urban Marathi setting were elaborate and even had tiny details of the accessories of the characters while in the Urban English setting, these details were minimal. Students more or less adhered to the conventions of leaders, arrows and end lines for technical drawings (See Figure 4.21).

Figure 4.21: Sample of students' technical drawings of puppets (a) Urban English (b) Urban Marathi



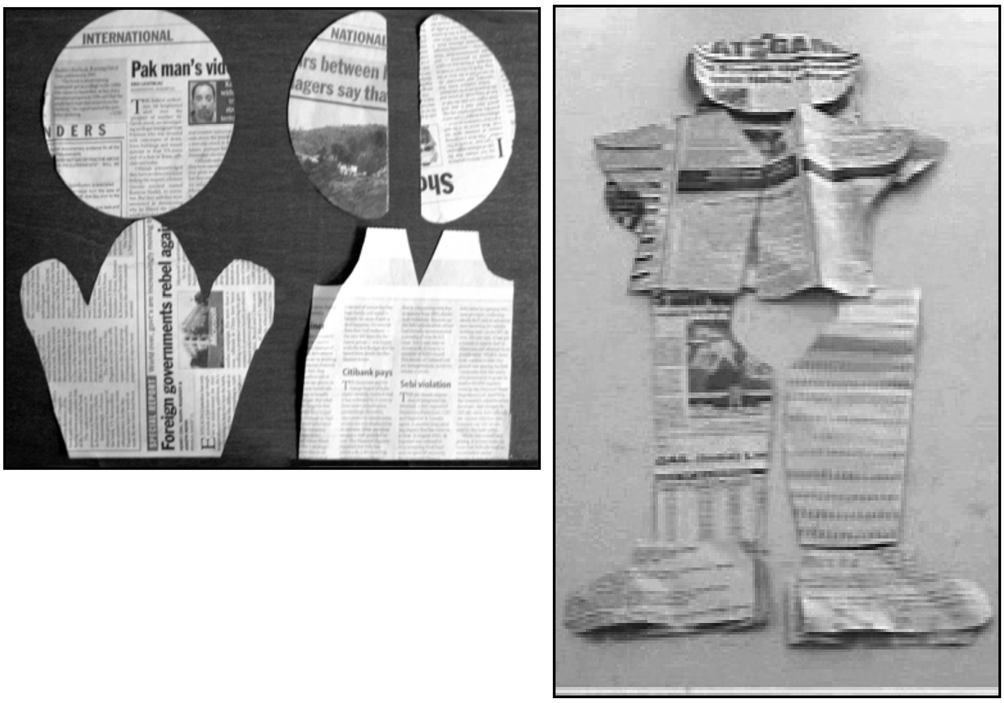
Like the technical drawings, students were exposed to making procedural maps in earlier units. These maps were made collaboratively, often with one member drawing the illustration, while another wrote the corresponding description. Some groups made fairly detailed procedural maps while others made rather sketchy ones. Students then listed materials required by them to make their puppet and the distribution of work among group members. Groups formally communicated to the class, their design productions, character sketches, list of materials and work distribution.

In these presentations, generally all the members of a group came to the front of the class and took turns at reading out various sections that had been worked on. Overall, these presentations increased interactions across groups. Students were free to express themselves in any language, but all chose to present in the medium of instruction of their school. The audience could ask questions, but only a few students actually did. The questions were often superficial or requested information already provided; aesthetic aspect of the puppet was the focus. Besides improving public speaking skills, the formal communication was aimed at facilitating "appropriation of ideas" and skills (Windschitl, 2001, p. 20) and at getting feedback on one's design. In a few cases, where feedback was received, it resulted in the group altering its design.

The students in rural setting were extremely shy, especially when they had to come to the front of the class and speak to the entire class. There was a phenomenon of 'echo' observed during communication- one student would whisper something to the speaker and then the speaker would say it aloud. Their presentations were often formal.

The step of making paper templates using newspapers was introduced as a precursor to making in order to help students estimate the relative body proportions and materials needed for making the puppet. These templates formed a crucial step in helping students visualize their puppet, especially its clothing and limbs. Most groups did not make paper templates for accessories. Figure 4.22 is a picture of paper templates made by students.

Figure 4.22: Paper templates made by students



Making

Once the paper templates were seen to be in order, we gave each group the materials and individual tools requested by them. Students placed their templates on the cloth, made markings, and then cut the cloth.

Making involves 'converting ideas to products'. This phase posed some unanticipated problems that affected our time schedules. In our first setting (Urban Marathi), we learnt that some students could not sew and time had to be devoted to teaching them the rudiments of sewing. While students were familiar with marking and cutting cloth, they had to be taught the technique of making a glove in which a puppeteer could place the hand and move the puppet. This was explained through paper templates and actual examples of the puppet. Yet, students found it difficult to make the torso and then attach the puppet's head to it. Students seldom referred to their design productions while making the puppet, and adapted the features of their product to their convenience and availability of materials.

The group divided the tasks according to the skills of its members, probably to save time. The member who knew sewing was assigned most of the sewing jobs with others helping her/him. Though we did not intend such distribution, students tended to take up jobs, which they could do quickly because of time constraints. In mixed-sex groups, most often girls took up/ were assigned sewing while the boys took up cutting and pasting jobs.

Groups fought over resources, such as needles, thread and scissors. Jones et al. (2000) in their study have also observed outbreak of fights for limited resources. The interactions among students and between students and us were the highest in the making phase. These interactions were focused on procedural aspects. Figure 4.23 shows students involved in different making tasks and sharing resources.

Figure 4.23: (a) Members of an all-girls' group marking the cloth using paper template (b) Members of a mixed-sex group involved in sewing parts of a puppet

All the groups managed to complete their puppets at the end of 10 hours. In the three settings we could see strengths and drawbacks in these puppets. While puppets in the rural setting were sturdier, those in the urban setting had greater diversity in characters. We wanted the students to evaluate their own handiwork in the next phase.

Evaluation and Communication of Product

We allocated time (about 45 minutes) for groups to evaluate their own puppet as well as the puppets of other groups using evaluation sheets provided by us. These sheets included open-ended and close-ended questions. After the evaluation, each group communicated to the rest of the class the details of their making as well as of their evaluation.

The close-ended questions on the evaluation sheet asked groups to rate each puppet on characteristics, such as, ease of handling, movements of joints (number of movable parts), overall neatness and resemblance to the character depicted. Most groups rated their puppets higher than those of other groups in response to the close-ended questions. The evaluation sheet also included questions like, “give suggestions for improving your puppet”, “differences between plan and actual making”, and “estimate the cost of your puppet.” Students arbitrarily calculated the cost price of the puppets, and manipulated the selling price to show profits. The suggestions for improvement were merely aesthetic.

During the formal communication of product and evaluation the audience often raised questions pertaining to the 'making' phase. Students gave and received constructive feedback. They appreciated aspects of others’ products and presented criticism respectfully. We also tried to get students to talk about connections between the puppetry unit and their regular school learning *(R= Researcher, G=Girl, [ ] = our comments).*

Box 4.3: Example of discussions between students and researchers during formal communication

R1: *What are the skills that you learnt while making the puppet or the skills that were specifically used for making the puppet?* (members think for a while)

G1: *Making puppets and stitching.*

R1: *Do you think that something you had learnt in school was useful here?* (silence)

R2: *Nothing you learnt in school was useful at all... while making this.*

G1: *Yes ma'am. The dialogues [writing] that we learnt in school and we also used it here.*

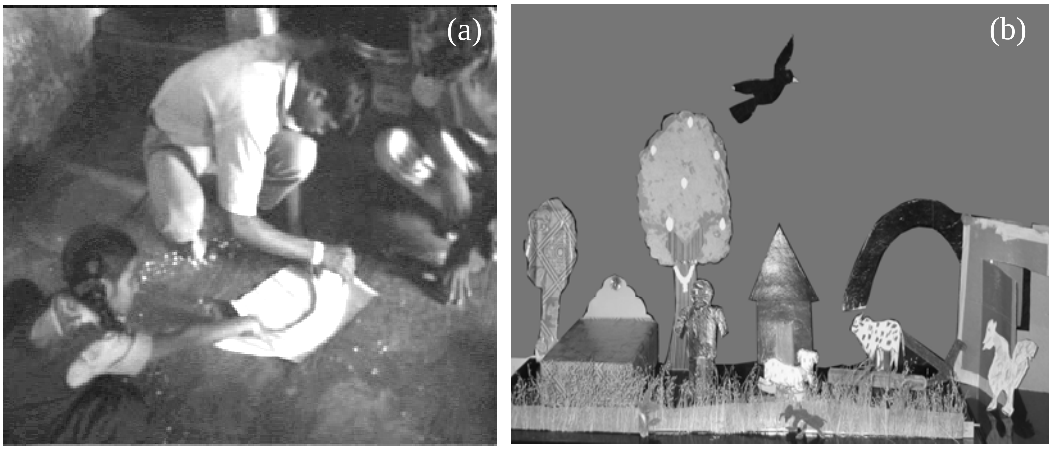
Students (chorus): *Measuring.*

The above conversation indicates that students spontaneously did not make these connections. When probed, they mentioned some linkages between their regular school- work and the puppetry unit, but were unable to articulate these clearly.

Designing and Staging the Show

Finally, the class came together to put up the puppet show lasting 10-15 minutes. This phase required the entire class to work together. The groups dissolved to form new teams voluntarily to design the show, set the stage, compose music or play it, create dialogues, prepare the necessary props and manage lighting on the stage. Then each team worked on the portion that they had committed to: the dialogue team rewrote the script for the play, one team conceptualized the stage and made props, and one arranged the lamps and gelatine paper to make coloured lights. In the Marathi medium settings the script for the show contained songs, poems and dialogues, in Marathi while the Urban English setting included popular songs from Indian movies. Figure 4.24 a shows the students from rural Marathi setting engaged in making props and 4.24 b shows a picture of the completed props by members of the same setting.

Figure 4.24: (a) Members of a mixed-sex group from Rural Marathi setting making props for the stage (b) Props made by students from Rural Marathi setting

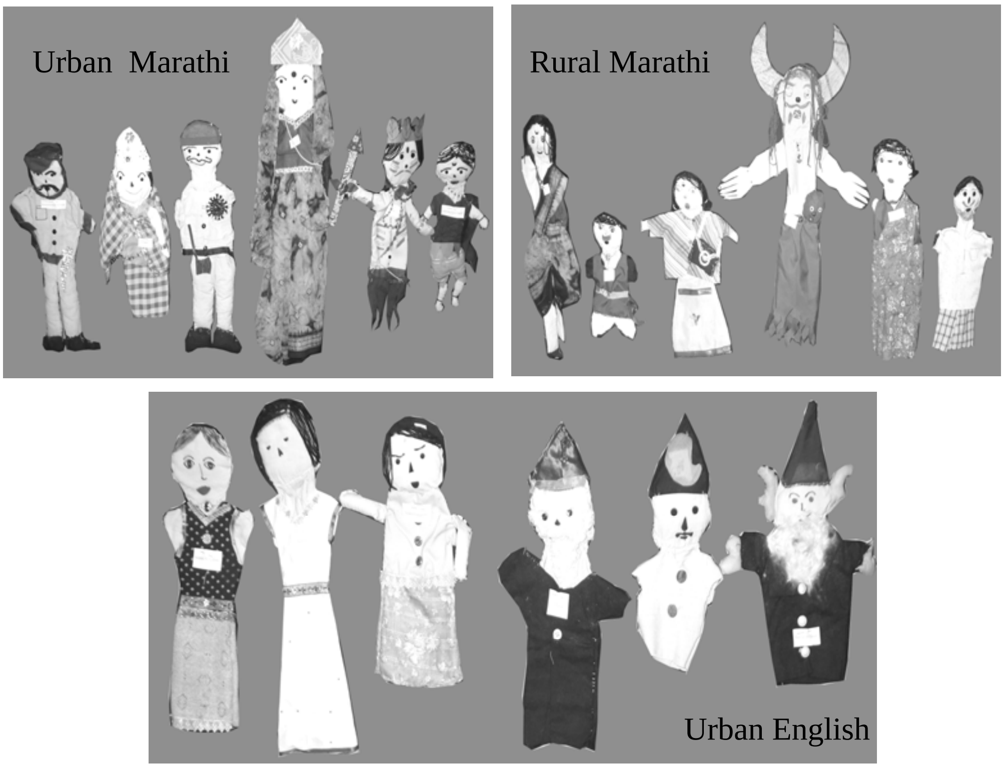


The class rehearsed and put up a show for an audience from outside the class, comprising teachers, outsiders or rest of the school. After the collaborative designing and making in groups, this was a second level of collaboration that involved the whole class. Teams of students needed to work co-operatively and co-ordinate as well as negotiate with other teams. Figure 4.25 is a picture of students from urban Marathi setting just after putting up the show for an audience.

Figure 4.25: Students from Urban Marathi setting staging the show

Students from the three settings were brought together for a sharing of their experiences of all the three units. Video recordings of the three puppet shows were played for the audience and an exhibition of the completed products was held at the same time. This gave an opportunity for students to learn about the existence of educational settings different from their own. Figure 4.26 has pictures of puppets made by students from all the settings.

Figure 4.26: Puppets made by students in the 3 settings



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CHAPTER 5

ANALYSIS OF FORMAL COMMUNICATION IN THE D&T UNITS

5.1 Introduction

Language is an essential medium of learning (Wegerif and Scrimshaw, 1997). According to Vygotsky (1978), language is a psychological tool that each of us uses to make sense of our experience. It is also a cultural tool by means of which we share our experiences with others and come to have a joint understanding. The experiences that promote children to talk are considered important means by which learners ‘accommodate to new concepts and give these shape’ (Westgate and Hughes, 1997, p. 129).

This chapter analyses formal communication that occurred while students from the three socio-cultural settings participated and worked in groups on the three D&T units. The purpose of first part of the chapter is to give a summary of the background of research in the area of communication, the communication involved (formal) in our D&T units, the analysis framework that we have used in the study, which is drawn from Dawes et al.’s framework (1992) for analysis of talk and finally the analysis of the three units on the basis of the framework.

5.1.1 Background to research in communication

There are two important strands of research, built on notions of ‘talk-for-learning’. One strand uses the notion of exploratory talk and its importance for learning and is focused on student talk with their peers. Example of research based on this notion is the Student Learning and New Technology Project (SLANT) that examined the quality of collaborative talk generated when students talked around computers in classrooms (Fisher, 1993; Mercer, 1995; Wegerif and Mercer, 1996).

In a second strand of research, classroom talk is conceptualized as a process of ‘cognitive socialization’ (Edwards and Mercer, 1987, p. 155) and a focus on teacher-student dialogue is maintained through the concept of ‘instructional conversations’ (Edwards and Mercer, 1987; Tharp and Gallimore, 1988; Gallimore and Tharp, 1990).

Under this research paradigm, studies were conducted that were concerned with the effects on learning when particular teacher-student participation structures did not meet the social needs, or 'match' the cultural practices, of children from cultures with different interactional styles. The studies examined the extent to which discourse patterns and participation structures used by mainstream teachers differed from the discourse patterns of other cultures (Cazden, 1988; Michaels, 1986; Tharp, 1982).

Much of the research on peer talk in classrooms has been undertaken with young children (three to eleven year olds) (Edwards, 2005). Most of the contexts studied are not D&T related (exceptions: Rowell, 2004; Murphy and Hennessey, 1999, 2001 worked in D&T contexts), though there are significant examples of the studies of talk in science and problem solving areas (for example, Lyle 1996, Webb and Treagust, 2006, Stamovlasis et al., 2006, Rojas-Drummond et al., 2006). Other studies, such as Maher (1991), are undertaken outside of naturalistic classroom environments and therefore raise questions about the applicability of the findings for secondary school classrooms. Studies of peer talk in Indian classrooms contexts specifically in the areas related to technology are particularly rare and hence the need for this study. This study falls in the first stand of research that we have mentioned earlier.

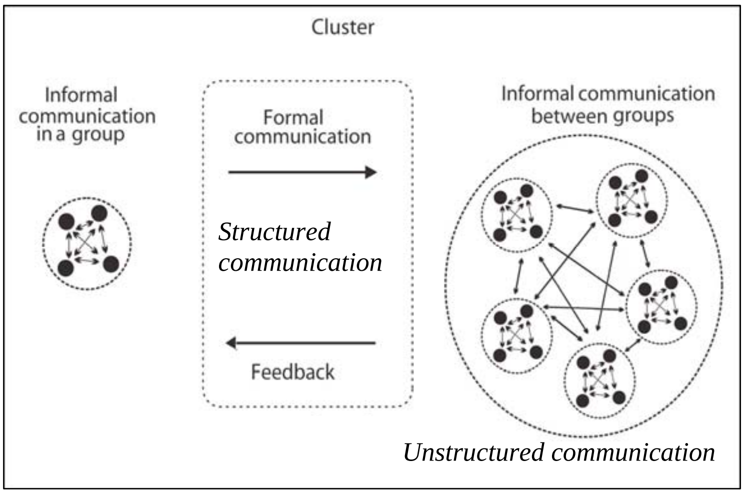
Given the importance of discourse in socio-cultural perspectives of learning, Wegerif and Mercer (1996) have analysed different types of discourse that occur when children reason together to solve problems. In these studies emphasis is placed on how language mediates the way knowledge is constructed. A coding scheme for analysing dialogues developed by Dawes et al. (1992) was used in our study (with slight modifications in characterization of categories) to identify the types of talk that occurred when students engaged in collaborative D&T tasks. According to Mercer (1995), these discourses are considered to be 'social modes of thinking' that guide the construction of knowledge. The categories given by Dawes et al. (1992) include: (a) Disputational talk (b) Cumulative talk and (c) Exploratory talk. The description of each of these categories of talk has been discussed in section 2.3.5 of the review of literature chapter.

None of these categories is mutually exclusive and the decision to put a dialogue in one category depends upon the context in which the talk has occurred. So a dialogue in one instance may be categorized as one kind of talk and the same dialogue in another context could be put in another category of talk. Another point to note about these categories of talk is that no category is superior or inferior to the other, however, when we consider learning that occurs during the talks then exploratory talk has been characterized as the embodiment of critical thinking by Dawes et al. (1992).

5.2 Analysis framework for communication

During planning trials for each of our units, special attention was paid to communication aspects. It is natural that when students work in groups, they will communicate, talk, and gesture to each other spontaneously (informal communication). Along with informal kind of communication, steps were built into the D&T units planned by us, which explicitly required the students to communicate, both orally and in writing. While informal communication between group members helps in gathering information, generating ideas and sharing them with other members in the group, formal communication provided an opportunity for sharing ideas with the entire setting and group and getting their feedback to improve the design and the product (Refer Figure 5.1). Communication that was specifically built in by the researchers in the units was called 'structured communication'. 'Structured communication' was aimed at helping students strengthen their language and communication abilities.

Figure 5.1: Pictorial representation of structured and unstructured communication



Steps of 'structured communication' were:

- Suggest different words for the object/artefact to be made, in any language that they know
- Write poems/descriptive paragraphs on the activity/artefact being undertaken
- Make sketches of the conceived artefacts as well as draw step-by-step procedures for making it
- Evaluate the products made by own group and those made by other groups on a semi-structured evaluation sheet
- Formal oral communication by a group after the product was made and evaluated by the group (product communication)

5.2.1 Formal communication

During formal communication all the members of a group came to the front of the classroom as shown in Figure 5.2 and presented their work to other members in the setting, who questioned them and provided them feedback and suggestions. In each school setting there were 6 groups- two single-sex girls' groups, 2 single- sex boys' groups and 2 mixed-sex groups. The number and composition of sample groups and school settings is presented in Table 5.1.

Table 5.1: Number and composition of sample groups and school settings

Groups	Urban English	Urban Marathi	Rural Marathi	Total
Single-sex girls	2	2	2	6
Single-sex boys	2	2	2	6
Mixed-sex	2	2	2	6
Total	6	6	6	18

During each unit, formal oral communication happened at two stages: one called the *design communication* and the second called the *product communication*. Design communication occurred after students had designed their artefact and it involved describing their ideas/designs of the artefact to be made to the setting. The designs were a result of brainstorming within the group and were represented through drawings and written descriptions of the product. Here the focus was on conceptualization of the artefact with an emphasis explicating the process of designing and making the artefact. Product communication took place after the making and evaluation of the ready (made) artefact. The positive and negative aspects of their artefact, the difficulties encountered while making and possibilities for improving their artefact were discussed.

Figure 5.2: Members of a group in the Urban Marathi setting making a formal design communication infront of their cluster

The analysis of formal communication (oral) within each of the units has been done with respect to the following:

(a) Difference in students' (rural and urban and boys and girls) nature of dialogues in design communication
(b) Difference in students' (rural and urban and boys and girls) nature of dialogues in product communication

5.2.2 Data sources

In our analyses, we took the transcripts of the videotaped events as occasions for looking at students' communication and collaborative work done by group members during the trials of the units. We tried to be minimally invasive with our video recording, adjusting the camera to the existing classroom setting and interfered least with the ongoing events. Although it would have improved the sound quality if the individual groups had worked separate from each other but we did not change the position or setting of any of the groups for this reason.

For analysis, video data were transcribed and the transcripts of the formal communication were coded into the 3 categories of talk. The unit of analysis selected for formal oral communication was one complete or incomplete sentence uttered by a student at the time of formal communication. The percentage agreement between two raters for formal communication was estimated for each D&T unit separately. The percentage agreement between the raters was established for about 50% of the data. Two raters (researcher and her colleague) coded each of the sentences used for analysis and these raters remained the same for all the 3 units. After coding the transcripts independently (using codes descriptions given in Appendix P), the raters matched their codings and the codes that did not match were discussed. This discussion between the raters led to modification and clarification of some code description and characteristics and the final data were coded using the new code descriptions. The description of code categories in given in Appendix P. The raters using the new category descriptions recoded the data and then the percentage agreement between the rates was calculated. The percentage agreement between raters is reported along with the discussion of results for that unit.

While no time limit was set, in general it was observed that product communication lasted for a longer time as compared to design communication Typically a design communication lasted for 3-6 minutes and a product communication for 5-6 minutes The average times for design and product communication for each unit are mentioned along with the discussion of results for that unit. The frequencies of talks for each unit are given in Appendix Q.

5.3 Analysis of formal communication in the unit on bag-making

The bag-making unit was the first unit to be tried. It worked as a probe unit for us. Formal communication of students at two occasions – design and product communication was analyzed. Figure 5.3 (also clip) is a picture of students in the urban English setting formally communicating about their bag. The percentage agreement between raters was more than 60% for design and product communication (for design communication - 62% and for product communication - 61%). This value of inter-rater agreement is an indicator of substantial agreement between the two raters on categorization of the sentences. Given the nature of the data that had frequency of talks in various groups across the settings, independent sample t-test has been used for data analysis.

Groups in all the settings were asked to maintain files which had their groups' procedural maps, drawings, technical drawings, material requirement, distribution of work, cost estimation etc. In all the units, the design communication took place after the groups had completed designing their product and prior to making. For this communication all the group members came to the front of the classroom and explained or read out from their files what their group had planned to make and how they would go about making the product, in this case a bag (clip).

Figure 5.3: Members of a group in the Urban English setting during formal product communication in bag-making unit

Table 5.2 contains the percentages of talk in each category for design and product communication. Design communication on an average lasted for 4 min and product communication for 6 minutes.

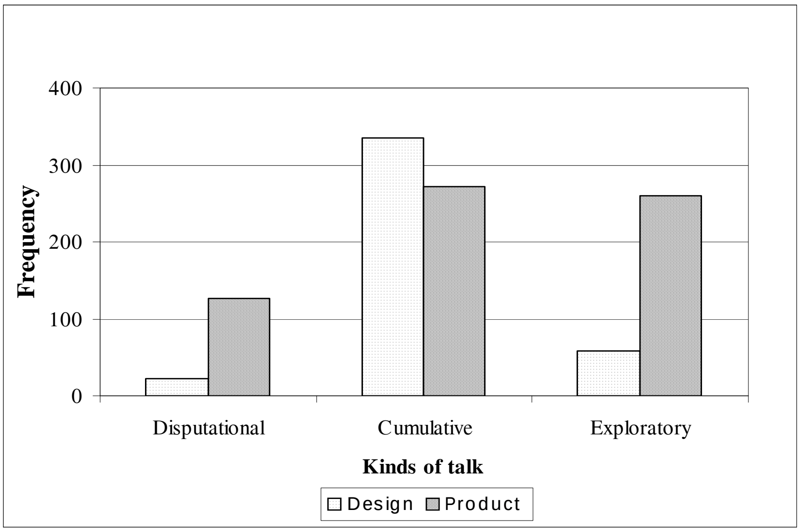
Table 5.2: Kinds of talks exchanged in design and product communication during bag-making unit

Types of talk	% Dialogues in Design Communication	% Dialogues in Product Communication	%Total
Disputational	5 (22)	19 (126)	14 (148)
Cumulative	81 (335)	41 (271)	57 (606)
Exploratory	14 (58)	39 (259)	30 (317)
Total	38 (415)	61 (656)	(1071)

**Figures in brackets indicate the frequency of talks*

Data in the form of the number of dialogues during formal communication, indicates that there were more verbal exchanges in the product communication (656, 61%) than in design communication (415, 38%) and this increase can be understood from the fact that students took longer time over product. Overall, the percentage of cumulative talks is the highest (57%), followed by exploratory (30%) and the least percentage of talks are the disputational talks (14%). Table 5.1 shows that there is predominance of cumulative talk in design communication (81%). While cumulative talk is highest even in product communication it is less dominant (41%). More importantly we can see that there is nearly four times as much disputational talk, about half as much cumulative talk, and about three times as much exploratory talk at the product communication stage compared to design communication. This data is also represented in Figure 5.4.

Figure 5.4: Comparison of talks during design and product communication in bag-making unit



The bag-making unit was the first of the units to be tried with students, and this was the first time that the students were asked to make a formal communication in our trials, and hence students were not very expressive about their designs, this was especially true of students from the rural Marathi setting. Most groups, when presenting their designs for the bag tended to stress on the physical characteristics of the bag- its dimensions, its colour, how they would decorate it etc.

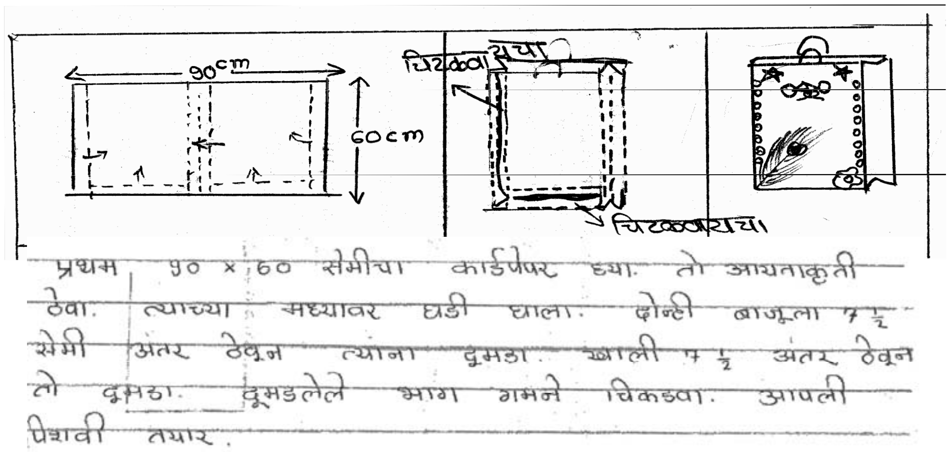
Most groups (12/18) wanted to make paper bags. All the groups, irrespective of the settings and the group composition spoke about the dimensions and the aesthetic aspects of their bags. The technical drawings and the procedural maps drawn by the students tended to be sketchy and often the text written in the procedural map did not match the drawing as shown in Figure 5.5. However, the procedural aspects of making the bags were presented well by most groups in their talk as shown in the transcript given in Box 5.1. Figure 5.5 has the procedural map along with the writing for making procedure by the same group whose transcript is given in Box 5.1.

It can be seen in the transcription given in Box 5.1 that this group has been more descriptive in their oral communication than what they have mentioned in their procedural map (Figure 5.5). While the unit was a team activity, work distribution in most of the groups was based on specific tasks. Example: '*Kavita: sticking, Surekha: putting the nara - thread, Suvarna: making the shape*' (rural Marathi group, translated) (also refer Figure 4.8 a). During formal communication of design, other students in the settings (the audience) asked a few questions to the presenting group, such as *'Please show us what you have drawn', 'how will you attach the handle?'*

Box 5.1: Formal communication during bag-making unit in an Urban Marathi single-sex boys' group

Boy1*: ….It's length 35 cm, and thickness 15 cm , it's breadth 25 cm , by doing like this [referring to the procedure] attach a handle to it. The length of handle is 17 cm. By doing like this [referring to the procedure] put a peacock's feather at one corner [of the bag]. The feather should be stuck completely. After putting a nice rose on the feather of peacock, and silver [sparklers] on it, stick it on the bag. Later on the other side [of the bag] glue one glass [piece], on its [bag's] ends glue two circular glasses [pieces]. On glasses stick two stars and on them stick a lace and your bag is made for you*. (Urban Marathi, Single-sex boys' group)

Figure 5.5: Mismatch between drawing and writing of procedural map

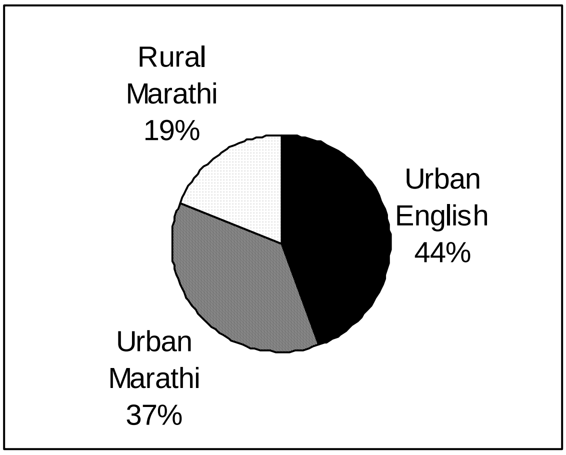


First take 90 X 60 cm card paper. Keep it rectangular. Make a fold in the middle. Keep 7 and 1/2 distance on both the sides. Fold it. Keep 7 and 1/2 cm distance below and fold it. The folded part is to be stuck with glue. Our bag is ready. (Translated) (Urban Marathi, Single-sex boys' group)

5.3.1 Comparisons based on socio-cultural settings

Figure 5.6 presents the percentage of talks in each of the three settings, which was highest in urban English (44%), followed by urban Marathi (37%) and the least exchange of dialogues took place in rural Marathi setting (19%). The details of the total dialogues that occurred in all the three settings in the bag-making unit during design communication and product communication are shown in Table 5.2.

Figure 5.6: Percentage of talks in the 3 settings for bag-making unit



In the rural setting, students could not express themselves well for various reasons including shyness and researchers had to continuously ask questions to guide them to give information about their designs. In the urban Marathi setting, groups tended to give a concise description of their bags (often it was in a point-wise form) and there were very few questions that were asked of them. They spoke of some newer materials (which the other settings had not thought of) like Velcro for using in their bag (they did not use this word but said, '*sticking strap which is used in foot wear*').

Table 5.3 indicates that overall there is an increase in frequency of talk in product communication in all the 3 settings. As can be seen from the table most exchange of dialogues took place among students of the urban English setting (476/1071, 44%) followed by urban Marathi students (392/1071, 37%) and least by students of the rural Marathi setting (203/1071, 19%)**.** It is interesting to note that while overall the total number of dialogues increased from design communication to product communication, but it is only in the urban Marathi setting that there is an increase in the percentage of dialogues (from 20% to 47%) during product communication, whereas in the other settings the percentage of dialogues during product communication have actually decreased.

Table 5.3: Dialogues exchanged during design and product communication in the 3 settings in bag-making unit

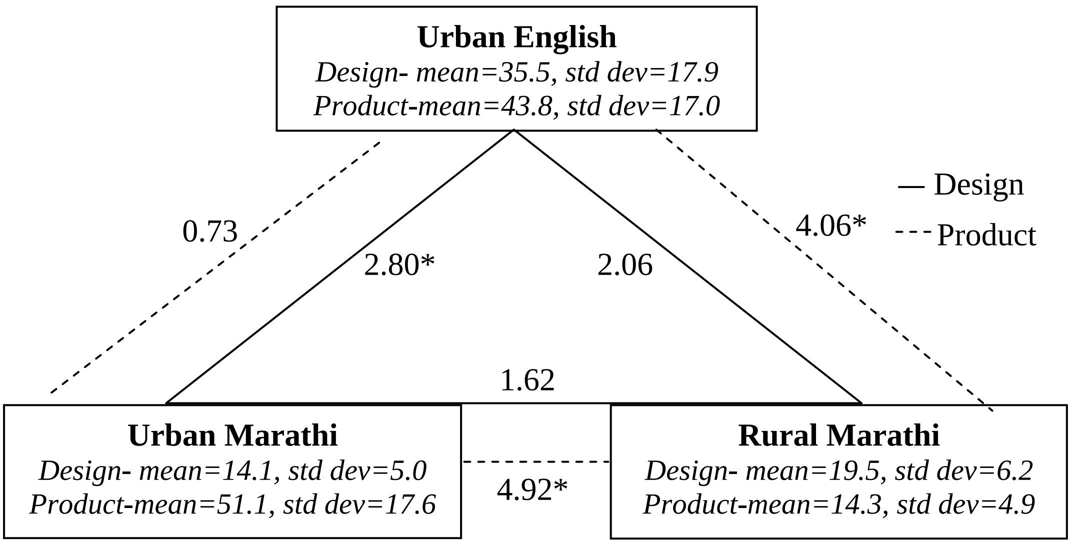
Settings	% Dialogues in Design Communication	% Dialogues in Product Communication	% Total
Urban English	51 (213)	40 (263)	44 (476)
Urban Marathi	20 (85)	47 (307)	37 (392)
Rural Marathi	28 (117)	13 (86)	19 (203)
Total	39 (415)	61 (656)	(1071)

**Figures in brackets indicate the frequency of talks*

The comparison of frequency of talks in the 3 settings for design and product communication is depicted in Figure 5.7. For design communication statistically significant differences were found between students of urban English (213) and urban Marathi (85) (t-value=2.80). However for product communication no significant differences were found between these two groups. Statistically significant differences were found in product communication between urban English (263) and rural Marathi

(86) (t-value=4.06) and between rural Marathi (86) and urban Marathi setting (307) (t-value=4.92) as well. The difference in the urban English and the Urban Marathi setting for design communication (Figure 5.7) could be explained by our classroom observations and field notes. We observed that urban Marathi students during their design communication read out from their files (as did other students), but in this setting, all the groups had written very briefly about the procedure of making, their material list was in a tabular form and they read out exactly from their files. While in the urban English and rural Marathi settings, this was not so. In these groups students did not tabulate the procedure of making and were more descriptive in their writings. On the other hand, the rural Marathi students were shy in formal communication and less talkative as compared to their urban counterparts.

Figure 5.7: Graphical representation of t-values across settings for design and product communication during the bag-making unit



**indicates significance at p<0.05, df=10*

Comparing the profile of talks for design and product communication in each of the 3 settings shows some interesting results. Table 5.4 compares the kinds of talk in the three settings during design communication and product communication.

Table 5.4: Comparison between the settings for types of talks in design and product communication during bag-making unit

Kinds of talks	Urban English		Urban Marathi		Rural Marathi	
	% Design	% Product	% Design	% Product	% Design	% Product
Disputational	9 (19)	24 (64)	4 (3)	19 (58)	(0)	5 (4)
Cumulative	75 (160)	36 (94)	80 (68)	36 (110)	91 (107)	78 (67)
Exploratory	16 (34)	40 (105)	16 (14)	45 (139)	9 (10)	17 (15)
Total	100 (213)	100 (263)	100 (85)	100 (307)	1000 (117)	100 (86)

**Figures in brackets indicate the frequency of talks*

The table indicates that disputational talk and exploratory talk increased in all three settings and cumulative talks decreased from design communication to product communication. The increase in disputational talk was considerable for all the three settings. The increase was over 2 times for urban English (from 9% to 24%) and about 4 times for urban Marathi (from 4% to 19%) settings and for rural Marathi setting it increased from 0 to 5%. The increase in exploratory talk was also considerable and it was over 2 times for each setting. The most increase was seen for urban Marathi students (from 16% to 45%), followed by urban English (from 16% to 40%) and then rural Marathi students (from 8% to 17%). The increase in exploratory talk is an indication of improvement in students' critical thinking skills, reasoning (Dawes et al., 1992) during product communication (i.e. after making the product). Cumulative talk decreased more than 50% from design communication to product communication in case of both the urban groups (urban English from 75% to 36% and urban Marathi from 80% to 36%). In the case of rural Marathi setting the decrease in cumulative was relatively less (from 91% to 78%). As mentioned earlier, cumulative talks involves mere addition or repetition of information.

5.3.2 Comparisons based on gender groups

Each setting had 3 types of gender groups - 2 each, of single-sex girls', single-sex boys' and mixed-sex. In our entire sample, there were 6 groups of each kind in the 3 settings. Figure 5.8 shows the percentage of talk in various gender groups (in all the settings) for the bag-making unit. The frequency of talks exchanged in single-sex boys' groups was the highest (449/1071, 42%), followed by single-sex girls' groups (323/1071, 30%). Mixed-sex groups exchanged the least number of dialogues (299/1071, 28%) during formal communication. Within mixed-sex groups, both boys and girls contributed to similar number of dialogues (girls- 146, boys- 150) and there were 3 dialogues in which both boys and girls spoke together.

Figure 5.8: Percentage of talks in single-sex and mixed-sex groups in bag-making unit

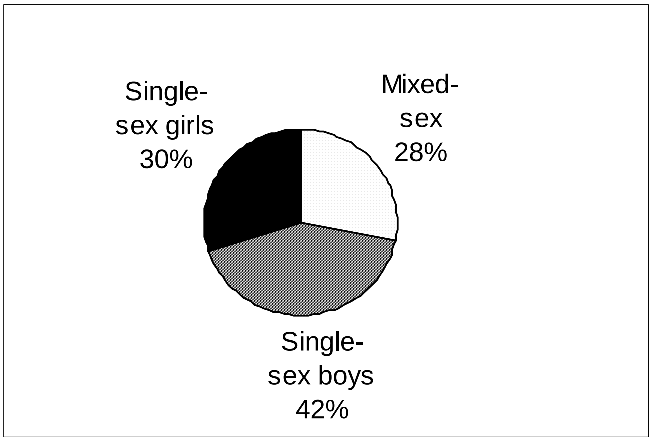


Table 5.5 presents the comparison of talks in the 3 gender groups for design and product communication. As can be seen in the table, in the single-sex girls' group there is an increase in percentage of talks for product communication (from 24% to 34%) while in single-sex boys' and mixed-sex groups there is a decrease (from 44% to 40% in single-sex boys' and in mixed-sex groups from 31% to 26%) in the percentage of talks during product communication.

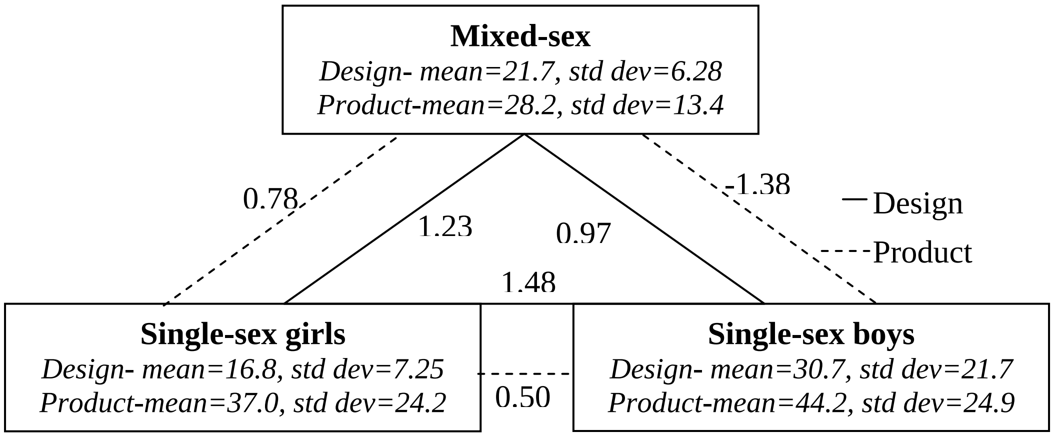
Table 5.5: Genderwise distribution of talk for design and product communication in bag-making unit

Gender groups	% Dialogues in Design Communication	% Dialogues in Product Communication	% Total
Single-sex girls	24 (101)	34 (222)	30 (323)
Single-sex boys	44 (184)	40 (265)	42 (449)
Mixed-sex	31 (130)	26 (169)	28 (299)
Total	39 (415)	61(656)	(1071)

**Figures in brackets indicate the frequency of talks*

Figure 5.9 presents a comparison of talks between different gender groups design and product communication. There were no significant differences between any of the gender groups for design and product communication.

Figure 5.9: Graphical representation of t-values across the gender groups for design and product communication during the bag-making unit



**indicates significance at $p<0.05$, df=10*

Table 5.6 presents a comparison of the kinds of talk in the gender groups for design and product communication.

Table 5.6: Percentage of talks during design and product communication in the gender groups during bag-making unit

Gender groups	Single-sex girls		Single-sex boys		Mixed-sex	
	Design	Product	Design	Product	Design	Product
Disputational	1 (2)	31 (46)	10 (15)	29 (43)	3 (5)	25 (37)
Cumulative	15 (88)	14 (84)	24 (143)	19 (117)	17 (104)	12 (70)
Exploratory	3 (11)	29 (92)	8 (26)	33 (105)	7 (21)	20 (62)
Total	(323)		(449)		(299)	

**Figures in brackets indicate the frequency of talks*

As can be seen in Table 5.6, there is a substantial increase in disputational and exploratory talks and a decrease in cumulative talks during product communication in all the groups. In the case of single-sex girls' groups, the increase in disputational talks during product communication is maximum (from 1% to 31%) and least in single-sex boys' groups (from 10% to 29%) while the increase in exploratory talks is most in the case of single-sex girls' groups (from 3% to 29%) and least in mixed-sex groups (from

7% to 20%). The decrease in cumulative talks was almost same for single-sex boys' group and mixed-sex group and the least decrease was for single-sex girls' group.

The comparison across settings for the gender groups is presented in Table 5.7. Overall single-sex boys' groups exchanged the most dialogues (449, 42%). Of all the single-sex girls' groups, urban Marathi single-sex girls' groups exchanged most dialogues (140, 43.%), followed by urban English (113, 35%). In the single-sex boys' groups urban English boys exchanged the maximum dialogues (237, 53%), followed by urban Marathi boys (139, 31%) while in the mixed-sex groups, the English medium groups exchanged the maximum dialogues (126, 42%), followed by urban Marathi groups (113, 38%) and least by rural Marathi groups (60, 20%). In the urban English settings single-sex boys exchanged the most dialogues (237, 53%), while single-sex girls exchanged the least percentage of dialogues (113, 35%). Overall single-sex boys exchanged the most dialogues (449, 42%) and mixed-sex groups exchanged the least (299, 28%). It is to be noted here that while overall single-sex boys exchanged most dialogues but single-sex boys in the rural Marathi setting exchange the least percentage of dialogues (73, 16%).

Table 5.7: Percentage of talks in different gender groups in the 3 settings in bag-making unit

Gender groups	Single-sex girls	Single-sex boys	Mixed-sex	% Total
Urban English	35 (113)	53 (237)	42. (126)	44 (476)
Urban Marathi	43 (140)	31 (139)	38 (113)	37 (392)
Rural Marathi	22 (70)	16 (73)	20 (60)	19 (203)
Total	30 (323)	42 (449)	28 (299)	(1071)

**Figures in brackets indicate the frequency of talks*

During formal communication most groups emphasized on aesthetics of their bag as well as their peers' bags. Improvements were mostly restricted to size and decoration. It was observed that students had vocabulary to express technical words correctly in the design context such *sahitya* (materials), *sushobhit* (decoration), *aakruti* (diagram). Yet, they were confused about language conventions while using some every day words like *laambi* (length), *unchi/ jaadi* (height/ thickness or width), *rundi* (breadth).During formal communication reinforcement aspects of the bag were least emphasized. Even when this aspect was mentioned, it was in terms of adding more material to sides. There were few instances where students spoke of joints and folds. They were unable to identify the weakest points correctly. Students in all the settings were appreciative of others' bags. The *veni* (braid) type handles were appreciated for their strength (clip).

5.3.3 Summary

The bag-making unit was the first unit to be tried with students in all the settings. Making a bag was familiar to most of the students and bag as an object was of common use to most students. During bag-making activity, there were more dialogues exchanged in product communication as compared to design communication. Of the 3 kinds of talk, cumulative talks were the highest, followed by exploratory talks and disputational talks were the least. Increase in exploratory and disputational talks was observed while a decrease in cumulative talk was observed for product communication. During formal communication students from the urban English setting were most interactive, followed by students from urban Marathi setting and students from rural Marathi setting exchanged the least dialogues. Significant differences were seen in the dialogues exchanged during product communication in urban English and rural Marathi setting and also between rural Marathi and urban Marathi settings. These differences were not seen during design communication. Significant differences were seen between urban English and urban Marathi settings for design communication. Single-sex boys' groups exchanged the most dialogues, followed by single-sex girls' groups and the least dialogues were exchanged in the mixed-sex groups. Boys and girls in mixed-sex group exchanged similar frequency of talk. Among the single-sex girls' group urban Marathi girls exchanged the most and rural Marathi girls exchanged the least percentage of dialogues. In the single-sex boys' group urban English boys exchanged the most and rural Marathi boys exchanged the least percentage of talks. This pattern was also seen in the mixed-sex groups. However no significant differences were found between any of the gender groups.

5.4 Analysis of communication in the unit on making a working model of Windmill

The unit on windmill was tried after bag-making activity. The students who participated in the unit more or less remained the same as in the case of the bag-making unit except for a few additions or dropouts. The windmill unit was tried in the consecutive week after the bag-making unit in the case of urban English setting, about after 8-9 months of bag-making unit in the case of urban Marathi and rural Marathi students (Refer 4.3 for more details about the sample). The unit required students to work in groups and come up with a design of a windmill that could lift a given amount of weights. Students were given the option of changing their group names.

Students worked on this unit for a period of 15 hours. The details of how this unit was conducted have been elaborated in the chapter on Methodology (Refer section 4.5.2). The formal communication that occurred at two occasions – at the designing stage (before making the artefact, called design communication) and once after making the artefact (called product communication) have been analyzed for the unit on windmill, as was the case in the bag-making unit. The average time taken for design communication was 6 minutes and for product communication was 5 min. This was so because windmill unit was more complex than bag-making unit and students needed to understand and then explain how they would design it and then make their model. Figure 5.10 is a picture of a group in rural Marathi setting communicating about their windmill model. Two researchers coded the talks that occurred at the design and product communication stage and inter-rater reliability was established for about 50% of the data. The percentage agreement between raters was found to be 66% for design communication and 76% for product communication.

Figure 5.10: Students from Rural Marathi setting during formal product communication in windmill unit

Over all, there were 1208 exchanges of dialogue during the windmill unit. As presented in Table 5.8, number of dialogues exchanged during design communication (614, 51%) was slightly higher than product communication (594, 49%) unlike in the bag-making unit, where product communication had higher percentage of dialogues as compared to design communication. Of all the talks, cumulative talks were highest (771, 64%), followed by exploratory talk (331, 27%). The least percentage of dialogues was of disputational kind (106, 9%). This pattern of talks was observed for both design as well as product communication. Similar pattern of talks was observed in the bag-making unit also. If we compare between design and product communication for each kind of talk then we find that cumulative talks decreased to almost half and exploratory and disputational talks increased almost two times during product communication. A figurative representation of Table 5.8 can be seen in Figure 5.11.

Table 5.8: Kinds of talks exchanged in design and product communication during windmill unit

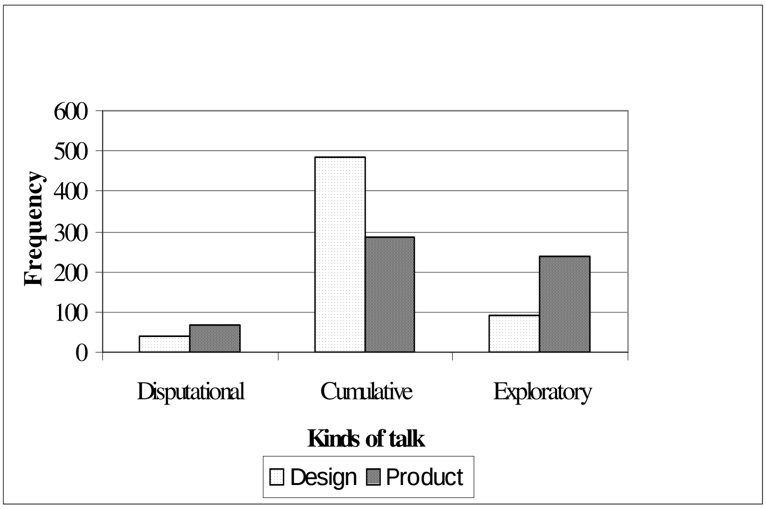
Types of talk	% Dialogues in Design Communication	% Dialogues in Product Communication	%Total
Disputational	6 (39)	11 (67)	9 (106)
Cumulative	80 (484)	48 (287)	64 (771)
Exploratory	15 (91)	40 (240)	27 (331)
Total	51 (614)	49 (594)	(1208)

**Figures in brackets indicate the frequency of talks*

Observations of the design communication indicated that students discussed their design plans in detail (unlike in the bag-making unit). There were a lot of exchange and counter-exchange of questions for clarification and modification of ideas. Students attempted to reflect on their own ideas and also ideas of other groups in the setting to see both the strengths and flaws in their own reasoning and that of their peers.

Light (1991, 1993) while discussing the role of negotiations, had pointed out that children use language to make plans explicit, to make decisions and to interpret feedback which facilitates problem solving and promotes understanding. Perhaps these increased exchanges of dialogues during design communication (as compared to product communication) could have occurred because a) windmill was the second unit to be tried in all the settings and students may have got more comfortable each other and the researchers as well as with the format of the unit and so the frequency of talks increased overall for windmill unit, b) secondly, windmill context was not as familiar to the students as a bag which was directly useful for them and therefore windmill unit was novel as compared to the bag-making unit; and c) thirdly since windmill is a more complex artefact than a bag and therefore students may have wanted to get their ideas clearer before proceeding to making helped students try to get their ideas clearer at the initial stage before making the product.

Figure 5.11: Comparison of talks in the 3 settings during design and product communication in windmill unit

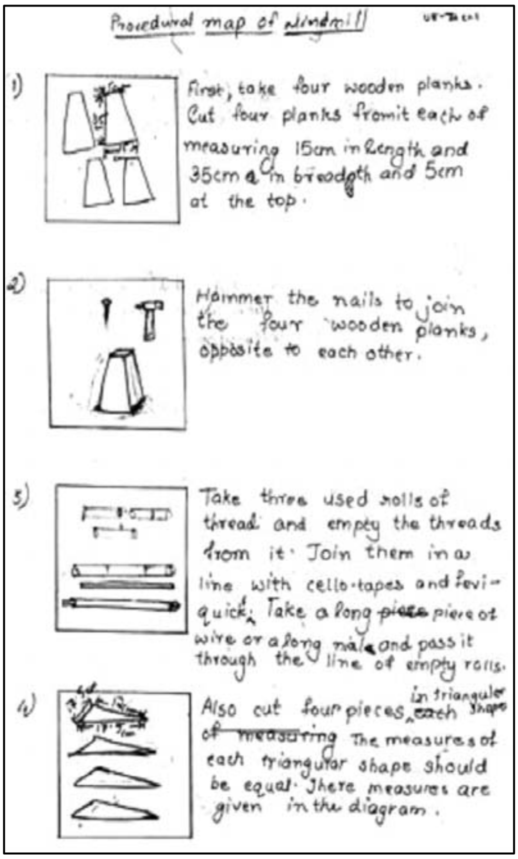


During design communication, students within a group generally took turns to read out, with one member reading out the entire procedure for making, another one the work distribution, the third member reading about materials needed but in some cases it was observed that students (specifically in the rural Marathi setting) shared within themselves, even the procedure for making the windmill. In all the settings, students' foci of design communication were *dimensions and the procedure of making* the windmill. Box 5.2 is an example of an excerpt from English mixed-sex group named Science Kingdom, describing how their group went about making their windmill model and Figure 5.12 is an illustration of the procedural map made by the same group.

Box 5.2: Formal communication at design stage during windmill unit (single-sex girls' group in the Urban English setting)

G1 (reading out from the file- refer Figure 5.12) Procedural map of our windmill.
Step 1- First take 1wooden plank and cut 4 planks from it, each of measuring 15 cm in length, 35 cm in breadth and 5 cm at the top. Hammer the nails to join 4 wooden planks opposite to each other.
Step 3: Take 3 used rolls of thread and empty the threads from it, join them in line with cello tapes and fevikwick. Take a long piece of wire and pass it through the line of the empty rolls. Step 4: Also cut the 4 pieces in triangular shape for the blades. The measures of each triangular shape should be equal. Join the 4 blades to the shaft with fevikwick and cellotape. Join the shaft on the wooden planks with fevikwick and cellotape. The windmill is ready.

Figure 5.12: Part of procedural map for windmill unit (single-sex girls' group in the urban English setting)



Apart from describing the procedure, groups communicated about the *materials* they would need for making their windmill and the work distribution within the group. This was often a reading of what the students had written in their files. We can see from the dialogues given below that *work distribution* within groups was mostly based on main activities that students had anticipated for making. This was not necessarily followed in actual practice. Following (Box 5.3) is an excerpt from another urban Marathi mixed-sex group named Swatantra Vir Savarkar on the material requirement and work distribution within the group.

Box 5.3: Communication of materials required and work distribution

B1: *1) Card board (length20 cm, and breadth 7cm, thickness 6cm), 2) Blade (length 10 cm, and breadth 5cm), 3) Nail (Quantity 7)*

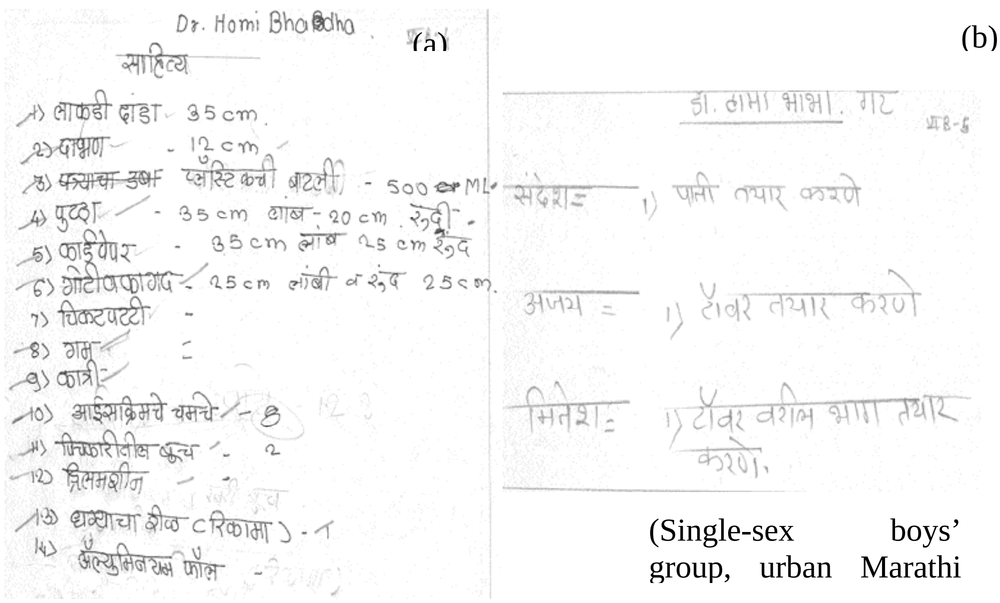
B1 (now for decoration) *4) Silver paper, 5) Gum, 6) Fevicol etc., 7) Scissor, 8) Stand - length 11 cm, breadth 11cm, 9) Cardboard strips, 10) Wooden box, 11) Nails –1 (also refer Figure 4.12 a and b)*

[work distribution]

G1*: We will work as follows: Cutting four strips of cardboard –Yugandhara and Prachi, Sticking the four strips – Omkar and Amul. Making hole and inserting nail –Omkar and Amul, Cutting vanes of cardboard - –Omkar and Amul. Placing vanes- Omkar. Lower part of the windmill means placing the stand – Omkar. Decoration Prachi and Yugandhra.* (also refer Figure 4.4) (Mixed-sex group, Urban Marathi setting)

Figure 5.13 is an example of material list and work distribution written by a single-sex boys' group named Homi Bhabha from the urban Marathi setting.

Figure 5.13: (a) List of materials required by a group and (b) work distribution in windmill unit



(Single-sex boys' group, urban Marathi

During the design communication, the audience often questioned the groups presenting their designs. These questions mostly pertained to procedural aspects of the activity and were factual in nature. A few examples of factual questions that were asked during the windmill unit are given below in Box 5.4 with the name of setting in which they were asked given in brackets at the end of the question.

Box 5.4: Examples of factual questions asked by the audience during formal communication

Example 1: Audience (Girl) *to the presenting group, 9 cm long piece of wood, where will it be put? That wooden rod, how will you join?* (Rural Marathi setting)
Example 2: Audience (Boy): *They will join the blades to the wood, how will the blade move then?* (Rural Marathi setting)
Example 3: Audience (Boy): *Which material will you make the shaft?* (Urban English setting)
Example 4: Audience (Boy): *As you said you drew the shape of a box and then cut it to get the box. But, then how will you join them together?* (Urban Marathi setting)

During the product communication, students mostly described how they went about making their windmill models, problems encountered by them, data on amount of weight their model could lift and the number of rotations it could make and how they thought they could further improve their model. Example of an excerpt from a rural Marathi single-sex boys' group named Indian is given below in Box 5.5.

Box 5.5: An example of students describing their windmill during formal communication of product

B1: *We had taken lots of time for making the tower. We took four rods and we made it stand and on it we attached a ply on the tower. Nacelle- For making a nacelle we faced lots of problem. When we were making nacelle that time [of] plastic pipe …..We did lots of hard work while making hole the size of a rod and ….. And in the plastic pipe we inserted the rod with the blades.* (Single-sex boys' group, Rural Marathi setting)

During product communication most groups tried to provide a rationale for their actions such as, "*The tower is strong, the shaft is big thereby helping the blades move* *smoothly…. The shaft is big thereby helping the wind….. So it helps the wings to move smoothly."* They also analyzed the negative points of their windmill and were explicit about reporting them e.g, "*The joints of the blades are quite weak. The windmill could not lift 30 grams of weight. The base is not strong.*" (Urban English -Single-sex girls' group named Nature).

It was interesting to note that questions asked during the product communication were less in number as compared to design communication. The questions asked were either factual, soliciting reasonably simple, straightforward answers based on obvious facts or awareness or evaluative (involving cognitive or/and emotional judgment) in nature. The excerpts given in Box 5.6 are examples of factual questions asked. In example 1 given in Box 5.6, a boy in the urban English setting, asks the question to a member of single-sex girls' group. In example 2 of Box 5.6, a question is asked of single-sex girls' group from urban Marathi setting

Box 5.6: Examples of factual questions and the responses to them in the windmill unit

Example 1: Audience (Boy): *Why have you put that [those] 4 sticks behind the wings?*

G1 (member of the presenting group): *So that it is strong, it will not bend forward or backward.* (Single-sex girls' group, Urban English setting)

Example 2: Audience (Boy): *Hello, how did you make a hole in the wood stick?*

G1 (member of the presenting group): *By hole making machine we made the hole.*

Audience (Boy): *You mean drilling machine?*

G 1(member of the presenting group): *uh (nods her head in agreement*) (Question asked of a single-sex girls' group-Urban Marathi setting)

The evaluative kind of questions usually required sophisticated levels of cognitive and/or emotional judgment. There were a few instances during product communication, where evaluative questions were asked and presenters answered these questions with a lot of details rather than providing just monosyllabic answers, as is exemplified in the two examples of dialogues given in Box 5.7.

Box 5.7: Examples of evaluative questions and detailed responses to them in the windmill unit

Example 1: Audience (Girl): *What could you have done in order to lift more weight by windmill?*

Boy (member of the presenting group): (explains using the model) *Since these blades are heavy, they could not spin easily with the wind. We will make them light. And …and… because the dabhan [thick, long needle which was used as a shaft in this model] is slightly thin it can't rotate. We will make it thick.*(urban Marathi setting single-sex boys' group (Homi Bhabha)

Example 2*:* Audience (Boy): *Do you think…uhh, you have put this plank of wood* [going to their model and pointing out to the wooden plan on the back side of the model], *do you think it is useful for your windmill?*
All group members*: Yes*
B1: *This is not so sturdy (pointing to the front plank of the model) so we took this plank*
B2*: First we did not stick this plank (pointing to the middle block of wood).*

At times, students appreciated a technique and wanted to learn the technique that the presenting group has used in their model and wanted them to explain it, as in this case given in example 1 in Box 5.8. On the other hand, there were instance of students critiquing the products during formal communication of product (example 2 Box 5.8).

Box 5.8: Examples of appreciation and critiquing during formal product communication phase

Example 1: Audience: *What did you do to make the four pillars….strong?*
G1: *From here we hammered the nails…..*
G2: *(Going to the model): From here we put in the nails and also from here (meaning the base)- the bottom.* (Mixed-sex, urban English setting)

Example2: Audience (boy): *The weight of the rotor is not equal to the cap [which was put at the back for balancing], so will it be balanced?*
B1: *We do not need to balance it because it is an iron nail whereas we are using only paper and plastic over here [pointing to the vanes].* (Mixed-sex group, urban English setting)

5.4.1 Comparisons based on socio-cultural settings

The break up of the percentage of dialogues exchanged in each of the 3 settings is presented in Figure 5.14. Interestingly the percentage of talk exchanged in both the urban English and urban Marathi settings were the same (36%), though the frequency of talks was slightly more for the urban English setting. The rural Marathi setting exchanged about 28% of dialogues of the total talk. It is to be noted here that in the bag-making unit, students from the rural Marathi setting had the least number of talks. However, the frequency of dialogues exchanged in the urban English was more than that of urban Marathi. (Refer Figure 5.6). This gap got closed in the windmill unit.

Figure 5.14: Percentage of talks in the 3 settings for the unit on windmill

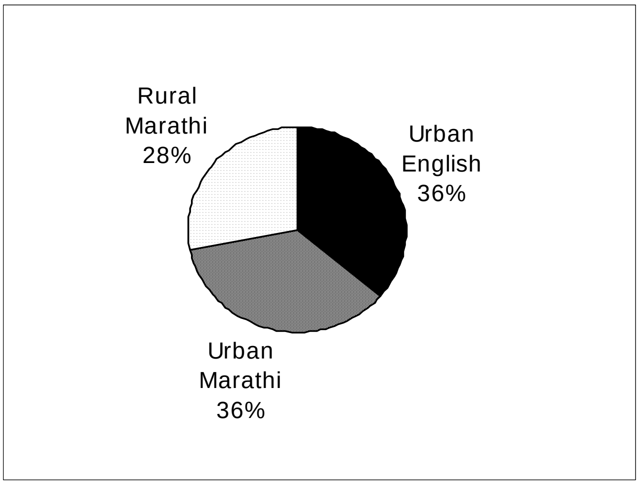


Table 5.9 presents the comparison between design and product communication in the 3 settings. Overall in the case of windmill, there were slightly more dialogues exchanged in design as compared to product communication. As can be seen in Table 5.9, that during design communication, urban Marathi and rural Marathi settings contributed to almost similar percentage of talk (urban Marathi 34% and rural Marathi 35%), while students from the urban English setting exchanged fewer dialogues (209, 31%). However during product communication there was a difference in the patterns of talks exchanged- groups from the rural Marathi setting exchanged the least percentage of dialogues (125, 21%) and maximum dialogues were exchanged among the English medium students (247, 42%). This decrease in the frequency of talk from design to

product communication in the rural Marathi setting was responsible for students from this setting exchanging the least dialogues overall (338, 28%). This pattern of dialogues was typical to the windmill unit, perhaps due to its technical nature and unfamiliarity with students' personal lives (though the students recognized it to be of social value).

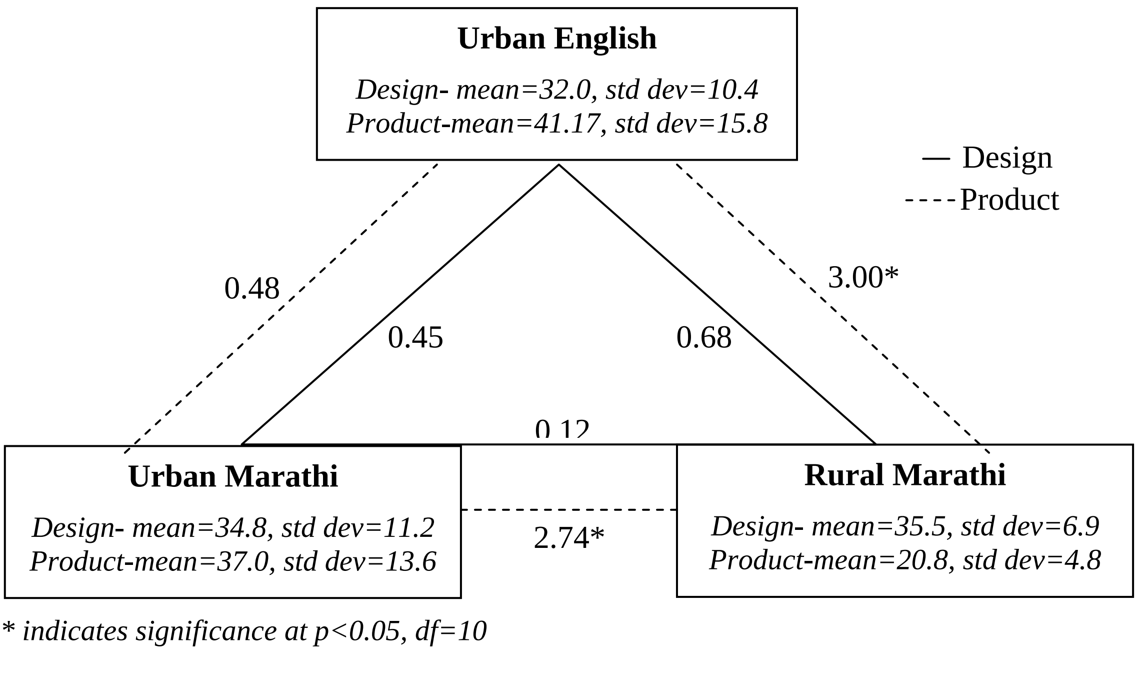
Table 5.9: Dialogues exchanged during design and product communication in the 3 settings during the unit on windmill

Settings	% Dialogues in Design Communication	% Dialogues Product Communication	%Total
Urban English	31 (192)	42 (247)	36 (439)
Urban Marathi	34 (209)	37 (222)	36 (431)
Rural Marathi	35 (213)	21 (125)	28 (338)
Total	51 (614)	49 (594)	(1208)

**Figures in brackets indicate the frequency of talks*

Figure 5.15 gives the comparison across settings for design and product communication for the windmill unit.

Figure 5.15: Graphical representation of t- test across settings for design and product communication during the windmill unit



** indicates significance at p<0.05, df=10*

A comparison of design communication across the 3 settings indicates that there were no significant differences among the settings for design communication. In the case of product communication, significant differences between urban English (247) and rural Marathi setting (125) (t-value =3.00) and between students from rural Marathi setting (125) and urban Marathi setting (222) (t-value=2.74) were found. Similar findings for product communication were also observed in the bag-making unit. However, in the bag-making unit, there had been a significant difference for design communication between urban English and urban Marathi setting.

Table 5.10 presents the comparison of kinds of talks in the 3 settings for design and product communication. Highest percentage of dialogues exchanged in all the 3 settings was of cumulative kind. Exploratory talk increased from design to product communication in all the 3 settings. The highest increase in exploratory talks during product communication was in the case of rural Marathi students (from 9% to 42%, almost 4 times), followed by urban English (from 17% to 45%) and the urban Marathi (19% to 35%). Cumulative talk decreased in all the settings, with the decrease of almost half in the case of urban English setting and lesser decrease in the urban Marathi and rural Marathi settings. Disputational talks increased to over two times in the case of urban English setting and there was a slight decrease in the case of rural Marathi setting that is indicative of increased consensus among students.

Table 5.10: Comparison between the settings for types of talks in design and product communication for windmill unit

Kinds of talks	Urban English		Urban Marathi		Rural Marathi	
	%Design	%Product	%Design	%Product	%Design	%Product
Disputational	7 (14)	19 (46)	6 (12)	7 (15)	6 (13)	5 (6)
Cumulative	76 (146)	37 (91)	76 (158)	59 (130)	85 (180)	53 (66)
Exploratory	17 (32)	45 (110)	19 (39)	35 (77)	9 (20)	42 (53)
Total	100 (192)	100 (247)	100 (209)	100 (222)	100 (213)	100 (125)

**Figures in brackets indicate the frequency of talks*

The increase in disputational talk does not necessarily have negative connotations as Barbieri and Light (1992) have pointed out the importance of using talks to reconcile conflicting suggestions for action. In the bag-making unit, disputational talks had increased during product communication in all the settings, which is different in the windmill unit where disputational talks decreased in the case of rural Marathi students.

5.4.2 Comparisons based on gender groups

Figure 5.16 shows the contribution of talks by each gender group. The most frequent talk was from single-sex boys' groups (40%), followed by single-sex girls' groups (33%) and least talk was observed in the mixed-sex groups (27%).

Figure 5.16: Percentage of talks in single-sex and mixed-sex groups windmill unit

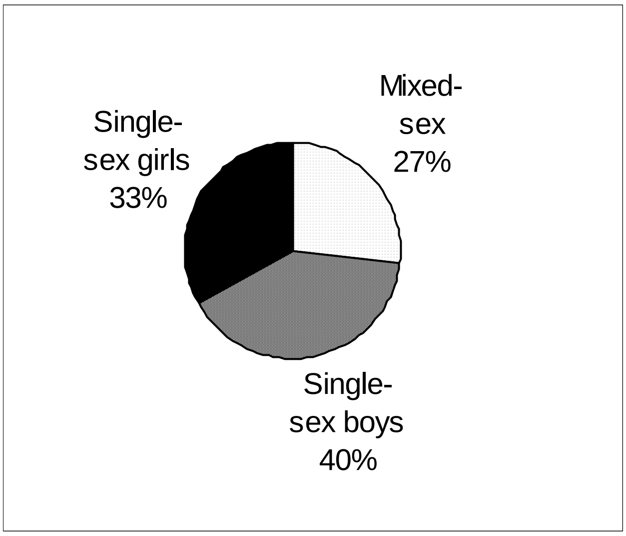


Table 5.11 compares the frequency of talks in the three gender groups for design and product communication during the windmill unit.

Table 5.11: Genderwise distribution of talk for design and product communication in windmill unit

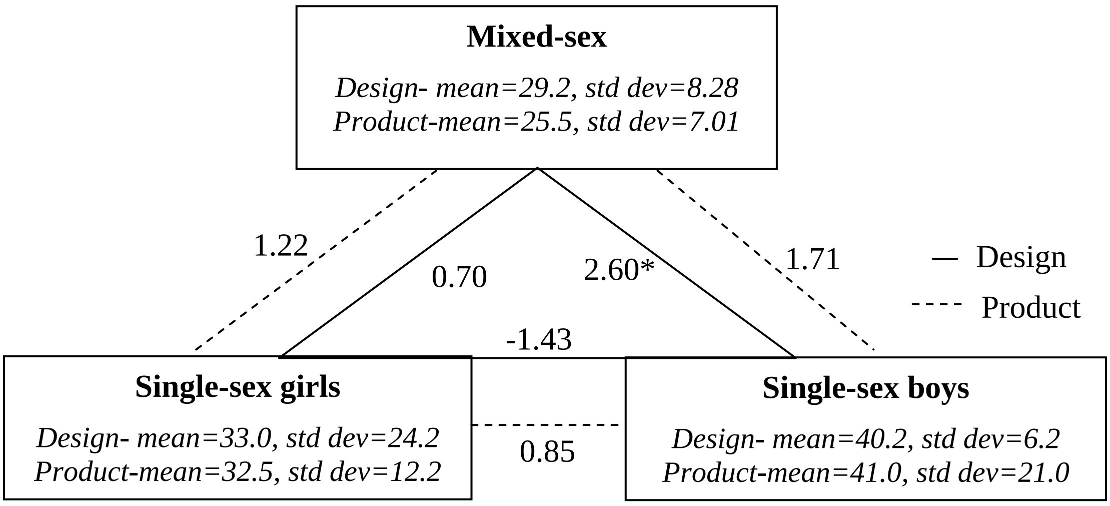
Gender groups	% Dialogues in Design Communication	% Dialogues in Product Communication	%Total
Single-sex girls	32 (198)	33 (195)	33 (393)
Single-sex boys	39 (241)	41 (246)	40 (487)
Mixed-sex	29 (175)	26 (153)	27 (328)
Total	51 (614)	49 (594)	(1208)

**Figures in brackets indicate the frequency of talks*

It is to be noted in Table 5.11 that in case of single-sex girls' groups there was not much difference in the percentage of talks exchanged during design and product communication. There was an increase in the percentage of talks in single-sex boys' groups during product communication (from 39% to 41%) and a decrease in talks in the case of mixed-sex groups (from 29% to 26%). In the mixed-sex groups, boys exchanged more dialogues (186/328) as compared to girls (137/328) and there were 5 dialogues in which all the group members spoke together. This observation of single-sex boys' groups contributing to most dialogues, followed by single-sex girls' group and least by mixed-sex group was also seen in the bag-making unit (Table 5.5).

Figure 5.17 gives the comparison between gender groups for windmill unit. Statistically significant differences were found during design communication between mixed-sex group (175) and single-sex boys' groups (241) (t-value= 2.60). However no significant differences were found between any groups during product communication.

Figure 5.17: Graphical representation of t-values across gender groups for design and product communication during the windmill unit



** indicates significance at p<0.05, df=10*

Table 5.12 presents a comparison of the percentage of the kinds of talk in each of the gender groups for design and product communication. Majority of dialogues exchanged in all the gender groups were of the cumulative kind, followed by exploratory talks and least were disputational talks. This pattern of talks remained similar for all the 3 gender groups. Similar pattern of talks for overall frequency was observed for bag-making unit when all the groups were compared for each of the kind of talks (Refer Table 5.5). Disputational and exploratory talks increased during product communication in all the gender groups while cumulative talks decreased during product communication. In the single-sex girls' groups, increases in disputational and exploratory talks were the highest. Disputational talks increased almost 2 times while exploratory talks increased was almost 3 times.

Table 5.12: Percentage of talks during design and product communication in the gender groups during unit on windmill

Gender groups	**Single-sex girls**		**Single-sex boys**		**Mixed-sex**	
	Design	**Product**	**Design**	**Product**	**Design**	**Product**
Disputational	10 (11)	22 (23)	17 (18)	25 (26)	9 (10)	17 (18)
Cumulative	21 (162)	12 (95)	23 (179)	16 (123)	19 (143)	9 (69)
Exploratory	8 (25)	23 (77)	13 (44)	29 (97)	7 (22)	20 (66)
Total	(393)		(487)		(328)	

**Figures in brackets indicate the frequency of talks*

Table 5.13 presents the comparison of talks between gender groups across settings. It is interesting to note that in all the settings, mixed-sex groups exchanged the least (328, 27%) and single-sex boys' groups exchanged the most dialogues (487, 40%) during formal communication.

Table 5.13: Percentage of talks in different gender groups in the 3 settings in windmill unit

Gender groups	**Single-sex girls**	**Single-sex boys**	**Mixed-sex**	**%Total**
Urban English	38 (150)	37 (180)	33 (109)	36 (439)
Urban Marathi	36 (142)	37 (182)	33 (107)	36 (431)
Rural Marathi	26 (101)	26 (125)	34 (112)	28 (338)
Total	32 (393)	40 (487)	27 (328)	(1208)

**Figures in brackets indicate the frequency of talks*

In Table 5.13, of the 3 settings, the two groups from the urban setting exchanged similar percentage of talks (36%) and the rural Marathi students exchanged the least (28%). In terms of the gender groups, single-sex girls' groups from the urban English setting exchanged the most dialogues (150, 38%) and least dialogues was exchanged among rural Marathi single-sex girls' groups (101, 26%). Single-sex boys' groups in both the urban settings exchanged similar percentage of talks (37%). In the mixed-sex groups, students from all the 3 settings exchanged almost similar percentage of dialogues (33% to 34%).

5.4.3 Summary

The windmill unit was the second unit to be tried with the students. Windmill was a more complex activity as compared to bag-making. More dialogues were exchanged during design communication as compared to product communication, unlike the bag-making unit where a higher percentage of dialogues were exchanged during product communication. Students from urban Marathi and urban English settings contributed to the maximum number of dialogues and students from rural Marathi were least interactive during formal communication. Overall there were no significant differences between in the frequency of talks in any settings. However there were significant differences in product communication between urban English and rural Marathi groups. There was a reduction in cumulative talk observed during product communication as in the bag-making unit and increase in disputational and exploratory kind of talks. Single-sex boys' groups exchanged most dialogues, followed by single-sex girls' groups and mixed-sex groups were least interactive during formal communication. Within the mixed-sex group, boys contributed to more dialogues as compared to girls. Similar pattern with respect to gender groups was observed in the bag-making unit. There were significant differences found in talks exchanged between mixed-sex group and single-sex boys' groups during design communication. On comparing the mixed-sex groups across the 3 settings, it was observed that students from all the settings exchanged almost similar percentage of talks. This also means that the students of mixed-sex groups from rural Marathi setting were almost as good as their peers in the same kind of gender group from the urban settings.

5.5 Analysis of communication in the unit on Puppetry

The unit on puppetry was the third and the final unit that was tried with students. The unit on puppetry had the same kind of sample (with 3 settings - urban English, urban Marathi and rural Marathi) as of the bag-making and windmill units. The details of students who participated in the trials of puppetry unit are given in the chapter on Methodology (Refer section 4.3). The puppetry unit required students to collaborate across time and tasks towards the macro task of putting on a successful puppet show. As in other two units, for this unit also, two researchers in the team coded the transcripts of formal communication dialogues that took place during design communication and product communication, independently. Some results of formal communication during puppetry unit have been presented at a conference (Mehrotra et al., 2007 c). The percentage agreement between raters for design communication was 82% and for product communication was 67%. The average time taken for design communication was 3 minutes and for product communication was 5 minutes.

Figure 5.18: Members of a group from Urban Marathi setting during formal product communication in puppetry unit

The unit on puppetry as visualized by us involved 2 levels of collaboration – one among the group members in a setting to design and make the puppet and another level of collaboration among all groups to put up a show. Figure 5.18 is a picture of students formally presenting about their puppets. During the trials of the unit, care was taken to include local socio-cultural aspects along with technological concepts in including materials, form and function which provided a richer technological experience (as commented by Moreland and Cowie, 2007). By situating the unit in the local context we were able to get the students to associate themselves actively in the designing, making and the evaluation process. The interweaving of social/local with technology concepts helped students to relate their daily life experiences with the project at hand. While commenting on the technological literacy concepts included within our unit of puppetry Dakers (2007, p.133) said, "…the activity combines many contexts beyond fabrication…broadens the learning experience to take account of expressive aspects which serve to convey messages within a socio-cultural context…allows the students the freedom and space to socially contextualize the activity for themselves, through communication and collaboration." These were some of the reasons why students' participation in this unit was high.

The analysis of the coded dialogues is given in Table 5.14. Over all 1049 dialogues were exchanged during design and product communication. The number of dialogues exchanged during product communication was almost double as compared to design communication. There were more verbal exchanges in the product communication (650, 62%) for all the groups across the 3 settings as compared to design communication (399, 38%). The increase in frequency of talk from design to product communication was similar to the bag-making unit but unlike the windmill unit.

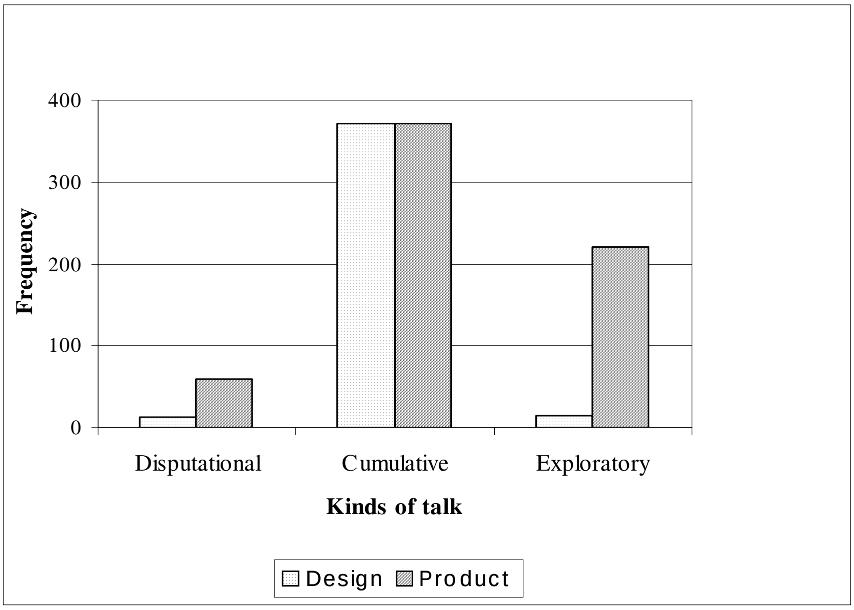
Table 5.14: Kinds of talks exchanged in design and product communication during puppetry unit

Types of talk	% Dialogues in Design Communication	% Dialogues in Product Communication	%Total
Disputational	3 (13)	9 (60)	7 (73)
Cumulative	93 (372)	57 (370)	71 (742)
Exploratory	4 (14)	34 (220)	22 (234)
Total	38 (399)	62 (650)	(1049)

**Figures in brackets indicate the frequency of talks*

Of the 3 kinds of talks, cumulative talks had the highest frequency (742, 71%), followed by exploratory talks (234, 22%) and least number of dialogues exchanged was of the disputational kind (73, 7%). Similar pattern of talks was observed for bag-making as well the windmill unit (Table 5.1 and Table 5.7). During product communication, exploratory talks increased by almost eight times and disputational talks doubled. However, cumulative talks reduced from 93% to 57%. Similar pattern of talks was also observed in bag-making and windmill units. Fernandez et al. (2001) carried out studies of conversations of children working on computer and they found that exploratory talks were used the least and disputational talks were most frequently used talks by children participating in the study. They explicitly taught the participants ground rules for exploratory talk and in the post-test, students' performance on group tasks improved. Wegerif (2002), in his study interprets the increase in exploratory talk as indicative of students being able to change their minds in response to good arguments. Figure 5.19, shows the comparison of the 3 kinds of talks in design and product communication.

Figure 5.19: Comparison of talks in the 3 settings during design and product communication in the puppetry unit



During the puppetry unit, students in all the settings had to come up with a common story from where they would choose the characters to make as puppets. In each of the settings, all the groups were asked to come up with a story with 6 characters and present it to others groups in their setting and after all the groups had presented their stories, a common story would be selected by consensus. After a common story was chosen, all the members in a setting could choose to modify the story or some character of the story, if they desired. Once the story for the puppet show was finalized, each group had to choose a character and make its sketch (draw and write) and ultimately make a puppet of it. In this way each setting had 6 puppets made for the puppet show, which was to be performed at the end of the unit.

During formal communication of design in the puppetry unit, a group of students came up and gave details about the character they were going to make and what procedures would they follow for making the puppet. As in the other 2 units, students were required to make sketches, technical drawings, procedural maps, write about the character, the materials needed and the work distribution with in the group. It was observed that during design communication, urban English and urban Marathi students gave brief descriptions of their characters. Their descriptions were mostly restricted to the physical and behavioural characteristics of the puppet while in the rural Marathi setting, students tended to give long descriptions of their puppet character. The following excerpts (Example 1 and 2) given in Box 5.9 are transcripts of students describing the physical and behavioural characteristics of their group's puppet.

Box 5.9: Emphasis on physical and behavioural characteristics of puppets during formal communication

Example 1: G1 (member of the presenting group, describing a tribal male): *Characteristic: Costume- leaves of tree, Age- 20-25 years, Colour of skin- Wheatish and black, Hairstyle- Simple hair, Voice- (mimicked), Body structure- Medium height and fat, Work/Occupation- Protecting the forest goddess, Movement- of hands, legs, back and front, Time- 3 hours for making, Behaviour- That of a person with a good attitude, Expressions- Angry or compassionate.* (Single-sex girls' group, Urban Marathi setting)

Example 2: G1 (member of the presenting group, describing a female villager): *This lady lives in Aathgoan and is a farmer. She is standing on her farm to cut grass. She has worn a Marathi sari and green bangles with it….she is loving by nature and is 45 years old. She has a red bindi on her forehead…she has worn a nose pin and earrings…she has worn chappals and her sari is also green…Her name is Shantabai.* (Single-sex girls' group, Rural Marathi setting)

During design communication, it was observed that in all the settings, audience asked very few questions and most of the questions asked were factual in nature. Example of a question asked from a mixed-sex group named Aashirwad, from rural Marathi is given below as example 1 in Box 5.10.

In the product communication, it was observed that students once again described the character of their puppet, the procedure they followed to make, results of its evaluation, gave suggestions for improvement of their puppet and priced their puppet. As in other units, audience asked the presenting group questions on their artefact and the process of making. There were more questions from the audience during product communication as compared to design communication and more elaborate answers to those questions also, though most of the questions asked were once again factual as exemplified in the transcript given as example 2 in Box 5.10.

Apart from factual questions, other kinds of questions asked by students in the product communication were more open ended and evaluative in nature and their explanations were more vivid. Example 3 in Box 5.10 gives a question asked to a mixed-sex group named Fantastic four in the urban English setting.

Box 5.10: Examples of questions asked during formal communication in puppetry unit

Example 1: Audience (boy): *Where does he live? What does he eat? What is his occupation?*

G1 (member of the presenting group): *He stays in Bhinar [name of a village]. His occupation is farming.* (Question asked from a Mixed-sex group, Rural Marathi setting)

Example 2: Audience (girl): *How is his behaviour?*

G1 (member of the presenting group): *He behaves lovingly with all.*

Audience (girl): *What is his dress like?*

G1 (member of the presenting group): *White dhoti [wrap around] and green banian [vest].* (Question asked from Single-sex girls group, Rural Marathi setting)

Example 3: Audience (Boy): *How could you have got expressions on the face [of the puppet]?*

G1 (member of the presenting group): *We could have made a conical nose and stuck it here, then it would look more like a dwarf. We could have put cotton here* (indicating above the eyebrows), *then it would have looked a little old.* (Mixed-sex group, Urban English setting)

In product communication, students also talked of the problems faced by their group while making the puppet. An example is given below in Box 5.11.

Box 5.11: Communication of problems encountered during making by students in formal product communication

B1 (member of the presenting group): *Initially while making our puppet's hands, we had stitched them on the outer side (also indicated by pointing gestures to the puppet shoulder joint). Therefore, it was looking ugly. Even the neck we had stitched like this, and this was also looking ugly. To improve this (make it look better) with the help of glue we stuck and stitched the hands from inside and made our Aadivasi [tribal].* (Single-sex boys' group, Urban Marathi setting)

Overall students paid a lot of attention to the aesthetic aspects of their puppet character and this was communicated in their formal communication. Hennessy and Murphy (1999) have also observed in their study with secondary school children that in open-ended tasks, pupils were mostly concerned with minor or aesthetic details of the product.

Figure 5.20: A drawing of a puppet character emphasizing the accessories (Urban Marathi - Single-sex girls' group)

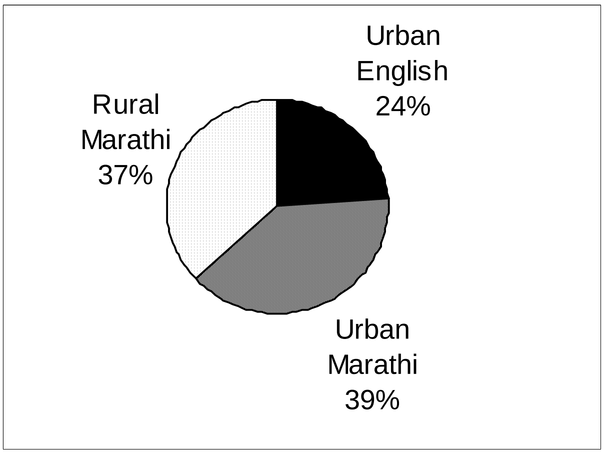
Box 5.12: Description of physical appearance of the character emphasizing accessories

G1 *(*member of the presenting group): *7 cm circle for face, pale orange colour, 3 bracelets to wear on hands and 3 anklets to wear in legs, 2 necklaces made of beads, necklace of sea-shell and beads, etc.* (Urban Marathi – Single-sex girls' group)

5.5.1 Comparisons based on socio-cultural settings

Figure 5.21 presents the distribution of the percentage of talks in the 3 settings. Overall the urban Marathi setting had the maximum interactions (414/1049, 39%) followed by the rural Marathi setting (383/1049, 37%) and the least number of interactions were observed in the Urban English (252/1049, 24%).

Figure 5.21: Percentage of talks in the 3 settings for puppetry unit



This pattern (of talk profile), of students from the rural Marathi setting contributing more to the interactions than students from urban English setting occurred for the first time and that students from urban English setting contributed so little to total interactions also occurred for the first time in our trials. As mentioned, in bag-making students from the rural Marathi setting were shy during their formal communication and after repeated exposure to the researchers they could have overcome the shyness. Another contributing factor could be that perhaps this unit was more appealing to rural Marathi students than the earlier units and thus they were able to communicate more during design and product communication.

Table 5.15 presents the frequency of talk in each of the 3 settings for design and product communication. The number of dialogues exchanged during product communication (650, 62%) was more than design communication (399, 38%). For design communication, rural Marathi setting exchanged the maximum frequency of dialogues (255, 64%), followed by urban Marathi (81, 20%) and the urban English students (63, 16%). During product communication this pattern differed. The case of rural Marathi setting is interesting here. The frequency of talks in the rural Marathi setting reduced by more than half (from 64% to 20%) during product communication whereas in the other settings there was an increase by around 50%. This increase was more in the case of urban Marathi students who increased from 20% to 51% than the urban English students who increased from 16 % to 29%. The contribution of rural Marathi students to the total pool of talks (383, 37%) comes mainly from their formal communication during the design phase.

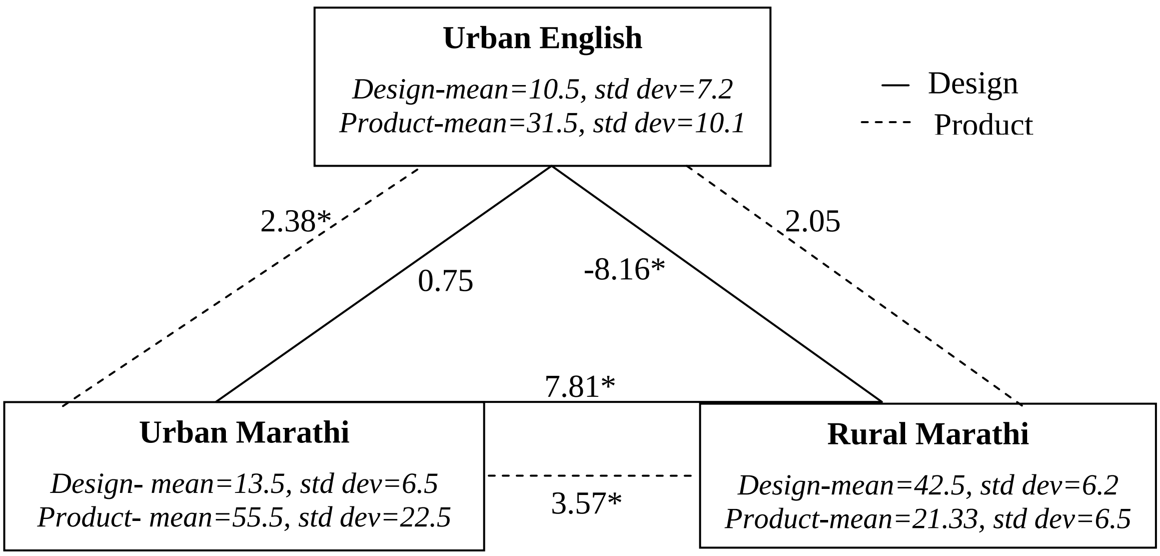
Table 5.15: Dialogues exchanged during design and product communication in the 3 settings during the puppetry unit

Settings	% Dialogues in Design Communication	% Dialogues in Product Communication	Total
Urban English	16 (63)	29 (189)	24 (252)
Urban Marathi	20 (81)	51 (333)	39 (414)
Rural Marathi	64 (255)	20 (128)	37 (383)
Total	38 (399)	62 (650)	(1049)

**Figures in brackets indicate the frequency of talks*

The comparison of talks across the settings for design and product communication is presented in Figure 5.22.

Figure 5.22: Graphical representation of t-values across settings for design and product communication during puppetry unit



**indicates significance at p<0.05, df=10*

As can be seen in Figure 5.22, significant differences in design communication were observed between urban English (63) and rural Marathi (255) settings (t-value =8.16) and also between urban Marathi (81) and rural Marathi (255) settings (t-value=7.81). In case of product communication, statistically significant differences were found between urban English (189) and urban Marathi (333) settings (t-value=2.38) and also between urban Marathi (333) and rural Marathi settings (128) (t-value =3.57).

Table 5.16 gives the comparison of the three kinds of talks for design and product communication in the 3 settings. As can be seen in the table, there is an increase in disputational and exploratory talks and a reduction in cumulative talks in all the 3 settings for product communication. The increase in disputational and exploratory talk from design to product communication was also seen for the bag-making and windmill unit for this setting (Table 5.4 and Table 5.10). The increase in exploratory talks during product communication was most for urban Marathi (2% to 39%), followed by urban English (16% to 42%). It is interesting to note the pattern of disputational talks. In the rural Marathi setting, the increase in disputational talks during product communication is almost negligible while maximum increase occured in the case of urban English (from 6% to 18%). This pattern of low increase in disputational talks during product communication in case of rural Marathi and more increase in the case of urban English was also observed in bag-making and windmill.

Table 5.16: Comparison between the settings for design communication and product communication for puppetry unit

Kinds of talks	Urban English		Urban Marathi		Rural Marathi	
	%Design	**%Product**	**%Design**	**%Product**	**%Design**	**%Product**
Disputational	6 (4)	18 (34)	0	6 (21)	4 (9)	4 (5)
Cumulative	78 (49)	40 (76)	98 (79)	55 (182)	96 (244)	88 (112)
Exploratory	16 (10)	42 (79)	2 (2)	39 (130)	1 (2)	9 (11)
Total	(63)	(189)	(81)	(333)	(255)	(128)

**Figures in brackets indicate the frequency of talks*

5.5.2 Comparisons based on gender groups

Figure 5.23 presents a pie chart with the contribution of talks by the 3 gender groups. As can be seen in Figure 5.23 that single-sex boys' groups exchanged most dialogues (389/1049, 37%), followed by single-sex girls' groups (339/1049, 32%) and the least frequency of dialogues were exchanged in the mixed-sex groups (321/1049, 31%). Similar trend was also seen in bag-making and windmill units.

Figure 5.23: Percentage of talks in single-sex and mixed-sex groups for puppetry unit

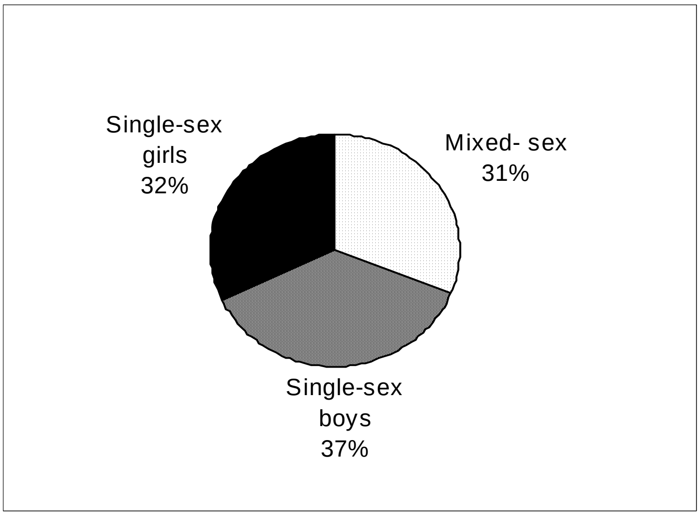


Table 5.17, shows the distribution of talks in design and product communication by the three gender groups. As can be seen in the table, the frequency of talks in single-sex girls' groups reduced from 34% to 31% and for the mixed-sex groups it reduced from 36% to 28% during product communication, while the frequency of dialogues exchanged increased in the case of single-sex boys' groups (from 30% to 41%). Of the 321 dialogues exchanged in the mixed-sex group, girls contributed to more number of dialogues (172) as compared to boys (149). This is the first time in all the 3 units, where the girls in the mixed-sex group have contributed to more dialogues as compared to the boys in the group. The pattern of increase of talks in single-sex boys' groups was seen in the windmill unit and decrease in talk in single-sex girls' group during product communication was not seen in the earlier two units (Refer Table 5.5, Table 5.11).

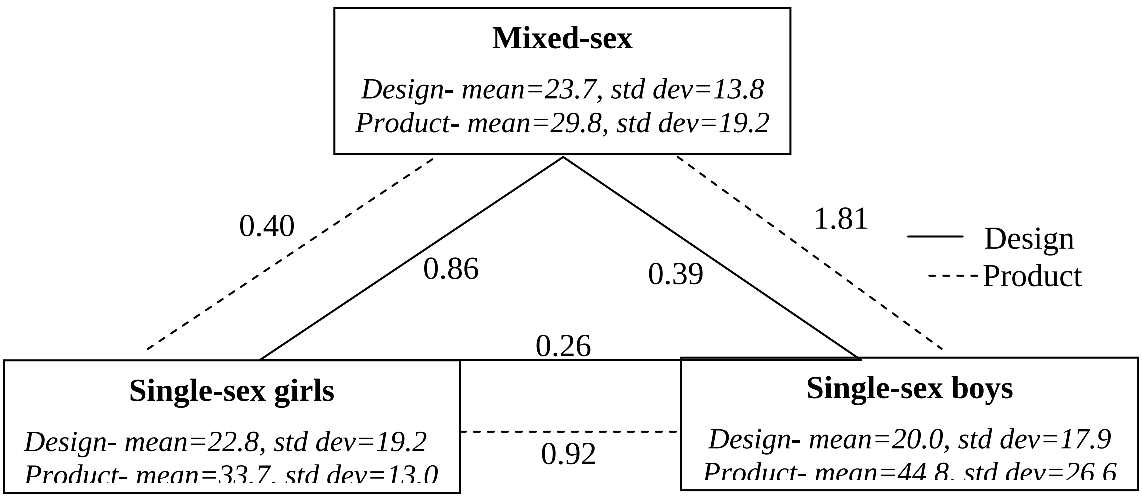
Table 5.17: Genderwise distribution of talks for design and product communication during puppetry unit

Gender groups	% Dialogues in Design Communication	% Dialogues in Product Communication	%Total
Single-sex girls	34 (137)	31 (202)	32 (339)
Single-sex boys	30 (120)	41 (269)	37 (389)
Mixed-sex	36 (142)	28 (179)	31 (321)
Total	38 (399)	62 (650)	(1049)

**Figures in brackets indicate the frequency of talks*

Figure 5.24 presents the comparison of the frequency of talks in the 3 gender groups for design and product communication. As can be seen from the figure, there is no statistically significant difference between any of the gender groups for design and product communication for the puppetry unit.

Figure 5.24: Graphical representation of t-values across gender groups for design and product communication during puppetry unit



** indicates significance at p<0.05, df=10*

The comparison of each kinds of talk in the 3 gender groups for design and product communication is presented in Table 5.18. There was an increase in disputational and exploratory talks for all the gender groups for product communication. This trend of talks was also found in the bag-making and windmill units. The increase in disputational talks during product communication was maximum in the case of single-sex boys' groups (from 1% to 30%) and least in the mixed-sex groups (from 10% to 27%). Maximum increase in exploratory talks occurred in the single-sex boys' groups (from 0% to 34%) and least in the mixed-sex groups (from 5% to 29%). The pattern of cumulative talks in the three gender groups was yet different. In the single-sex boys' groups cumulative talks increased in product communication for (from 16% to 23%) but it decreased in the case of single-sex girls' groups (from 18% to 15%) and mixed-sex groups (from 17% to 12%).

Table 5.18: Percentage of talks during design and product communication in the gender groups during the unit on puppetry

Gender groups	Single-sex girls		Single-sex boys		Mixed-sex	
	Design	**Product**	**Design**	**Product**	**Design**	**Product**
Disputational	7 (5)	25 (18)	1 (1)	30 (22)	10 (7)	27 (20)
Cumulative	18 (130)	15 (112)	16 (118)	23 (167)	17 (124)	12 (91)
Exploratory	1 (2)	31 (72)	0 (1)	34 (80)	5 (11)	29 (68)
Total	(339)		(389)		(321)	

**Figures in brackets indicate the frequency of talks*

Comparison of gender groups across the 3 settings is presented in Table 5.19. Students from the urban Marathi setting exchanged the maximum dialogues (414, 39%), followed by rural Marathi students (383, 37%) and the least dialogues were exchanged in urban English setting (252, 24%). This pattern of talk where rural Marathi students do not have the least talks is unique to the puppetry unit.

Table 5.19: Percentage of talks in different gender groups in the 3 settings in unit on puppetry

Gender groups	Single-sex girls	Single-sex boys	Mixed-sex	%Total
Urban English	25 (86)	22 (84)	26 (82)	24 (252)
Urban Marathi	34 (115)	46 (179)	37 (120)	39 (414)
Rural Marathi	41 (138)	32 (126)	37 (119)	37 (383)
Total	32 (339)	37 (389)	31 (321)	(1049)

**Figures in brackets indicate the frequency of talks*

As can be seen in Table 5.19, single-sex boys' groups exchanged the most dialogues (389, 37%), followed by single-sex girls' groups (339, 32%). Similar trend was observed in the windmill unit (Table 5.12) and also in the bag-making unit (Table 5.6). Within the single-sex boys' groups we see a contrast. While the single-sex boys' groups from the urban Marathi setting exchanged the highest percentage of talks (179, 46%), single-sex boys' groups from the urban English setting contributed the least percentage of dialogues (84, 22%) for this unit. Among the single-sex girls' groups, rural Marathi girls contributed to the maximum dialogues (138, 41%), followed by girls from urban Marathi setting (115, 34%). In the single-sex boys' groups it is the urban Marathi students who exchanged most dialogues (179, 46%) followed by rural Marathi students (126, 32%) while in the mixed-sex group both rural and urban Marathi students contribute equally (37%) to the talk. A striking observation from table is that urban English students across all the 3 gender groups have contributed the least.

Abu-Haider (1995, p. 183) has commented that 'women are more prolific conversationalists when communicating in all women's group'. In our work we found that boys were most prolific conversationalists when communicating in all boys' group. The dynamics in mixed-sex groups in the urban and the rural settings was such that an academically bright person of the group (whether a boy or a girl) directed most of the group activities and was the most active person of the group. By a co-incidence, it so happened that in each of the settings one mixed-sex group, was led by a boy and the other was led by a girl. Literature in the area of grouping has given some mixed findings. Despite equivocal achievement Howe (1997), has indicated that groupings with equal numbers of boys and girls may be preferable to allow balanced discussion across genders (Slavin, 1990; Webb, 1991). Research also indicates that stable groupings over time improve collaborative activity and achievement.

Qualitatively within mixed-sex groups, when students worked on a problem, the girls and the boys within a group tended to form sub-groups and the work got divided or taken up according to the skills possessed by the members. In most instances girls would stitch the puppet while the boys would make paper cuts, mark measurements and arrange for materials. Even in those mixed-sex groups where girls were the 'leaders', they chose to take up much of the stitching tasks. Browne and Ross (1995) have observed that from a very young age children seem to have clear ideas about what work is for girls and what boys do. This could be true for our tasks too. We also observed that while the units were in progress, girls seemed to care about interpersonal relationships - they tried to resolve or avoid cross-sex misunderstandings and often acted as mediators.

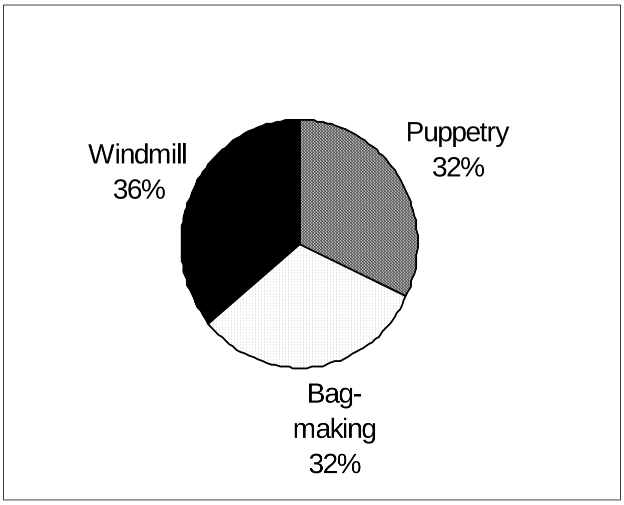
5.5.3 Summary

The unit on puppetry was the final unit to be tried with students in our sample. The puppetry unit involved students in 2 levels of collaboration - one at the group level and the second collaboration occurred when groups had made their puppets and needed to put up a puppet-show. There were more dialogues exchanged during product communication as compared to design communication. Similar pattern was seen in the bag-making unit. There was increase in exploratory and disputational talk in the product communication as was the case in bag-making and the windmill units. Students from the urban Marathi setting had the highest frequency of talk and urban English students had the minimum frequency of talk during design and as well as product communication. Rural Marathi students participated most actively during design and product communication in this unit as compared to any other unit. For design communication, differences were found between urban English and rural Marathi settings and also between urban Marathi and rural Marathi settings. For the product communication statistically significant differences were found between urban English and urban Marathi and also between urban Marathi and rural Marathi. Among the gender groups, it was observed that single-sex boys exchanged the most frequency of dialogues, followed by single-sex girls and by mixed-sex groups. Among students in mixed-sex groups, girls contributed to more dialogues as compared to boys for the first time in all the 3 units. Within each gender group students from the urban English setting have contributed least to the dialogues. There were no statistical differences observed between any gender groups for design and product communication.

5.6 Comparison of talks across the 3 units

In all the units that we tried with the students (bag-making, making a model of windmill that could lift some weights and making a puppet and putting up a puppet show) the frequency of dialogue exchanged varied with the units. Figure 5.25 presents the frequency of dialogues exchanged in the 3 units. Overall the frequency of talks during the windmill unit was the highest (1208, 36%), followed by the bag-making unit (1071, 32%) and the puppetry unit (1049, 32%). In the bag-making and the puppetry units students took more time for product communication, while for the unit on windmill, students took more time during design communication as compared to product communication.

Figure 5.25: Percentage of talks exchanged in the 3 units



The comparison of dialogues during design and product communication in the 3 units is presented in Figure 5.26. The bag-making and puppetry units have similar profile of talks and differ from the windmill unit. The bag-making and the puppetry unit had more exchange of dialogues during product communication while in the windmill unit, the opposite occurred. In the windmill unit dialogues exchanged during design communication were more as compared to product communication.

The possible reasons for the differences could be the fact that bag-making and the puppetry unit involved elements of personal use and students had greater familiarity to the artifacts. Students were more acquainted with the materials and the tools required for making bags and puppets as well as some part of its procedure and it seems that this familiarity could have affected their frequency of dialogues. On the other hand, making a windmill that could lift some weight was a problem that was probably not at the same level of familiarity to the students as bag-making and puppet. The windmill unit was a novel experience for students.

Another difference in the 3 units was the level of technical complexity involved. Bag and puppet are relatively simple artifacts that require relatively fewer skills in making and so the talks during design communication were less. During product communication in both these units, students gave detailed descriptions of the artefact and their groups' procedure for making it – this elicited more participation from other students in the setting and questions on their procedure and consequently frequency of talks in product communication was more than the design communication. On the other hand, windmill is an object that is mechanical and complex and involves various parts and movements of these parts and so the skills and the concepts needed in making the model were more complicated and students discussed about these more within their own groups as well as across the groups. The product communication in windmill involved students reporting the performance of their windmill in lifting weights and the angle at which their model worked the best and the number of rotations it could make per minute. Reporting of this 'empirical' kind of data/observations had lesser scope for discussions among the groups and consequently the frequency of dialogue exchange in product communication for windmill was less as compared to design communication.

Figure 5.26: Comparison of 3 units for design and product communication

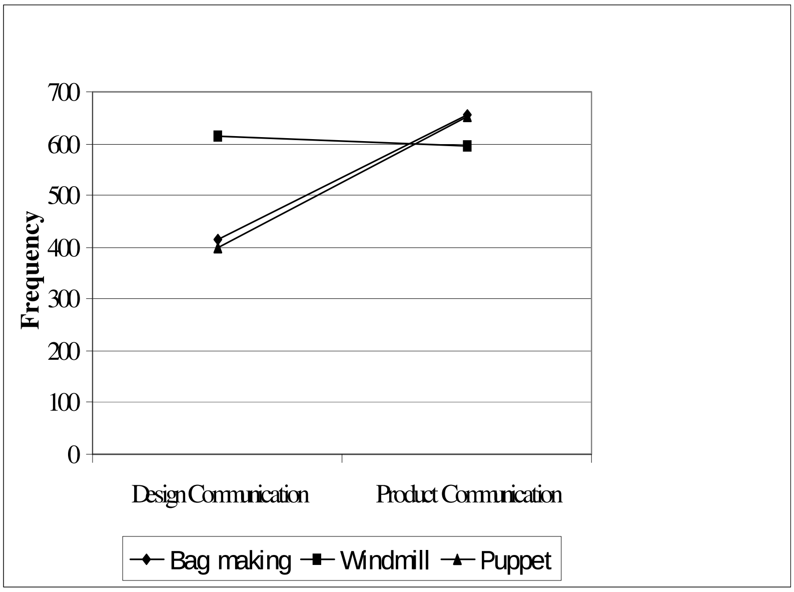


Table 5.20 presents the profile of talks during the 3 units for design and product communication. Overall there was more exchange of dialogues during product

communication (1900, 57%) as compared to design communication (1428, 43%). Of the 3 kinds of talks, cumulative talks were highest (2119, 64%), followed by exploratory talk (882, 27%) and disputational talks (327, 10%). As can be seen from Table 5.19, cumulative talk though having the highest frequency, decreased to almost half during product communication while disputational and exploratory talks increased almost thrice. The increase in exploratory talk was greater as compared to increase in the disputational talk.

Table 5.20: Overall dialogues (in all the settings) for design and product communication for all the 3 units taken together

Types of talk	% Dialogues in Design Communication	% Dialogues in Product Communication	%Total
Disputational	5 (74)	13 (253)	10 (327)
Cumulative	83 (1191)	49 (928)	64 (2119)
Exploratory	11 (163)	38 (719)	27 (882)
Total	43 (1428)	57 (1900)	(3328)

**Figures in brackets indicate the frequency of talks*

The increase in overall talks during product communication (1900) as compared to design communication (1428) could be explained by the fact that after making the product students were able to talk more about it rather than at the designing stage when they were anticipating the making of product. The increase in talks during formal product communication also indicates that students learnt to draw benefit from sharing ideas, accommodating others' responses and drawing on others' understandings and incorporating them in their work. In situations where students work together in groups they tend to verbalize their understanding. Teasley (1995) found that when asked to talk aloud, students working in pairs on a task generated more elaborative talk than students who worked individually. It was suggested that in talking to someone else, knowledge becomes more elaborate because communication implies the need to be understood by the other, which results in more coherent explanations/talks.

The observation of kinds of talks in the 3 units for design and product communication is presented in Table 5.21. Overall there was an increase in disputational and exploratory talks and a decrease in cumulative talks in product communication. This pattern of increase in exploratory and disputational talks and decrease in frequency of cumulative talk in product communication that was seen in overall talks was also seen in each of the 3 units. Increase in exploratory talks indicates an increase in learning as Mercer (1996) has pointed out that exploratory talk is considered more valuable for learning because there is no automatic consensus (as with cumulative talk) or unproductive dispute (as with disputational talk), but rather, productive argument, questioning and exploration. The increase in exploratory talks during product communication for the windmill unit was the highest, followed by bag-making unit and the puppetry unit.

Table 5.21: Profile of talks in the 3 units for design and product communication

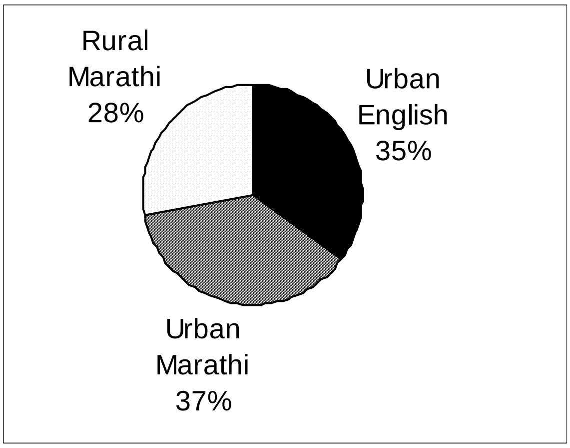
Kinds of talk	Bag-making		Windmill		Puppet		Total
	Design	Product	Design	Product	Design	Product	
Disputational	5 (22)	19 (126)	6 (39)	11 (67)	3 (13)	9 (60)	10 (327)
Cumulative	81 (335)	41 (271)	79 (484)	48 (287)	93 (372)	57 (370)	64 (2119)
Exploratory	14 (58)	39 (259)	15 (91)	40 (240)	4 (14)	34 (220)	27 (882)
Total	12 (415)	20 (656)	18 (614)	18 (594)	12 (399)	20 (650)	100 (3328)

**Figures in brackets indicate the frequency of talks*

5.6.1 Comparisons based on socio-cultural settings

The frequency of talks contributed by the 3 settings for all the 3 units taken together is presented in Figure 5.27. The maximum exchange of dialogues took place in the urban Marathi setting (1237, 37%), followed by urban English (1167, 35%) and the least exchange of dialogues took place in the rural Marathi setting (924, 28%).

Figure 5.27: Percentage of talks in the 3 settings for the 3 units



The frequency of talks in the 3 settings for design and product communication is presented in Table 5.22. In design communication, we see that students from the rural Marathi setting exchanged the maximum dialogues (585, 41%) while least number of dialogues was contributed by the urban Marathi setting (375, 26%). In the product communication, this pattern of talks was reversed and students from the urban Marathi setting exchanged maximum dialogues (862, 45%) and rural Marathi students exchanged the least number of dialogues (339, 18%). There was a decrease in percentage of talks during product communication in the case of rural Marathi setting (from 41% to 18%) whereas in urban English and urban Marathi settings there was an increase in the percentage of talks. In all the three units in all the settings, students exchanged a lot of questions. Most questions were factual in nature and there were a few evaluative questions (Refer section 5.2.1; 5.2.2; 5.2.3).

Table 5.22: Dialogues in the 3 settings for design and product communication for the 3 units

Setting	% Dialogues in Design Communication	% Dialogues in Product Communication	%Total
Urban English	33 (468)	37 (699)	35 (1167)
Urban Marathi	26 (375)	45 (862)	37 (1237)
Rural Marathi	41 (585)	18 (339)	28 (924)
Total	43 (1428)	57(1900)	(3328)

**Figures in brackets indicate the frequency of talks*

On comparing the kinds of talks across the settings (Table 5.23), it was observed that the cumulative talk was the highest (2119, 64%), followed by exploratory talks (882, 27%) and disputational talks were least frequently exchanged (327, 10%). Maximum disputational talks were exchanged in urban English setting (181, 16%) and least in rural Marathi setting (37, 4%). Cumulative talks were most frequent in rural Marathi setting (776, 84%) and least frequent in the urban English setting (616, 53%). The percentage of exploratory talks was similar in urban Marathi (401, 32%) and urban English setting (32%) and was least in rural Marathi setting (111, 12%).

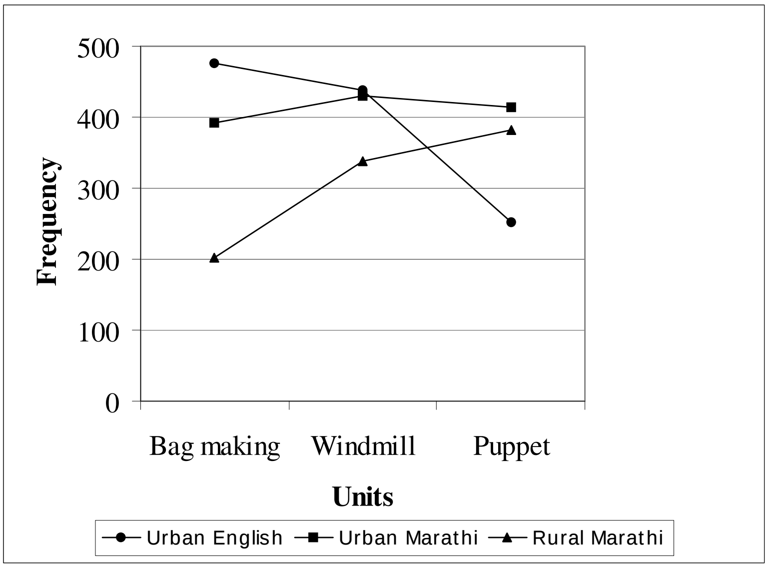
Table 5.23: Kinds of talks in 3 settings for design and product communication for the 3 units

Kinds of talk	% Dialogues in Urban English	% Dialogues in Urban Marathi	% Dialogues in Rural Marathi	%Total
Disputational	16 (181)	9 (109)	4 (37)	10 (327)
Cumulative	53 (616)	59 (727)	84 (776)	64 (2119)
Exploratory	32 (370)	32 (401)	12 (111)	27 (882)
Total	35 (1167)	37 (1237)	28 (924)	(3328)

**Figures in brackets indicate the frequency of talks*

Figure 5.28 compares the frequency of talks in the 3 units across the 3 settings. Exchange of dialogues in the 3 settings followed a similar pattern for bag-making and windmill with highest dialogues being contributed by urban English group followed by urban Marathi and least contribution from rural Marathi setting. On the other hand for puppet, maximum frequency of talks was observed in the urban Marathi setting, followed by rural Marathi and urban English setting students contributed the least to talks in puppet. Both the groups from urban area were closer to each other for two units (bag-making and windmill) than to the rural group and both the Marathi medium settings were similar in puppetry unit.

Figure 5.28: Comparison of talks in the 3 units across the 3 settings

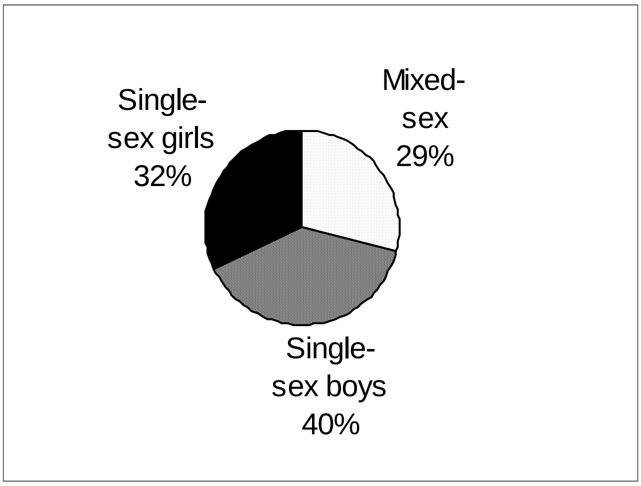


The differences in the profile of talks in rural and urban settings could be explained by the 'general acculturation' in urban and rural areas. Urban students have greater exposure to complexity and diversity, which could be responsible for differences in the performance of urban and rural students in cognitive tasks (Weisner, 1976). Bernstein (1971) suggests that differences in communication can be traced to socio-economic backgrounds. The differences between students from rural and urban areas can be explained in terms of the 'restricted' codes of communication used by students from rural Marathi medium setting. Most students from rural Marathi setting were tribals and socio-economically disadvantaged, whereas students from the urban areas were mostly from middle class families and were accustomed to 'elaborate' codes during formal communication in the class. Tizard et al. (1983) have argued that setting has a marked effect on the language of working class girls and this effect is more in terms of language style than language deficit. According to them the language style of girls from working class families changed more between home and school than that of the middle class girls. Differential home and parental experience in cities, difference in language skills and use may also be reasons for differences. Rural students in our sample were from a tribal school where they lived and studied, the school had a library that was 'malnourished' and there were far fewer opportunities for access to educational resources for these students as compared to students from urban areas. It is to be noted (as shown in Figure 5.28) here that students from rural Marathi setting improved in formal communication consistently from bag-making unit (203) to the windmill unit (338) and to the puppetry unit (383). These observations indicate that when rural students were provided the opportunity to participate in D&T units, they became more interactive and shared their views and comments openly. In the puppetry unit, the students from rural Marathi setting improved in their formal communication and could surpass the students from urban English setting. Perhaps it is nature of the puppetry unit with its challenges to imagination and creativity that prompted the rural students to participate more actively during formal communication. Puppetry is an ancient Indian art and is still popular during festivals in smaller towns and villages. Since the students from the tribal setting were from villages, there is a possibility of them being more familiar with the nuances of the art and therefore were able to better communicate.

5.6.2 Comparisons based on gender groups

Figure 5.29 presents the frequency of talks in the 3 units in the 3 gender groups during design and product communication.

Figure 5.29: Overall percentage of talks exchanged in the gender groups



In all the 3 units, single-sex boys' groups exchanged the maximum number of dialogues (1325, 40%) followed by single-sex girls' groups (1055, 32%) and least number of dialogues was exchanged in the mixed-sex groups (948, 29%). Observations similar to our study with respect to exchange of dialogues in boys and girls groups have been reported by Eckert (in Eckert and McConnell-Ginet, 2003, p.117). In her observations of fifth and sixth grade classrooms, she observed that boys talked more than girls in ‘public performance’. She also found that as students moved into preadolescence, it became ‘childish’ for girls to speak or ask questions without being sure of their statements and they wanted to avoid doing ‘stupid’ things. On the other hand, boys continued to raise hands without knowing the answer or talked even if they were ignorant about something and yet maintained their status. Maltz and Borker (1982) in their study have found that boys and girls learn to use different strategies in the same-sex peer groups. Girls’ groups tend to have an egalitarian ethos, so girls use strategies that maintain equality within groups, while boys learn to use strategies that raise their status such as attempting to seize centre stage by displaying knowledge, challenging and resisting challenges.

The frequency of dialogues exchanged during design and product communication in the gender groups is presented in Table 5.24. In trials of all the 3 units, least dialogues were exchanged in mixed-sex groups (948, 28%). The fact that students in the mixed groups contributed least number of dialogues in all the units could be an indication that in mixed-sex groups both boys and girls were restrained in talking.

Table 5.24: Dialogues in the 3 gender groups for design and product communication for the 3 units

Gender groups	% Dialogues in Design Communication	% Dialogues in Product Communication	%Total
Single-sex girls	31 (436)	33 (619)	32 (1055)
Single-sex boys	38 (545)	41 (780)	40 (1325)
Mixed-sex	31 (447)	26 (501)	28 (948)
Total	43 (1428)	57 (1900)	(3328)

**Figures in brackets indicate the frequency of talks*

In order to understand which sex in mixed-sex group was more affected, the dialogues in the mixed-sex groups were scrutinized to ascertain the speakers of the total mixed-sex dialogues. Within the mixed-sex group, boys exchanged more dialogues as compared to girls. There were 8 instances where all the group members have spoken together or the sex of the speaker could not be identified. Our results of talks in the mixed-sex groups also indicates that though both boys and girls are affected in a mixed-sex group but girls tend to be more affected than boys. In a study by Lynn Smith-Lovin et al. (1986) college students were asked to work in groups on a gender-neutral task. It was observed in the study that males and females made the same average number of contributions while they worked in the same-sex group however, in mixed-sex groups both male and female participants modified their behaviour in the direction of 'gender-appropriate' participation rates and males tended to contribute more talks and women in the group contributed less.

Figure 5.30 presents the comparison of talks in the 3 units by gender groups. As can be seen that the mixed-sex group has remained the lowest in the frequency of talks whereas the single-sex groups have changed from unit to unit.

Figure 5.30: Comparison of talks in the 3 units by gender groups

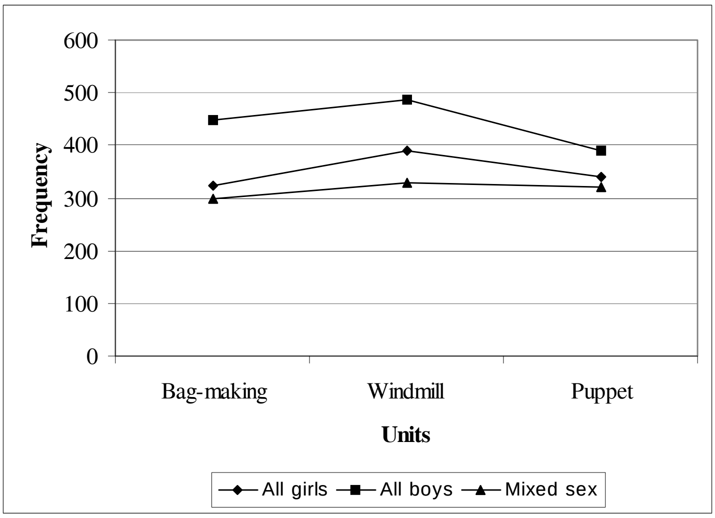


Table 5.25 presents the frequency and percentage of kinds of talks exchanged in the gender groups. Cumulative talk was most frequent (2119, 64%) in all the gender groups across the settings, followed by exploratory talks (882, 27%) and disputational talks (327, 10%). Single-sex boys' groups exchanged maximum frequency of each kind of talk, followed by single-sex girls' groups and mixed-sex groups.

Table 5.25: Kinds of talks in the 3 gender groups

Gender groups	Disputational	Cumulative	Exploratory	% Total
Single-sex girls	32 (105)	32 (671)	32 (279)	32 (1055)
Single-sex boys	38 (125)	40 (847)	40 (353)	40 (1325)
Mixed-sex	30 (97)	28 (601)	28 (250)	28 (948)
Total	10 (327)	64 (2119)	30 (882)	(3328)

**Figures in brackets indicate the frequency of talks*

Table 5.26 presents the frequency of talks in the gender groups across the 3 settings. Single-sex boys' groups contributed to the maximum percentage of talks (1325, 40%), followed by single-sex girls' groups (1055, 32%) and mixed-sex groups (948, 29%). Among the single-sex girls' groups, groups from urban Marathi setting exchanged the maximum dialogues (397, 38%), followed by girls from urban English setting (349, 33%). Single-sex girls' groups from the rural Marathi setting exchanged the least dialogues (309, 30%). In the single-sex boys' groups, the boys' groups from the urban settings exchanged almost similar percentage of talks (38%) and boys' groups from the rural Marathi setting spoke the least (324, 24%) during formal communication. Within the mixed-sex groups, groups from urban Marathi setting exchanged highest percentage of dialogues (340, 36%), followed by urban English group (317, 33%) and mixed-sex groups from the rural Marathi setting exchanged the least (291, 31%).

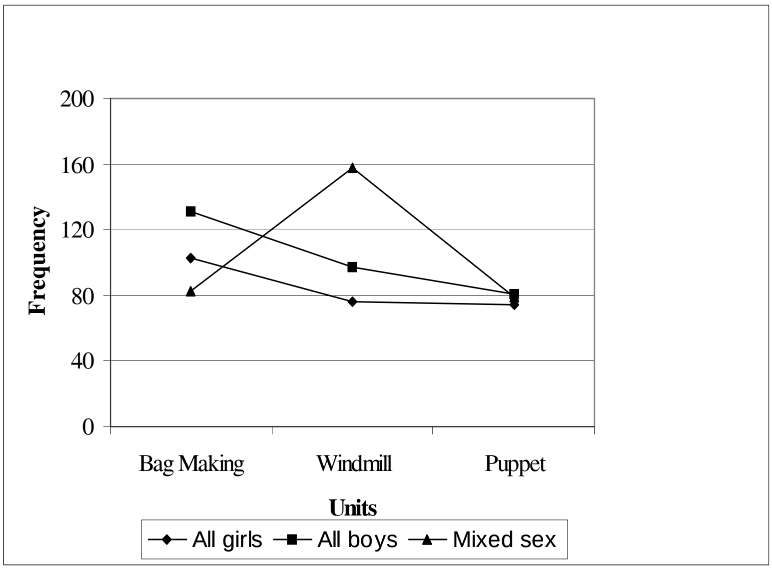
Table 5.26: Talks in all units in the 3 settings based on gender groups

Gender groups	Single-sex girls	Single-sex boys	Mixed-sex	%Total
Urban English	33 (349)	38 (501)	33 (317)	35 (1167)
Urban Marathi	38 (397)	38 (500)	36 (340)	37 (1237)
Rural Marathi	29 (309)	24 (324)	31 (291)	28 (924)
Total	32 (1055)	40 (1325)	28 (948)	(3328)

**Figures in brackets indicate the frequency of talks*

Of the 3 kinds of talk in the 3 settings for all the units, there was an increase in exploratory talk and decrease in cumulative talks during product communication. Figure 5.31 compares exploratory talks by group composition across the 3 settings. The figure shows that the trends in single-sex girls' groups and single-sex boys' groups were similar for all the units but it was opposite in mixed-sex group. Exploratory talks were lowest for puppetry for all the groups but for the windmill unit, exploratory talk was most in the mixed-sex group.

Figure 5.31: Comparison of Exploratory talks in the 3 units across the 3 settings for single-sex and mixed-sex groups



5.6.3 Summary

Overall the frequency of talks exchanged in product communication was more than design communication. This pattern of talk did not hold true for all the 3 units. In the windmill unit, frequency of dialogues exchanged during design communication was higher than product communication while in the bag-making and the puppetry units the frequency of dialogues exchanged for product communication were more. From this pattern, there seems to an indication that the frequency of talk in formal communication depends on the nature of the units. Cumulative talk decreased in product communication in all the 3 units while there was an increase in exploratory and disputational talks. Exploratory talks were least common in the puppetry unit and most often used in the windmill unit. Exchange of dialogues in the 3 settings followed a similar pattern for bag-making and windmill, with highest dialogues being contributed by urban English, followed by urban Marathi and least contribution from rural Marathi. For puppetry, students from the urban Marathi setting contributed maximum talks and urban English contributed the least frequency of talks. Disputational talks were more common in urban groups than in rural settings and more common in single-sex boys groups than single-sex girls groups.

Overall, single-sex boys' groups exchanged the most dialogues, followed by single-sex girl's groups and mixed-sex groups. Within the mixed-sex groups in the 3 units, girls contributed to more dialogues in the puppetry unit while boys contributed to more dialogues in the windmill unit. For the bag-making unit, boys and girls in the mixed-sex groups contributed to almost similar number of dialogues. In terms of settings, students from the urban English setting exchanged the most dialogues, followed by urban Marathi and least dialogues were exchanged in the rural Marathi setting. For each kind of talks (disputational, cumulative and exploratory), single-sex boys' groups exchanged maximum frequency of talks while mixed-sex groups exchanged the least frequency.

CHAPTER 6

ANALYSIS OF INFORMAL COMMUNICATION, COLLABORATION & PEER EVALUATION

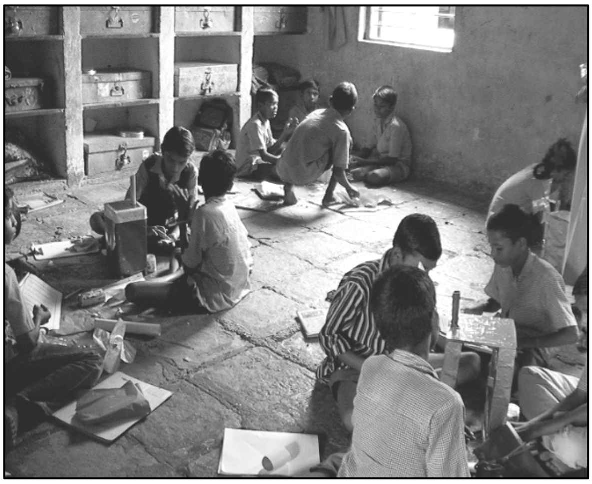
6.1 Introduction

Working together in a group or teamwork is a soft skill that is highly valued in the job market. The need for technical skills combined with soft skills such as skills of communication, effective presentation, negotiation, teamwork, social-esteem and self-management is being increasingly stressed by organizations. There have been complaints from the industry/corporates of a mismatch of skills and competencies needed in working life and those obtained by an individual at school and college (Nayak, 2003). The roots of developing soft skills lie in the school experiences of students. Technology tasks provide an opportunity where teamwork could be encouraged, not merely for completing a project with pre-determined goals but also for learning to work and operate as a team. Collaboration goes beyond mere working in groups, to synthesizing the knowledge brought to the situation by each group member (Roschelle, 1992). Collaboration or working in teams requires participation in activities of interest and concern to the learners. By its very nature, D&T is a social and collaborative endeavour and this aspect needs to be reflected in D&T education.

Just as technology tasks have a potential to encourage teamwork, similarly collaboration also has beneficial effects on learning of technology (Rowell, 2002). Rowell recommends that skills needed for collaboration have to be recognised and nurtured from childhood. Ridley (1998) argues that we come together in groups and conform to the norms of those groups, out of a human need for reciprocity. Gender also influences the processes involved in collaborations and the transition from observing to doing a task, as perceptions of teamwork may differ between boys and girls. Besides, among mixed-sex groups, different perceptions of teamwork may emerge. Studies have shown that satisfactory social relations among members of a team enhance a group's efficiency (Wood and Rhodes, 1992).

While collaboration is about ability to work in teams, informal communication refers to the casual verbal and non-verbal exchanges that take place between members of a group while working on a common task. Interactions between group members and also across groups may be used for planning, building relationship among group members apart from clarifying ideas and getting them across to the members. Informal communication helps to build shared knowledge within the group, reflecting on one's action, negotiating actions/plans and making decisions. Informal communication could take place either by verbal means or even through gestures. Informal communication helps members to exchange information on a variety of topics either directly related to the task at hand or even unrelated. Figure 6.1 shows the typical setting of the rural Marathi class during the trials of the units. This picture was taken while students were engaged in the windmill activity; it gives a feel of groups, their physical separation from other groups and the kind of informal communication occurring in the setting.

Figure 6.1: Informal communication during the unit on windmill



In D&T tasks, it is essential for students to evaluate the processes as well as their outcomes. Evaluation 'allows students to make a judgment about the aspect of design as it develops, or to reflect on the strengths and weaknesses of the design once it has been completed' (Kimbell et al., 1996, p. 70). The quality of the product/artefact being made can be judged periodically while it is being made (formative assessment) and after the intended product has been made or the goal has been achieved (summative assessment). For D&T, both these assessments are necessary (Kimbell et al., 1996).

Evaluation of quality of a product includes, identifying criteria for judgment, suggesting ways for improvement, considering alternative solutions to the problem, resolving conflicting demands to produce an optimum solution or using evaluation sheets to review progress (Kimbell et al., 1996). Both, self-evaluation as well as peer evaluation are important for assessment in technology tasks. Self-evaluation helps in reflecting on one's own work in a critical way while peer review helps students make value judgments about the worth and quality of their own and other people's products (Ritchie, 2001). According to Weaver and Cotrell (1986) a peer-rating format in an activity can encourage among the participants a greater sense of involvement and responsibility, establish a clearer framework, promote excellence, direct attention to skills and learning and provide increased feedback.

Self-evaluation and peer-assessment are often combined or considered together as they have many advantages. By judging the work of others, students gain insight into their own performance. Thus according to Brown et al. (1994), 'Peer and self-assessment help students develop the ability to make judgments, a necessary skill for study and professional life.' In our D&T units the student or the group undertook peer and self - assessment.

Apart from 'structured communication' that was built into the units, students continued interacting informally with each other within and across their groups which brought about or aided students' learning. According to Roth (1998) communication among 'communities' is indicative of students' growing competence in a field or a practice or, in other words, students' learning.

6.2 Framework used for analyzing collaboration, informal communication and evaluation

This section elaborates on our attempts to analyse the elements of collaboration, informal communication and evaluation observed while students worked in groups for the three units. This analysis has been done at the group and the larger classroom/setting level. Transcripts of video and audio-recorded data were used for analysis, supplemented with field notes. In the analysis that follows, small excerpts from transcripts from all the three units and the settings have been used to exemplify learning or change of practice that occurred in the course of the trials. The transcripts were considered natural protocols of students' efforts in making sense of events and structuring of their physical and social environment.

We focused on the informal communication and collaboration at the group level by observing group dynamics (includes roles taken by different members of a group during a group task), conflicts and resource sharing, and the observations of informal communication (both nonverbal and verbal). Analysis at the level of classroom community was done by following the emergence of shared knowledge or learning among group members, that was evident in terms of *use of techniques, practices, tools and facts learned while 'on-the-job'.* This study sought to document instances of actions (as well as talk) that can be taken as evidences for learning, as new resources and practices became available and 'diffused' throughout the setting.

With regards to evaluation and peer review, the self-evaluation as well as evaluation done by peers, of the products is presented. This is complemented by an assessment of product by the researcher. Each of the units had specific criteria on which products could be rated and the analysis is presented according to settings and gender groups.

Although it is difficult to draw definite conclusions based on instances from small transcripts and description of the associated actions, this coarse-grained analysis gives an idea of the dynamics of the classroom and the learning that occurred as a result of students working in groups.

6.3 Collaboration and informal communication at the group level

Informal communication is an important component of collaboration. It mediates interactions in collaborative technology tasks not only through verbal discourse but also nonverbally, through sharing of technical (physical) tools, drawings, writings and gestures (Dillenbourg et al., 1996). Informal communication and collaboration in our study was seen through the language used by the group members during communication and gestures used while communicating ideas and emotions.

Borden and Perkins (1999) have proposed a collaboration checklist that includes leadership, planning, decision making, conflicts, conflict resolution, capacity building, communication, connectedness, customs, political climate, rules, resources and catalysts. While most of the studies on collaboration have been done in the context of internet/computer use, Jeong and Chi (1999) have proposed several factors in an educational context, such as, cognitive conflicts, partner expertise, and amount of verbalization that are responsible for improving learning in collaboration. In our work we focused on collaboration through group dynamics, conflicts and resource sharing and informal communication.

Group dynamics or the nature of interactions that take place within groups was seen through the roles taken on by different members of the group, the relations between group members, and the environment that was maintained in the group. Rowell (2002) has analyzed group interactions in terms of establishing roles such as, manager-assistant and identities in terms of participatory contributions such as, tutoring, imaging and planning, manipulating, testing and mediated participation.

Conflicts can, in particular, affect the overall learning environment of the classroom, they exist whenever incompatible activities occur (Deutsch, 1973). Johnson and Johnson (1995) have categorized school related conflicts among students as controversy, conceptual conflict, conflict of interests and developmental conflict. Jones et al. (2000) reported the occurrence of conflicts within interacting groups over sharing of resources in classrooms. They found a gender-related patterns in how students in dyads relate to each other and the materials. In our analysis we focused on conflicts and their resolution around resource use and work distribution.

6.3.1 Roles played by different members of a group

Analysis of the video records showed that students adopted different roles within and across groups - *as leader, worker, communicator, critic, writer/artist and mediator*. This informal role-adoption was evident through patterns of behaviour or comments made by the individuals. While no leader was formally appointed, we observed that one of the members of the group tended to assume the position of a leader (clip). The 'leader' was either an academically bright student or a physically well-built one. The leader suggested ideas or initiated a line of thought and action. In the urban setting, an academically bright girl was the accepted leader of single-sex girls group; other students including boys also evinced an interest in being part of her group. A mixed group (rural) had two boys (big build, older) who were also the accepted leaders of the entire class.

In the transcript given in Box 6.1 (clip) below, a girl (G2) took on the role of the leader of the group and other members consulted her before doing any task. She even rebuked her group members. The following is an excerpt of a conversation that took place between her and her group members during the planning phase of the unit on puppetry:

Box 6.1: A group member playing the role of a leader

G1 (one girl to another girl—G2—in her group): *What do we have to do now?*

G2*: We need to make the procedural map first.*

G1: *Now?*

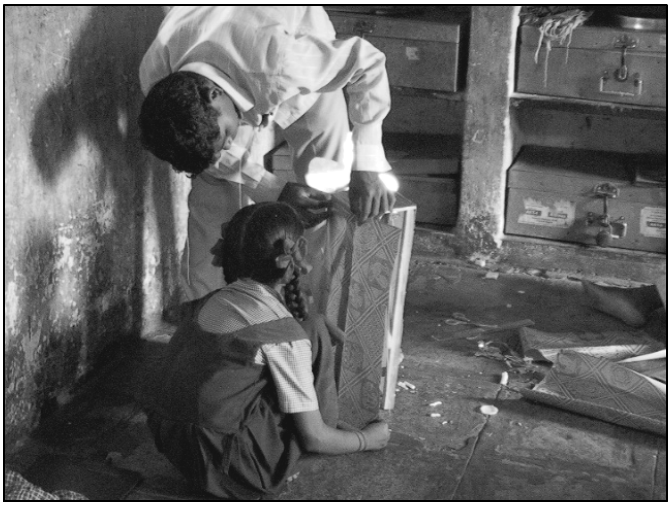
B1 (boy): *What! Procedural map also?*

G2 (to B1): *Yes. If you want to make, then make, if you don't want to make, don't make!*

(After this conversation, the group got on to making the procedural map) (Mixed-sex, Urban English setting)

In many groups there was a worker-assistant relationship seen among group members. Here one member took on the role of an assistant, helping the worker to carry out some task. Figure 6.2 shows a photograph from the rural Marathi setting during the windmill unit, where the worker-assistant relationship can be seen clearly. In this group the boy shown in the picture does most of the job while others (in this picture only 1 member is seen) help him implement his ideas.

Figure 6.2: Example of worker-assistant relationship in Rural Marathi setting



In the windmill unit, there were many groups where one specific member of the group took all the measurements, while evaluating their windmill as well as the windmill made by other groups, while another member was noting down what s/he said. This was another instance of worker-assistant relationship that often existed within the groups.

In some groups (especially the ones from rural Marathi setting), it was observed that the group members engaged in one task at a time. For example, if during bag-making activity, the group had to take measurements of the cloth then one of the members would take the measurements while other group members will help him/her out, similarly when the group engaged in making the body of the bag, then only one member would work while others would wait for him/her to finish the task and then begin the next task. This was in contrast to working of many groups in the urban setting where many tasks would be done simultaneously (clip).

Other roles that members took on depended on their possessing some specific skills like, drawing, composing poems, decorating or possessing good public speaking skills. Such members took on the roles of an *artist* (taking up the work of making drawings in the group), *writer* (writing product descriptions, story, dialogues, poems) and *communicator* (who would take a lead during formal communication).

A *mediator* would help resolve conflicts and maintained the cohesion of the group. This mediation could also be in interactions with other groups. For example, in the puppetry unit when the second level of collaboration was introduced all the groups in a setting worked together in putting up a stage show. When all the groups came together, the existing groups dissolved and regrouped to form new teams for managing stage setting, music, lights, dialogues and compering. Generally there was a bonding in the setting and the new teams emerged spontaneously. At times group loyalties played a part in making members unwelcome in the new teams as seen in the following response of two boys in the English medium setting (Transcript is given in Box 6.2, clip) in their attempts to turn away someone who was earlier in the group of one of the music team members but now not part of the music team.

Box 6.2: An example of students not welcoming new members in a group

B1 (a boy in the music team): *Go away, go away* (along with gestures)
B2 (another boy in the music team): *Why do you come here?* (Urban English setting)

6.3.2 Conflicts, conflict resolution and sharing of resources

There were many instances of disagreements among group members that were observed over the course of the trials. Often arguments took place because of unfavourable work distribution (clip), over control of resources, or having to comply with a group decision. For example in the urban English setting in the mixed-sex group, the members felt that they were being pushed into doing some tasks during bag-making activity as the following excerpt given in Box 6.3 indicates.

There were frequent debates between group members on the procedural aspects of the activity. The ability of an individual to resolve conflicts with peers helps to determine his or her level of acceptance or rejection by the peers as well as the successful completion of a task. The conflicts that occurred within or across groups were usually settled without the intervention of the researchers. However, one conflict that occurred in the English medium setting in the puppetry unit where one story had to be selected for the entire setting from 6 different stories written by the groups was hard to resolve.

It was difficult for groups to agree on a common story and discussions and arguments took nearly 30 minutes to get resolved, and that too only after the researchers' intervention. In contrast, in both the Marathi medium settings, students were able to decide on a common story relatively soon without wasting much time on arguments.

Box 6.3: Conflicts within a group

B1: (asking another member of the group- G1) *What are we going to do?*

B2 (saying it with sarcasm to another boy of the same mixed-sex group): *After she has written, we will write it in 'fair' on a new sheet- that's our work!* (Mixed-sex, Urban English setting)

Another interesting observation was in relation to the dynamics of resource use. Most of the resources for making were provided by the researchers. The dynamics of resource usage within groups in different settings was interesting. Some resources were available in plenty, while others were in limited supply. Attempts at controlling limited resources played a crucial role in leading to conflicts. In the context of trying to control limited resources such as scissors and other materials like beads for decoration etc., it was observed that boys in mixed-sex groups usually exercised control over resources and girls had fewer chances to handle these while in single-sex girls' groups tools were usually shared (clip).

Figure 6.3: Control of resources in a group during bag-making unit

Figure 6.3 (also clip) is a photograph taken during the bag-making unit in the urban Marathi setting in a mixed-sex group, where group members are trying to establish control over scissors. Studies in secondary schools have shown that girls rarely engage in playing with tools and equipment, while boys not only have more experiences, but also a perceived expertise with equipment (Jones et al., 2000). Escalation of conflicts was also a function of time. As a session neared its close, the groups preferred to have all the resources handy and were reluctant to share.

However, in our study, we observed that conflicts emerged even over abundant resources (needles and thread). Fights broke out over the sharing of small or easily available resources: members of single-sex boys' group in the urban Marathi setting prevented other group members from borrowing their needles though there was an unlimited supply of these provided by the researchers. Some groups were not willing to share common resources (sand from the garden became a commodity of contention, clip) during the windmill unit.

With regards to sharing, we found that communication space too could be shared. During formal communication, some groups gave a role to each member in public speaking, whereas in other groups this space was not shared or not claimed (clip). In one of the urban Marathi mixed-sex group, in all the 3 units, a particular boy took the lead/'limelight' by introducing the group, its members and what they were making and he announced the name of the group member who would speak. After the announcement, other members would speak.

We found evidences of sharing as well as attempts to establish control over resources. In some groups, members who completed their work helped other members and groups: in the Urban Marathi setting, members from an all-girls group provided help to a mixed-sex group in draping the puppet.

There has been an acknowledgement of the importance of tools and equipments in learning (Carter et al., 1999; Jones et al., 2000). Detailed studies have been carried out in which researchers have studied the dynamics of tool usage and its implications for learning. Carter et al. (1999), have reported in their study on students' use of science tools in a ninth grade physical science classroom that physically handling tools is an essential for learning more about the tools and that boys initially dominate the use of tools and that willingness to use tools indicates an awareness of the importance of tool usage for mediating understanding. In our study, there were instances where boys dominated the use of instruments and tools (clip). These were seen in acts of grabbing and trying to gain control over limited resources within a group (such as - scissors, hammers, rulers, toys etc., clip).

6.3.3 Nonverbal communication

Informal communication among group members is harder to track than formal communication for various reasons. One of the reasons is that informal communication need not always be verbalized. The expression of emotions and attitudes is more non-verbal than verbal. There is a need to understand the role of non-verbal behaviour - anything other than utterances - as a dimension of communicative competence (Gunawan, 2001). Non-verbal communication can be a part of verbal exchanges when some ideas or skills are being communicated, or they may be independent of verbal components. We saw the former in acts of explaining and gestures for communicating ideas and emotions, such as showing a 'V', indicating victory (successful completion of the task). Students also communicated without words, by grabbing, trying to gain control over limited resources, ignoring, maintaining eye contact or pushing and shoving. According to Roth (2002) gestures are very important indicators of learning. Gestures express new levels of understanding before students expresses their new understanding in words. In all the 3 units students used their hands and facial expressions to convey messages within their groups (clip). There have been studies that have indicated that gestures help in construction of shared knowledge and descriptions. Moschkovich (as cited by Hennessy and Murphy, 1999) conducted a study in the area of Mathematics in which students were expected to work together on problems of linear graphs and they had to reach an agreement after using computer graphing to test their predictions. It was observed that 'in the process of contesting, elaborating and clarifying their descriptions, students refined and disambiguated the meaning for many terms (e.g. 'steeper') and developed more precise descriptions of lines. (p. 7)' It was concluded that gestures, talk, everyday meanings and metaphors, and reference objects are all used by peer collaborators as coordinated resources for unpacking the meaning of a description, and for building upon each other's justifications, i.e. for moving towards shared descriptions. Figure 6.4 (clip) shows a photograph of a student from urban English setting explaining the movement of windmill blades through gestures combined with talking.

Figure 6.4: Gestures being used for communicating ideas about the motion of windmill

Physical movements were used for giving estimates of length, height of objects (See Figure 6.5 a, in rural Marathi setting during puppetry unit, clip). In one instance in the urban English setting, in the designing phase, students across groups used a ruler along with their hands to tell other groups the approximate height of their puppets, since the story characters were a mother and her two daughters, so the students discussed their heights through gestures (Figure 6.5 b, clip). In the windmill unit gestures were common when students discussed the movement/motion of the windmill. Similarly in the bag-making unit, often dimensions of the bag were discussed within the groups with hand gestures (clip). Non-verbal communication, such as ignoring or refusing to look at/listen to another, also showed gendering. Girls in mixed-sex groups often found it difficult to be heard; a boy from the urban Marathi medium continued to ignore a girl from his group, who persistently tried to contribute to a discourse, calling out to the boy "Aye, aye….." (clip)

Figure 6.5: Gestures being used by students to give estimate of length in (a) Rural Marathi and (b) Urban English setting

6.3.4 Verbal informal communication

Besides the non-verbal aspects, the informal communication also had a verbal component. We observed an interesting insight about language issues. In the English medium setting, while English was used for formal presentation, a colloquial form of Hindi was used for the informal talk. The urban Marathi medium students spoke Marathi and Hindi in their informal talk but wrote and presented in Marathi while in the rural Marathi setting, Marathi was used almost exclusively for writing, presenting and talking, with a few words in Hindi. Group members, especially those who were the leaders of the groups, used a lot of commands. Boys tended to use swear words and slang while addressing each other. These were not necessarily aggressive speech patterns. There were gender differences in the students' language use, often through explicit comments, such as, "*Yeh ladies lok ka cheez hai*"… ("This is ladies' stuff".) "It's nice that you have *ladki lok* (girls) in your group" (an urban English single-sex boys' group member to another group). Girls in mixed-sex groups often found it difficult to be heard; a boy from the urban Marathi mixed-sex group continued to ignore a girl from his group, who persistently tried to contribute to a discourse.

Table 6.1: Examples of differences in communication

Girl - Girl pair	**Boy - Girl pair**	**Boy - Boy pair**
Tell me one thing, do we insert the hands first? *(Use of 'we')* (Urban English, single-sex girls group)	*What do you think, he is- a basketball player?* (a boy commenting about the length of the sleeves on seeing the paper cut-out of the puppet) (Urban English, mixed-sex group*)*	*Hey you! Pass the needle (Command)* (Urban Marathi single-sex boys group - translated to English)

Jones et al. (2000) have also reported in their study of 8 dyads of students that males tended to use more of individualized language as compared to girls and that boys were more likely to be competitive with their partners for ideas and for access to resources. In the language that students used during informal communication, it was observed that girls often tried to use relational orientations ('we', 'us') within and across group discussions where as boys used individualized language (use of 'I', me', 'mine') more often. This can be seen in the example given in Table 6.1, which has transcripts from the puppetry unit.

Interactions within mixed-sex groups were often different from those within single-sex groups. Work distribution was often clearly gendered. Girls took on, or were allocated by their group, activities of writing and drawing (clip). On the other hand, activities such as, cutting the paper/cloth, hammering rivets, drilling and sometimes even sewing was done by boys (clip). There seemed to be a tacit assumption that the spheres of work of the two sexes are different.

In this section we looked at various elements of collaboration and informal communication that happened within groups and across groups such as group dynamics, conflict and conflict resolution, sharing of resources, verbal and non-verbal talk. Most results presented in this section have been published earlier (Mehrotra et al., 2007 b). The next section looks at learning that occurred through collaboration in the entire setting during the 3 units.

6.4 Evidences of learning through collaboration and communication at the classroom level

In the earlier sections it has been emphasised that collaboration and communication took place in the groups as well as among the individuals. The chapter on formal communication focussed on the nature of talks that occurred during the formal communication in the 3 units. Section 6.3 focussed on collaboration and informal communication at the group level. This section will focus on learning that occurred as a result of collaborations at the classroom level.

Collaborative learning is not only about collaborating to learn, but also learning to collaborate (Collazos et al., 2002), and for this reason attempts are made to assess participants' progress in terms of the quality of the learning process and not just the outcome. According to Haller et al. (2000), the use of collaborative and cooperative learning has specifically been used to retain women in engineering courses since women tend to prefer collaborative to competitive learning. Strongly positive results have been reported for women working in collaborative teams (Felder et al., 1995) although gender bias in such teams can diminish their effectiveness (Tonso et al., 1994).

6.4.1 Realization of common goals

All the units in our study were designed so that students had many opportunities for participating in collective activities. We observed that initially many students had problems working in groups together with others and many students were more concerned with achieving their own goals rather than work for collective group goals. But once students began working in groups, they accommodated to the fact that group goals (example making a windmill model that can lift some weight) were as important as individual goals (example making the parts of the windmill, attaching the assembly to the tower, decoration etc.). The following is a transcript (given in Box 6.4) between members of a single-sex girls' group in urban Marathi setting while they were making their group's bag. This conversation took place between G1 who was responsible for making the bag handles and G2 who was responsible for stitching the body of the bag.

Box 6.4: Evidence of group members having separate goals

G1 (to G2): *See if the [length] is fine for the bag.*
G2 (first ignores and then puts the handle on the bag to check its length): *It is fine…but do not make it too big…hurry up with your work…I am about to finish my work.*
G1: *I will put double stitches [on the bag handle] and it will take me time* (Single-sex girls', Urban Marathi setting)

The above transcript shows that the members of this group, although working on making a bag, were less interested in how the others in the group were doing their share of work, and were more focussed on trying to do their portion of job efficiently.

Realization of the common goal among students could also be seen in the puppetry unit, at the second level of collaboration, when all the students came together and regrouped themselves to be able to put up a successful puppet show for an audience. Students with the help of researchers chose a compère for the show, from among the group members. For choosing an appropriate person, 2-3 students often rehearsed the lines and then chose the best person as the narrator for the show.

Not only did group members realize the common goal but there were also evidences of the entire setting taking cognizance of the goals of the units and modifying their actions according to 'best fit' for the unit. For example in the puppetry unit, students in the urban English medium setting discussed across groups the heights of their puppets and through this discussion they wanted to ensure that the physical appearance of the characters of the story was in accordance of their roles/characters of mother and her two daughters (clip). The following is an excerpt, given in Box 6.5, of a transcript, where students are discussing the height of the puppets.

The transcript shows that despite each group having to make one puppet character, the groups among themselves tried to ensure appropriateness of the characters for the story and made efforts to work towards the common goal of putting up a successful puppet show. This transcript is in contrast to the transcript given in Box 6.4, where members within a group were not interested in how others in the same group worked.

Box 6.5: Evidence for realization of common goal

G1 (member of a single-sex girl's group showing to members of another single-sex boys' group, with ruler the height of the puppet that they were planning to make)
B1 (member of single-sex boys' group): *What are you making? Snow White?*
G1: nods to indicate yes
B1*: Snow White is going to be this big! (Showing surprise)…. their mother would be this small (gestures with hand the height of the puppet that their group was planning to make). How will it look in the show?….*
G2 (another member of the single-sex girl's group): *Ok we will reduce the height of our puppet*. (Urban English setting)

6.4.2 Diffusion of learning through techniques and tools

In this sub-section, 'diffusion' of learning through practices, tools, techniques and facts has been discussed under separate sub-heads with suitable examples in each. The examples given do not strictly belong to one category or the other, as it may seem in the way that it is described here, it is only for the ease of clarity. The term 'diffusion' has been used by Roth (1996) to describe the observation that more and more members of a community/classroom use a certain resource or engage in specific practice. By using these resources and adopting the practices, the community itself is transformed and by the incorporation of new members with their experiences and knowledge resources, there is learning in the entire community and hence its transformation. According to Lave and Wenger (1991) changes in the existing practices of the community are constitutive of 'progress'.

The data showed that when students knew what others were doing, they could adjust their actions, redefine their problems, utilize new materials, or build on explanations, or utilize the knowledge from their earlier experiences to solve the problem. This is exemplified by the transcript of talk (Box 6.6) that occurred during bag-making unit in the urban Marathi setting in a single sex girls' group.

Box 6.6: Evidence for diffusion of learning through techniques and tools

G1: (telling G2): *You start stitching from the other side. Take another needle.*

G3: *How do you tie a knot like this?*

G2: *Which kind?*

G3: *The one that you are tying now?*

(G1 was tying a knot to the thread at the point at which the thread had finished in the needle and a new thread needed to be put).

G1: *I did not know how to put this knot. My mother showed it to me yesterday. Yesterday only, I learnt how to stitch a button [also].*

G3: *I had never seen this before*. (Single-sex girls, Urban Marathi)

In the example given above we can see that not all the members of the group were equally at ease with stitching and one of the members who was ‘better’ at it was mainly responsible for the task. In this case, there is a clear acknowledgement by group members of not knowing the technique to stitch and a keenness to learn. In this transcript, one can see how a simple technique like stitching and learning to tie a knot is transferred from one member to another in a group through observation and practice.

All the groups worked in a single classroom and this afforded a situation in which information could be easily exchanged and students could find out about their peers’ work. In an instance during the windmill unit, one of the groups struggled to make swift moving blades of their model. Then one member of this group moved around to see how other groups were making their blades and observed a windmill model whose blades were bent at an angle (to trap air) and were moving swiftly. The member went back to her group and modelled her windmill’s blades according to what she had seen and this time the windmill model of her group worked properly.

The above incidence apart from being an instance of learning from others can also be seen as an instance of ‘copying’ or cheating that students engaged in and got their ideas. According to Vygotsky (1997) copying and mimicking are facets of learning and children do not copy/imitate mindlessly rather it is accompanied by understanding. When students work with other students who are doing similar kind of tasks, they do not just copy, rather the act can be seen as using the ideas of other people to change their ideas and to improve on them. Rogoff (1990) uses the term ‘appropriation’ to refer to a similar mechanism whereby ‘an agent reinterprets his/her own action or utterance under the light of what his/her partner does or says next’ (Dillenbourg, 1990, p. 11). There were other instances of ‘copying’ (imitation according to Vygotsky) in which the practices and tool use got transferred and embodied in other students’ thoughts and practices. Not only did students learn from each other but researchers also played a role in teaching techniques to students. Students at times told the researchers, ‘Teacher, we have forgotten “backstitch” ’ and the researchers had to tell them the technique again.

The emergence of a practice at the level of the classroom not only afforded new opportunities for learning but also changed the classroom in surprising ways. At the start of the units i.e. in the trials of bag-making unit in all the 3 settings, students avoided tasks that required skills of stitching, consequently there were very few cloth bags made (2 in urban Marathi setting, 1 in urban English setting and 2 in the rural setting). At this stage, students could manage without knowing the skill to sew by making paper bags. However in the puppetry unit, it became necessary for them to sew and they had to learn it. In the urban settings researchers had to take a small session on sewing with the students, either with the entire setting or on group basis. Students were made to practice on scraps of cloth, while in the rural setting many students knew some stitching and went ahead with it while a few needed to be taught. Thus the puppet unit ensured that all the members of the classroom had to learn the skill of sewing. It was interesting to note that, some members resisted learning the technique and they often resorted to using Fevicol (gum-sticking material) as a substitute to stitching. The example of stitching shows that change in practice did not come about instantly. It took several days for students to be convinced that they needed to acquire this skill, and while most members did acquire, some did not. Once learnt, the skill can be used in other contexts and thus there is a diffusion of learning through techniques.

In our study, we focused on a few tool related practices in the community of participating students. One such practice was the use of rivets for strengthening the holes in which the handles of the paper bags were put. This example is from the urban

English medium setting. A girls' group found the holes punched in their paper bag (for handles) were beginning to tear and making their bag weak thus reducing its load bearing capacity. While discussing this problem, one member suggested putting rivets in the holes to strengthen this area of the bag. Rivets were available with all other common materials that were kept for the class. One of the members of the group got a few rivets, however, none of the members knew how to fix them properly in the punched holes. One of the researchers was called for help and the group was shown how to fix rivets (Figure 6.6).

Figure 6.6: Students learning to fix rivets in bag-making activity

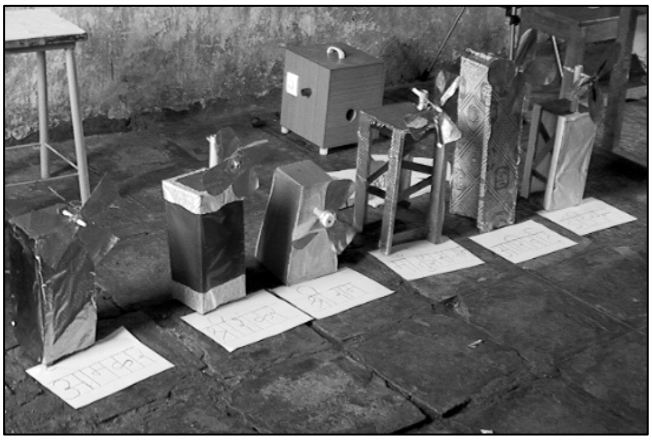
After observing the researcher, the members of the group took turns to fix each rivet (there were 4 holes in which rivets needed to be fixed). This practice soon spread to a mixed-sex group seated next to the single-sex girls group (who had just learned the use of rivets), who also requested the researcher to teach them how to put rivets in the handle slots. After these groups, the remaining 3 other groups who had made paper bags in the same setting used the same technique. The above example of the use of objects (like rivets) indicates that an idea once learned by a group to solve a problem successfully is passed on to other groups in the community. The tool usage once learnt as in this case, could also be applied in other situations.

It was also observed that not all members of a setting practiced the use of certain tools. For instance those groups that made their windmill of other materials such as plastic bottles, aluminium foil etc. did not go to use tools such as drilling machine or saw, but often gathered around to watch students working with them. Thus, even the students who did not practice the use of the tools were keen and eager to observe the use of the tools as shown in Figure 6.7. However, it was observed that, during the use of these tools, not all students adopted the right practice. Some students used these tools unsafely and had to be checked. No student was hurt while using these tools.

Figure 6.7: Student observing another student using a drilling machine

The complex interaction of individual, tools and community could be seen through a practice that spread quickly among the members of rural Marathi setting in the windmill unit. The practice involved making wooden ‘stool-like’ structures for windmill towers. All the windmills made in the rural setting had similar towers, but of varying lengths. The idea of ‘stool-like’ tower surfaced in many groups simultaneously and it appeared as though students in this setting were pre-decided on the design of their towers. In other words, the idea of making ‘stool-like’ tower was a fashion. Despite all their towers being similar, their blade designs and shaft assemblies were different. One of the reasons why students could have similar ideas is that the same problem may be posed to them, as was in this case and there could be a high level of activity around the same issue, which encourages members to have similar ideas. Figure 6.8 is a photograph of windmill models made in the rural Marathi setting. The towers made in all the models are similar.

Figure 6.8: Stool-like towers made in Rural Marathi setting



Another example of diffusion of a tool-related practice was the use of drilling machine and saws in the windmill unit. Unlike in the previous example of the use of rivets to strengthen bag handles, where students could figure out the problem but did not know the solution to it, in this case students knew the solution to their problem but they did not know the right use of tools such as drilling machine and saws. In case of windmill unit, students knew that they needed to cut wooden planks, make holes in the planks (for assembly) etc., they were even aware how this could be done but they did not know how to use the tools available. In all the 3 settings, the vise (a metal tool with movable jaws that are used to hold an object firmly in place while work is done on it, typically attached to a workbench) had been put at one or two tables and students came there to see how the plank could be fixed on it and cut by a saw. In most of the settings the researchers initiated the use of these tools and students came ahead to try it on their own. There were instances of many students gathering near the tables that had vises attached to them to observe other members using tools and also guiding members on correct ways of using the tools if they had used them before.

6.4.3 *Diffusion of learning facts while 'on-the-job'*

School education lays emphasis on the learning of facts and has various subjects that present different contexts that students are expected to know. Diffusion of learning facts refers to the situation when students are explicitly given/taught facts and then they implement/use these facts in their practice. However there are certain facts that are not explicitly taught to the students but are learned while they work with others in the class and get an opportunity to handle tools and materials themselves in order to solve a problem.

In all our units, we planned to have some explicit linkages to other school subjects, such as Mathematics, Biology, Social Studies (history, geography, civics or citizenship studies), Drawing etc. For this purpose in each of the units we had a session on ‘concepts’ related to that unit. For example in the bag-making unit, we formally explained to the students the idea of measurements and making technical drawing and procedural map. We observed that during the trials, when students actually engaged in making bags, they could not make appropriate connections to costing. Many groups could not make the procedural map or technical drawing in a precise way - their writings and drawing often would not match. While explicit facts may not have found application in students’ practices, however students learned facts while they were ‘on-the job’. For example during the bag-making unit students learned that having strong joints in the bag was the key to increasing the overall strength and durability of the bag and a few groups took steps to strengthen their bag’s joints and the handles of the bag.

In the case of the puppetry unit, students were given talks on human body, joints, body symmetry, culture, use of gestures to convey information etc. Again while students were making their puppets not all the facts taught were applied in their making, for instance, none of the groups could make clear connections between making of joints in puppets and the human body joints but on the other hand we observed that the ideas of culture and dress code for culture etc. were implemented by students in all the settings.

We also observed that students resorted to trial and error method to uncover their mistakes and correct them, instead of using the fact taught to them. For instance, in the windmill unit, students were given information on various kinds of windmills, their parts, their movements and their history. Students used some of these facts, such as, they more or less used the correct terminology for the parts of windmill and understood the blades movements but the idea of having a strong, heavy tower to balance the shaft was learned while they tested their models. There was an instance where the whole model shifted with the wind current during testing and the group had to rework on its base to make it stronger. This is one of the instances, which indicate that students learned by trial and error while they were engaged in technology tasks. According to Roth (1996), there seems to be a possibility that the facts that originate within the community are appropriated quickly and by many people, whereas practices and facts that originated outside the classroom community are less readily adopted by students.

Another point to be kept in mind is that, collaborative learning though helpful in classroom situations, also has its drawbacks. One of the drawbacks of working in groups is inevitable conflicts that occur among members. These have been outlined in section 6.3.2. While working in groups some members tended to dominate the group activities and hence there was a possibility of ‘tunnel vision’ being created and members not getting a chance to try their hand at new skills. At the other extreme end, working in teams could also encourage a few members to be ‘free-loading.’

To conclude, diffusion of learning indicates that learning that occurs at the group level and at the community level (classroom) has to be understood in terms of changes in practice in tool usage, techniques and facts. This study provides some evidences of these changes studied in the context of D&T units in the Indian settings.

6.5 Evaluation of products

Opportunities for evaluation and feedback were built into the unit in the stages of designing and making as well as after the completed artefact was available. Each group presented details of their technical drawing, character sketch (in case of puppet) and completed product/artefact to the setting. Students gave and received feedback to these presentations in a healthy and constructive manner. The feedback helped the group to bring about changes in their design and procedure.

Groups evaluated their own finished products/artefacts as well as those made by other groups after making the product/artefact. For this purpose, semi-formal evaluation sheets were provided to the groups on which they had to rate their own product on certain criteria provided to them. Another semi-formal sheet was provided to the groups to rate other groups’ products on similar criteria as their own.

6.5.1 Evaluation of bags

Each student in a group evaluated the bag made by their own group and each group evaluated one other bag in the setting. Generally the researchers gave a similar kind of bag to the group to evaluate,that is if the group had made a cloth bag then that group would be given another group's cloth bag to evaluate. Most groups in the urban settings made paper bags whereas in the rural settings there was a mix of paper and cloth bags. In the urban English setting, only 1 cloth bag was made. Two groups in the urban Marathi setting made cloth bags and 1 group made a bag of paper lined inside with cloth. In the rural Marathi setting, 2 groups made cloth bags.

The criteria used for evaluating the bags were: their *appearance, strength, durability*, their *suitability for the purpose*, keeping in mind the constraints set at the beginning of the unit (carrying 5 books) Appendix I is the evaluation sheet used for evaluating one's own group bag. Appendix J is the evaluation sheet for evaluating another group's bag. A five point rating scale ranging from very good (5) to very poor (1) was provided for each of the criteria except 'purpose' for which a four point scale (4 -1) was provided and students had to select a rating for each attribute of the criteria. The evaluation sheet was made in English and then translated into Marathi for use by Marathi medium students. All the groups were rated by their peers on all criteria. However the product of one group in the rural Marathi setting (Suryadev), was rated in multiple ways by another group and hence it was difficult to ascertain the choices. The peer evaluation of this group is hence not provided in the analysis.

Table 6.2 presents a summary of how the groups in each of the settings rated their own bag on its appearance, strength, durability and purpose. The figures given in the Table 6.2 were arrived at by considering the ratings given by each individual in a setting on each of the and then averaging them (missing values not considered and averages calculated accordingly).

Table 6.2: Self-evaluation by groups in the 3 settings in bag-making unit

Criteria	**Urban English**	**Urban Marathi**	**Rural Marathi**
Appearance (5)	3.91	4.20	4.83
Strength (5)	4.26	3.75	4.46
Durability (5)	3.68	4.08	4.48
Purpose (4)	3.35	3.78	3.91
Total- self (19)	15.20	15.81	17.68

In all the parameters i.e. appearance, strength, durability, purpose, the self-rating by group members tended to be uniform. As can be seen in Table 6.2, students from the rural Marathi setting rated themselves the highest (17.68), followed by students from urban Marathi setting (15.81) and students from urban English setting (15.20) gave themselves the lowest ratings. Of the 4 attributes on which students had to rate their product, the urban Marathi students and rural Marathi students rated themselves highest on the appearance of their bags, while the urban English students rated their bags highest on its strength (though most were paper bags). It is to be noted here that all the ratings are above 15 on a scale where the maximum is 19. Thus the groups in all the settings do think that their product (bag) is almost excellent on the criteria provided.

Table 6.3 presents the ratings given by peer groups. Groups from the rural Marathi setting received the highest ratings from their peers in the setting. Urban English groups rated their peers more strictly. This characteristic was seen in self-evaluation also. For all the 3 settings, ‘appearance’ of the bag received highest rating. Peer ratings ranged between 14.15 - 17.2, which indicates that the peers also rated the bags as excellent.

Table 6.3: Peer-evaluation in the bag-making unit

Criteria	**Urban English**	**Urban Marathi**	**Rural Marathi**
Appearance (5)	3.83	4.16	4.60
Strength (5)	3.50	3.33	4.60
Durability (5)	3.66	3.50	4.40
Purpose (4)	3.16	3.66	3.60
Total- self (19)	14.15	14.65	17.20

Evaluation of bags by gender groups

The self and peer-evaluation of the products have also been analysed according to the gender group composition. Table 6.4 indicates the self-ratings by the 3 kinds of gender groups. Single-sex boys' groups rated their bags the highest (16.71), followed by the mixed-sex groups (16.21). Single-sex girls' groups rated their products the lowest (15.89). However, the ratings for all the gender groups were above 15.5 on a scale whose maximum rating was 19. For each of the attributes i.e. appearance, strength, durability and purpose the single-sex boys rated themselves the highest. Overall the gender groups have rated their bags highest in the attribute of 'appearance' and lowest in terms of 'purpose'. Generally all groups, irrespective of their group composition (whether single-sex boys or girls or mixed-sex groups) rated themselves higher than the rating given to them by other groups.

Table 6.4: Self-evaluation by gender groups in the in the bag-making unit

Criteria	**Single-sex girls**	**Single-sex boys**	**Mixed-sex**
Appearance (5)	4.31	4.35	4.28
Strength (5)	3.93	4.31	4.23
Durability (5)	4.10	4.25	4.00
Purpose (4)	3.55	3.80	3.70
Total- self (19)	15.89	16.71	16.21

The peer evaluation of bags analysed according to gender groups is presented in Table 6.5. The table indicates that the single-sex boys groups received the highest rating (15.80) from other groups and single-sex girls' groups the lowest ratings (14.65). This trend had been seen in self-evaluation. Thus while the single-sex girls' groups rated their products low, these were rated even lower by their peers.

Table 6.5: Peer-evaluation by gender groups in the bag-making unit

Criteria	**Single-sex girls**	**Single-sex boys**	**Mixed-sex**
Appearance (5)	4.00	4.40	4.16
Strength (5)	3.66	3.80	3.83
Durability (5)	3.83	4.00	3.66
Purpose (4)	3.16	3.60	3.66
Total- self (19)	14.65	15.80	15.31

Evaluation by researcher

One of the researchers independently scored the bags on the same attributes that the students had rated the bags. This was to get an estimate of whether the products made by the students were satisfactory/unsatisfactory from the point of view of the D&T unit. Table 6.6 gives the ratings of bags according to the researcher and the peer ratings for comparison. The researcher gave bags from the urban Marathi setting and the bags made by single-sex girls' groups the highest ratings. These ratings ranged between 14.15 to 16.15, which indicates a satisfactory completion of the task in all the settings and in all the gender groups. The range of ratings by peers was larger, that is 14.15-17.20.

Table 6.6: Ratings given by researcher and peers in the bag- making unit

Groups	Researchers	Peers
Urban English	14.15	14.15
Urban Marathi	16.15	14.65
Rural Marathi	14.15	17.20
Single- sex girls	15.32	14.65
Single-sex boys	14.16	15.80
Mixed-sex	15.00	15.31

Qualitatively the researcher felt that the bags made in the urban Marathi setting (though made of paper) were sturdy and attention had been paid to the joints, edges and the base of the bags. Materials like Velcro had been used and braided thread for handles were prepared (by one of the groups) unlike any group in the other settings. The emphasis in the bags made in the rural Marathi setting was their shiny decoration. The characteristic feature of the bags made by the urban English setting students was the use of a variety of tapes for reinforcing the edges and the corners of the bag. Only some groups had paid attention to strengthening their joints. Of the five cloth bags made, mixed-sex groups had made 2 cloth bags and the remaining 3 cloth bags were made by single-sex girls' group. No single-sex boys' group had made a cloth bag or a cloth reinforced paper bag.

6.5.2 Evaluation of windmills

The evaluation for windmill unit differed slightly from that of bag making unit. In this unit, unlike the bag-making unit, the evaluation of the product made by the group (self-evaluation) was done collectively in the group (and not individually as in bag-making). For peer evaluation of windmill, the group as a whole evaluated each windmill model. This evaluation procedure was followed for both the urban groups, while in the rural group, the procedure for self-evaluation remained the same but in peer evaluation of models, each individual evaluated all the models made in the setting.

For the unit on windmill students were given semi-structured evaluation sheets for evaluation of their windmill models as well as those made by other groups. The criteria that were provided to students on the basis of which they had to judge their models were: *strength, rotation of shaft*, *neatness* (i.e. aesthetics). Evaluation sheets were first prepared in English and then translated to Marathi for use in both the Marathi medium settings. Evaluation sheet to be used for one's own group is presented in Appendix K and that for a peer group is attached in Appendix L. Neatness and tidiness, sturdiness of the windmill, rotation of shaft were rated on a scale of 1- 3 with 1 being the lowest and 3 being the highest value. Figure 6.9 shows students from rural Marathi setting evaluating their windmill model.

Figure 6.9: Students from Rural Marathi setting engaged in evaluation of windmill

Number of rotations made by the windmill to lift certain weight, the angle at which the model worked the best and the distance of the model from the wind source were recorded by groups on the evaluation sheets. It was observed that while students took their measurements, there was lots of excitement and apprehension among them. The experience of taking actual measurements to test their model’s efficiency and recording them was a novel experience for most students in the sample. The testing of windmill models generally occurred after the students completed making their windmill but in the rural Marathi setting, testing had to be postponed till the students came to our institute due to lack of power supply in the school on the days of the trials.

The values reported for self-evaluation are the mean values of ratings given by groups for each of the attributes within a setting. Table 6.7 presents the self-evaluation ratings of groups in each setting. Students from the urban English setting rated their groups’ models the highest (8.16), they were followed by students from the urban Marathi setting (7.53) and rural students rated themselves the lowest (7.42). Students from all the settings rated their windmill models highest on the rotation of the shaft and lowest on the attribute of neatness and tidiness. All the groups rated their windmill models in the range of 7.42 - 8.16 out of a maximum of 9, which indicates that all the groups rated their windmill model well above average.

Table 6.7: Self-evaluation by groups in the 3 settings in the windmill unit

Criteria	**Urban English**	**Urban Marathi**	**Rural Marathi**
Neat and tidy (3)	2.50	2.28	2.16
Sturdiness (3)	2.66	2.42	2.60
Rotation of shaft (3)	3.00	2.83	2.66
Total- self (9)	8.16	7.53	7.42

Table 6.8 presents the results of the ratings given by peer groups to windmill models in various settings. For all the criteria, peer groups too have rated the windmill above average. Groups in the urban Marathi setting gave the highest rating to their peers. (7.69), followed by urban English (7.33) and rural Marathi students (7.07).

Table 6.8: Peer-evaluation by settings in the windmill unit

Criteria	**Urban English**	**Urban Marathi**	**Rural Marathi**
Neat and tidy (3)	2.33	2.58	2.51
Sturdiness (3)	2.50	2.56	2.51
Rotation of shaft (3)	2.50	2.55	2.05
Total- self (9)	7.33	7.69	7.07

Table 6.9 presents the comparison of self-evaluation of windmill with that of peer-evaluation. It was found that in urban English setting all the groups rated themselves higher than the rating received from their peers. In the urban Marathi setting, however, three groups 2 single-sex girl's groups and 1 single-sex boys' group rated themselves lower than what others rated them to be. In the rural Marathi setting, 2 single-sex girls groups evaluated their windmill lower than the scores given to them by their peers.

Table 6.9: Comparison of self-rating with peer evaluation for the unit on windmill

Settings	**Gender groups**	**Self-evaluation (9)**	**Peer evaluation (9)**
Urban English	Single-sex girls	7	7
	Single-sex girls	9	9
	Single-sex boys	9	5.2
	Single-sex boys	7	6.8
	Mixed-sex	9	8.2
	Mixed-sex	8	7.8
Urban Marathi	**Single-sex girls**	8	8.1
	Single-sex girls	6	6.3
	Single-sex girls	8	8
	Single-sex boys	6	6.3
	Single-sex boys	8	7.8
	Mixed-sex	9	8.3
	Mixed-sex	8	8
Rural Marathi	**Single-sex girls**	7	7.6
	Single-sex girls	3	7.3
	Single-sex boys	9	7.2
	Single-sex boys	8	7.6
	Mixed-sex	9	6.8
	Mixed-sex	6	5.6

Groups in bold are the groups whose self-rating was lower than the rating they received from peers

If we observe Table 6.9 carefully, we find that of the 7 single-sex girls' group, four groups rated their windmills lower than the ratings they received from their peers. This trend of single-sex girls groups rating their products low was seen earlier also in Table 6.5. In the case of single-sex boys groups, one group rated its windmill lower than the rating received from their peers while all the other groups rated their products higher.

Evaluation of windmills by gender groups.

Table 6.10 presents the ratings given by the gender groups for each of the attributes. Students in the mixed-sex groups rated their windmills highest (8.63), followed by the single-sex boys' groups (7.93) and single-sex girls' groups (6.73). Mixed-sex groups rated themselves the highest in all the three attributes i.e. neatness and tidiness, sturdiness and rotation of shaft.

Table 6.10: Self-evaluation done by gender groups in the windmill unit

Criteria	Single-sex girls	Single-sex boys	Mixed-sex
Neat and tidy (3)	2.00	2.50	2.60
Sturdiness (3)	2.10	2.60	3.00
Rotation of shaft (3)	2.66	2.83	3.00
Total- self (9)	6.73	7.93	8.63

Table 6.11 presents the ratings by peer groups analysed according to the gender composition of the groups. Groups rated the windmill models made by single-sex boys' the lowest while those made by single-sex girls' groups were rated the highest. This is interesting considering that girls had rated their product as low (Table 6.10).

Table 6.11: Peer-evaluation by gender groups in the windmill unit

Criteria	Single-sex girls	Single-sex boys	Mixed-sex
Neat and tidy (3)	2.58	2.30	2.41
Sturdiness (3)	2.37	2.52	2.55
Rotation of shaft (3)	2.70	1.98	2.46
Total- self (9)	7.65	6.79	7.42

Evaluation by researcher

Table 6.12 presents a comparison of the ratings by the researcher and the peer ratings. As can be seen in the table, researcher's ratings ranged between 7.56 – 9.00 (out of a maximum of 9 points) while the ratings of peer groups ranged between 6.81– 8.63.

These ratings are above average for all the windmill models and indicate that overall the models made by all the groups irrespective of their settings or gender composition were quite satisfactory.

Table 6.12: Ratings given by researcher and peers in the windmill unit

Groups	Researcher	Peers
Urban English	8.15	8.63
Urban Marathi	7.70	7.54
Rural Marathi	8.83	7.01
Single- sex girls	7.56	7.61
Single-sex boys	8.15	6.81
Mixed-sex	9.00	7.45

Qualitatively the windmills made by the students from the rural Marathi setting were very similar in appearance and also sturdy. Most of them had wooden towers (Figure 4.16). The windmills made in the urban Marathi setting were not as sturdy as the ones made in the rural Marathi setting. Some models had towers of wood but others had towers of plastic bottle, tins/cans, foil etc. The design of a few windmills was very innovative such as the one made by a single-sex girls' group (Sadaphuli), which was small but quite efficient. This windmill model had a tower shaped as trapezoid and the blades were made of a single piece of foil. Students in the urban setting had used a variety of materials such as plastic bottles, thermocole, wooden planks, sticks, aluminium foil, cardboard etc. for making their base (Figure 4.17). In the urban English setting, the bases of a few windmill models were not strong and they would shift in the face of blowers used for conducting trials to evaluate the capacity on windmill to lift weights. The shaft assemblies (the attachment of blades to the tower) made in all the 3 settings were complex i.e. the shaft would be attached to a piece of thermocole or a bottle-cap and then attached to the tower or an empty thread reel would house the shaft and then it would be inserted in the tower. Students at times needed to balance the assembly to reduce the wobble of the windmill models.

It was also observed that in general students concentrated more on making their windmill models sturdy. Of all the 19 windmill models made, 18 could lift weight successfully. Only one model made by a single-sex girls' group in the urban Marathi setting was not successful in lifting weights. This model had blades of paper that were not strong enough when faced with the blower.

6.5.3 Evaluation of puppets

In the case of puppets, the criteria used for evaluating included: *ease of handling the puppet, ease of its movements, resemblance to the character in the story and appropriateness of materials*. Semi-structured evaluation sheets based on the criteria of functions, aesthetics, materials, economics and design were provided to the students. Students had to rate the puppets on each of the attributes on a score from 0-10. Thus the scores for self-evaluation are out of 40. (Appendix M, self-evaluation sheet).

For self-evaluation of puppets, both the urban groups evaluated their puppets in groups (one evaluation sheet per group), while in the rural Marathi setting, each member of the group evaluated their puppets. For evaluating peer's puppets, students in all the settings, evaluated in groups (meaning each group evaluated peer groups' puppets). Sheet for evaluating peer groups' puppet is presented in Appendix N. The evaluation sheets were first made in English and then translated to Marathi for students from the Marathi medium.

Table 6.13 presents the scores given by groups to their own puppet on various attributes. Urban English students rated their puppets the highest (33.1), followed by students from the rural Marathi setting (31.2) and urban Marathi students (29.1). Students from the urban English setting scored themselves highest on the attribute 'appropriateness of materials used' and students from both the Marathi medium settings scored themselves the highest on the attribute 'resemblance to the character'. Ease of handling was scored low in all the 3 settings.

Table 6.13: Self-evaluation by groups in the 3 settings in the puppetry unit

Criteria	**Urban English**	**Urban Marathi**	**Rural Marathi**
Resemblance to character (10)	8.5	7.6	8.7
Workmanship (10)	8.2	7.5	7.5
Ease of handling (10)	7.8	7	6.6
Appropriateness of materials used (10)	8.6	7	8.4
Total (40)	33.1	29.1	31.2

While evaluating peers' puppets it was observed that in all the 3 settings, there was a large range of scores that were given by various groups. There were a few cases where the evaluation sheet was improperly filled and these evaluations had to be dropped. Table 6.14 presents the evaluation of puppets done by peers. In all the settings no puppet was rated below average on any of the attributes provided. Rural Marathi setting groups gave lower rating to the puppets made by their peers (27.45), while groups in the urban Marathi setting gave high ratings to the puppets they rated (35.92). The ratings received by the urban English groups were in between these two ratings that is 30.39.

Table 6.14: Peer-evaluation by settings in the puppetry unit

Criteria	Urban English	Urban Marathi	Rural Marathi
Resemblance to character (10)	7.34	9.30	7.14
Workmanship (10)	7.79	9.66	6.62
Ease of handling (10)	8.03	8.16	6.75
Appropriateness of materials used (10)	7.23	8.80	6.94
Total (40)	30.39	35.92	27.45

Table 6.15 presents the comparison of self-evaluation scores with the scores given by peers. Half of the groups (8/16) gave themselves higher scores than those given them by their peers. Of the 8 groups that scored lower than others, 5 groups were from the urban Marathi setting, 2 were from the rural Marathi setting and 1 was from the urban English setting. Two groups (1 urban English and 1 rural Marathi) did not rate themselves.

Table 6.15: Comparison of self-rating with peer-rating for puppetry unit

Settings	Gender groups	Self-evaluation (40)	Peer evaluation (40)
Urban English	Single-sex girls	35	30.4
	Single-sex girls	34.5	29.4
	Single-sex boys	23	30.8
	Single-sex boys	Did not rate	29.8
	Mixed-sex	37	32.1
	Mixed-sex	36	32.9
Urban Marathi	**Single-sex girls**	36	36.4
	Single-sex girls	28	35.4
	Single-sex boys	38	36.2
	Single-sex boys	19	34.2
	Mixed-sex	27	36.6
	Mixed-sex	27	36.8
Rural Marathi	**Single-sex girls**	27	29.6
	Single-sex girls	30	27
	Single-sex boys	25	26.4
	Single-sex boys	Did not rate	25.5
	Mixed-sex	28.5	27.4
	Mixed-sex	29.5	28.5

Groups in bold are the groups whose self-rating was lower than the rating they received from peers

Evaluation of puppets by gender groups

Table 6.16 presents the scores given by the 3 gender groups to their own puppets on various attributes.

Table 6.16: Self-evaluation by groups in the 3 settings in the puppetry unit

Criteria	Single-sex girls	Single-sex boys	Mixed-sex
Resemblance to character (10)	8.08	7.66	8.66
Workmanship (10)	8.20	7.75	7.33
Ease of handling (10)	8.16	5.50	7.16
Appropriateness of materials used (10)	8.66	7.25	7.66
Total (40)	33.10	28.16	30.81

As can be seen in Table 6.16, single-sex girls' groups scored their products the highest (33.10), followed by mixed-sex group (30.81) and the single-sex boys' groups (28.16). All the 3 gender groups scored their puppets differently on various attributes. Students in the single-sex girls' groups scored their puppets highest on the attribute 'appropriateness of materials used'. 'Workmanship' was scored highest in the single-sex boys' groups while in the mixed-sex groups, students rated their puppets highest on the attribute 'resemblance to the character'.

The evaluation of puppets for each of the gender groups by their peers is presented in the Table 6.17. Like in the case of setting, all the gender groups were given above-average scores by their peers (Range 30.47- 31.92). Single-sex boys groups' puppets were the lowest by their peers while those of the mixed-sex groups were rated the highest. Of the groups that rated themselves, it was observed that 3 single-sex girls', 2 single-sex boys' and 2 mixed-sex groups rated their puppets lower than their peers (Table 6.15).

Table 6.17: Peer-evaluation by gender groups in the puppetry unit

Criteria	Single-sex girls	Single-sex boys	Mixed-sex
Resemblance to character (10)	7.91	7.63	8.23
Workmanship (10)	7.92	7.99	8.16
Ease of handling (10)	7.80	7.34	7.80
Appropriateness of materials used (10)	7.73	7.51	7.73
Total (40)	31.36	30.47	31.92

Evaluation by researcher

The scores of peer evaluation of the puppets and the scores given by the researcher to the puppets are given in the Table 6.18. Interestingly, of the puppets made in the 3 settings, the puppets made by rural Marathi students were scored the highest (30.64) by the researchers and the peer groups scored them the lowest (27.45). Regarding the evaluation of puppets made by the 3 gender groups, the researcher as well as peer groups scored the puppets made by the mixed-sex groups highest. Puppets made by the single-sex boys groups were rated the lowest by the researcher, the peers and by the single-sex boys' group themselves.

Table 6.18: Ratings given by researcher and peers in the puppetry unit

Groups	Researcher	Peer groups
Urban English	27.82	30.39
Urban Marathi	29.98	35.92
Rural Marathi	30.64	27.45
Single- sex girls	29.15	31.36
Single-sex boys	28.15	30.47
Mixed-sex	34.14	31.92

Overall the puppets made in the rural Marathi setting were easier to handle as compared to the puppets made in the urban settings. All students made efforts to make their puppet characters fit the context of the story. Special emphasis was paid to aesthetic aspects of the puppets. Students from the rural Marathi setting made the most props and were innovative with their stage setting. The story chosen for the puppet show was the common story of 'Wolf, Wolf!" with a few modifications. In the urban Marathi setting too, most puppets were easy to handle and resembled the character that students tried to depict. Urban Marathi students made fewer props as compared to the props made by the rural Marathi students. The story selected for puppet show by this setting was from their textbook with the environmental value of conserving forests. In the urban English medium setting, most of the puppets made were difficult to handle and the props made by this setting were the least. The story selected for puppet show by this group was the only story in the 3 settings that was not set in the Indian context, through some of the characters managed to look Indian.

Qualitatively the puppets made by single-sex girls' groups were made with more appropriate materials and most were easy to handle (with some exceptions). The single-sex boys' groups and the mixed-sex groups had paid attention to making their puppets resemble the character in the story. Overall the puppets made by the mixed-sex groups in the 3 settings were better rated by the researcher as well as by their peers in the settings (i.e. in each of the 3 settings the scores given by peers to the puppets made by the mixed-sex groups was either highest or the second highest). However these ratings were close to those received by the single-sex girls' groups, which came a close second.

6.6 Summary

In all the 3 units, groups tended to rate the products made by their groups higher than those made by others. In none of the groups, for none of the units, was there a consensus about a product being the best or the worst. Aesthetics of a product was paid more attention to by groups rather than its functionality. For all the 3 units, different patterns of scores in the 3 settings emerged. For the bag-making unit, rural Marathi students scored their products the highest, followed by urban Marathi and urban English. For the windmill unit, this pattern was reversed and rural Marathi students scored their products the lowest while students from the urban English setting scored their products the highest. Urban English students gave maximum scores to their puppets (as in the windmill unit), followed by rural Marathi and urban Marathi settings. These observations are presented in the Table 6.19.

Table 6.19: Overall scores given by the groups to their products

Units	Urban English	Urban Marathi	Rural Marathi
Bag-making (19)	15.20	15.81	17.68
Windmill (9)	8.16	7.53	7.42
Puppet (40)	33.10	29.10	31.25

Table 6.20 presents the scores given by groups to their products according to gender. The single-sex girls' groups rated themselves the lowest in the 3 gender groups for bag-making and windmill units and highest in the puppetry unit. The single-sex boys rated themselves the lowest in the puppetry unit and highest in the bag-making unit while the mixed-sex groups have rated themselves at the second position for both the bag-making and the puppetry units.

Table 6.20: Overall scores given by gender groups to their products

Units	Single-sex girls	Single-sex boys	Mixed-sex
Bag-making (19)	15.89	16.71	16.21
Windmill (9)	6.73	7.93	8.63
Puppet (40)	33.1	28.16	30.81

The average ratings for all the products in all the groups were towards excellent, which indicates that the products made by all the groups were satisfactory and that particular no group- whether by setting or by gender -excelled at making any product.

6.7 Overall summary of the chapter

The analysis of informal communication and collaboration in the 3 units was carried out with the purpose of understanding how joint knowledge is developed when students worked in groups on common tasks. There were instances of learning within the smaller groups in which students worked as well as at the community or the classroom level. The observations of trials of the 3 units conducted indicate that D&T can encourage collaborations and can also be benefited by collaboration.

In the present study, the D&T units were designed so as to give students opportunities to investigate, analyze, synthesize, and evaluate ideas collaboratively in teams. Working in teams aided students in learning to share their resources (both material and non-material), as well as skills and knowledge. The sharing and the verbal / non-verbal exchanges inevitably helped students to better understand the processes involved in reaching the goal along with developing a perspective of the points of views of others. Collaboration is a social process and we observed various elements of collaboration and learning that occurred in the classroom as a part of D&T units. The evidences of learning at the classroom level were seen through realisation of common goals, diffusion of learning through tools, practices and facts while ‘on-the-job’.

Evaluation was one of the steps in our D&T units whereby students reviewed written and oral work of their group as well as other students and made suggestions for improvement. According to Kern et al. (2003) peer-review benefits learning in students in terms of developing their written skills, critical thinking, collaboration and professional responsibility. Collaboration allows opportunities for feedback. In our units, students presented their procedure verbally and through drawings to other groups who questioned them and asked for explanations. The reviews (feedback), led to defence of their design or necessary changes in it. The constructive criticism helped the groups to channelise their efforts in the right direction. It was observed that students tended to rate the product made by their group higher than those made by other groups. In the bag-making unit and the windmill unit, single-sex girls rated their products lower than other groups while in the puppetry unit, single-sex girls' groups rated their puppets the highest. While evaluating the products of others, students made a point of appreciating some aspects and presented criticisms diplomatically. In return, groups presented their rebuttal to the criticisms and justified their positions.

Students paid special attention to the aesthetics of the artifacts rather than its functionality. This was especially true for the bag-making unit. There was more variety in the windmill models made in the urban groups than in the rural groups. For the case of puppets, rural students were more creative in making their puppets as well as the props whereas in the urban English setting there seemed to be a mismatch in the story and the depiction of characters and the music that accompanied the puppet show.

The observations of trials of the units conducted in the multi-cultural settings indicate that D&T education can also provide one of the suitable ways of engaging both boys and girls from urban and rural areas in meaningful learning contexts. In India where technology education needs an introduction at the school level, collaborative learning framework can be one of the plausible ways for introducing the subject.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This thesis aims at understanding middle school students' attitudes towards technology and at the development and trials of D&T units in the Indian middle school classrooms. The units were aimed at engaging both boys and girls from rural and urban areas in the D&T activities. Communication and collaboration were at the core of the D&T units developed. The trials of three units developed were carried out in three different socio-cultural settings. The thesis presents an analysis of students' communication while they worked in groups during the trials, focusing especially on socio-cultural and gender aspects.

The study began with a survey questionnaire that was administered to Grade 6 students from schools in and around Mumbai. The questionnaire had two components - one comprised finding out students' ideas about 'technology-as-objects' and the other aimed at knowing their ideas about 'technology-as-activities'. Detailed interviews were conducted on a sub-sample of students to know their reasons for associating an object or an activity with technology. The survey was followed by development of D&T education units.

In India, technology education does not exist at the school level as a separate subject but it lies at the interface of school science, crafts/work experience and vocational education. However, technology forms linkages with all the three areas of the curriculum mentioned above and transcends their boundaries. Technology education also has a potential to provide a platform where students can come together and work in groups. Being able to work in groups is one of the proclaimed (but unmet) goals of technology education (Dyrenfurth, 1996).

In our study, collaborative learning was promoted through teamwork, the use of open-ended D&T activities and an encouragement of active participation and communication throughout the activities and units. If we reflect on the practices of the classroom especially in the Indian context, as well as research literature, we realise that group work or teamwork hardly exists in the classrooms even though it is desirable and relevant for the world of work. Teamwork skills are desirable for the society in general but children cannot be taught to behave in socially responsible ways - (this is not something that can be learned by instruction). Behaving in a constructive way in relation to others is best furthered by children being given opportunities to debate and recognize alternative points of view, and by being held responsible for their own behaviour, in short they should be given opportunities to communicate.

We believe that inclusion of D&T activities that emphasize on teamwork and communication should form an important part of the Indian school curriculum. In our efforts to introduce D&T education in the Indian context, we undertook the task of developing and carrying out trials of 3 D&T units keeping in mind the socio-cultural milieu of the students and the possibility of introducing group work within a classroom. The conclusions from the study are reported broadly under four heads: attitudinal survey, development of units, formal communication and informal communication, collaboration and evaluation in D&T units.

7.2 The attitudinal survey

The survey tried to uncover Grade 6 students' understandings of technology. A pictorial survey complemented with situational questions and interviews was conducted with students of 9 schools in rural and urban areas. Over 200 students from Marathi as well as English medium schools participated in the survey. Care was taken to have almost equal representation of girls and boys from rural and urban areas. The responses of the students to the questionnaires along with the reasons given by them for associating an object/activity to technology are presented under appropriate heads below.

Objects and activities associated with technology: Students predominately perceived technology as objects, in the category of communication and transport (e.g. computers, airplanes, cars etc). They often considered modern gadgets used in urban areas as related to technology. A few students related technology to natural objects (e.g. sun, flower etc). These students tended to associate motion and growth (as in case of flower turning towards light) of natural objects and phenomenon with life and technology. Another factor that guided students' choice of objects and activities was their school textbooks. If an object or an activity appeared in the science textbook, then student related it to technology. Other reasons for considering an object to be technology related were; it was 'human-made', was 'used for speeding' and 'easing activities', was 'composed of simple and/or complex machines and tools', and was 'useful'.

Students also gave reasons for why they considered something as 'not technology'. These reasons included an object 'not having a machine', 'not being related to science', or 'something found in nature'.

Activities that showed humans involved in using transport and communication related equipments such as working on computer or talking on phone, were considered related to technology by most students. On the other hand, pictures that showed skill dependent activities (e.g. wrestling, teaching, dancing etc.) were less often related to technology. A few students also related natural phenomena (e.g. thunder and lightning) to technology.

Objects along with humans (e.g. human playing a sitar, archery, human using a plough etc.) were more often associated with technology than a human or an object alone (e.g. sitar, bow and arrow, plough). Though students associated technology with only modern gadgets, they maintained that technology essentially evolved over time. Most students recognized the utilitarian and human-made nature of technological artefacts as well as activities.

People who use/create technology: Most students felt that all people use technology but not all people can make/create technology. Only a specific category of people, such as scientists working in laboratories, could create technology. A few students believed that small children, people staying at home and the elderly do not use any technology.

Temporal and locale aspects: Most students in the survey associated technology with modernity and believed that less technology existed in the past as compared to present times and that technology has evolved over time. Students often associated advent of technology with a specific historical event (e.g. discovery of light or Indian independence etc.) or a certain number of years (e.g. B.C., 100 years, 1000000 years).

Most students thought that there was more technology in the urban areas as compared to rural areas. The reason given for urban areas having more technology was the continuous supply of electricity and presence of industries as well as better means of transport. Some students seemed to have a clear idea about gradations of technology according to locale, with villages having the least technology and cities having the most technology, and towns being at an intermediate position.

Gender comparisons: Both boys and girls had similar perceptions of technology and associated similar objects and activities to technology. This is worth noting because while it demonstrates that adolescent males and females see technology similarly, they may see the role it plays in their lives very differently. Most students believed that both boys and girls use technology equally. However, they tended to restrict their mother's use of technology to objects found in the household whereas their father's use of technology extended well beyond home to workplace also.

Our survey also indicated that there were differences in students considering an activity to be suitable for a boy or a girl. Both boys and girls had stereotypical ideas about which career occupations were suitable. Professions such as nurse, cook, were suggested more or less exclusively for females whereas professions like pilot, soldier were considered suitable for males. Most students felt that teaching was a profession that was suitable for both boys and girls, followed by a doctor, dancer and scientist.

There was gendering of space too. Most students thought that the chores inside the house such as arranging vessels, dusting the house etc. were the domain of women whereas men were associated with work outside the house and also work that involved the use of tools and skills such as arranging the toolbox or replacing a fused bulb.

The findings of the survey have implications for teachers and educators who need to help students broaden their concept of technology to include activities, processes and systems apart from objects. One of the ways to broaden students' ideas about technology is to engage them in personally meaningful hands-on activities.

7.3 Development of the units

The D&T units that we developed had the following broad aims (a) building a collaborative working environment in the classroom, (b) situating the goals in the context of students/authenticity, (c) teaching technology with design at its core and (d) making the unit inclusive i.e. suitable for boys and girls from urban and rural settings.

The DMA model suggested by Kimbell (1994) served as a guide to the development of our units. We designed three units within a framework of collaborative learning where students shared a goal and were held together with a common sense of purpose. All the D&T units that we planned had the following phases: *Investigation and motivation, designing, planning, communicating about their designs, making and evaluating and communicating about their products*. The three units were: making a bag to carry books, making a working model of a windmill and making a puppet and collectively staging a puppet show.

Each unit was tried with 20-25 Grade 6 students (11-14 years of age) in each of the three settings: a rural Marathi medium school, an urban Marathi medium school and an English medium school. It was ensured that the number of boys and girls participating in the trials were about the same. To a large extent the same students participated in all the three units but a few dropouts were unavoidable. Each trial took about 15 hours spread across 5 days.

Opportunities for both formal and informal communication were built into the units during their planning. For all the units, students worked in groups, which were of one of the three kinds: *single-sex girls', single-sex boys' or mixed-sex groups*. We also ensured that the language used in classrooms was close to the everyday language of children so that students could have a better understanding of concepts and their applicability.

The trials of the units were carried out in the order of complexity of collaboration. Bag-making unit was tried first since a bag was considered a simple object to make. Windmill unit was tried after the bag-making unit. This unit was more complex, had more sub-parts and required a group of students to work on making a windmill that could lift some weight. After the students had made their windmill model, they needed to test it to check its efficiency. Puppetry unit was the last unit to be tried in all the settings and had two levels of collaboration. In this unit, students needed to come up with a story with six characters and construct the character and make the puppet and finally come together and put up a puppet show for an audience.

The concepts included in the units drew from various subjects of the school curricula such as science, mathematics, crafts and art and the social sciences. For example the puppetry unit required concepts from biology (human joints, body symmetry), mathematics (measurements), language (dialogues for the show), geography (dialects, dress, cultural aspects), economics (costing) and arts and crafts. As Doherty et al. (1994, p.114) point out; conceptual development in technology requires ‘assimilation of knowledge, practice and skills and the formation of values and attitudes’. The activities in which students engage should be challenging to them and at the same time should help them in gaining skills and knowledge that could be utilized in other subjects and in solving problems in real-life in general.

7.4 Formal communication in D&T units

Steps were built in to the D&T units that specifically required students to communicate their ideas. Formal oral communication required the group members to explain to the cluster their anticipated designs and their completed products. Thus formal oral communication occurred at 2 occasions: one after designing the product and the second time after groups had made and evaluated their products. Formal communication at both these stages was recorded and transcribed. The unit of analysis selected for formal oral communication was one complete or incomplete sentence uttered by a student at the time of formal communication. Inter-rater reliability in the form of percentage agreement between raters was established for each unit on about 50% of the data.

7.4.1 Theoretical framework of analysis used for formal communication

The broad framework of analysis was based on socio-cultural discourse analysis. Socio-cultural discourse analysis draws from Vygotsky’s idea of the conception of language as a cultural and psychological tool. It considers that all action is inextricably connected to the social context where it is happening and talk acts like a tool that mediates between higher order functions and actions (Wertsch, 1991). The transcripts of students' exchange of dialogues were analyzed using a modified form of the categories developed by Dawes et al. (1992) which categorizes talks into 3 kinds: *disputational, cumulative and exploratory talks*.

The conclusions from students' formal communication are being presented here as (a) comparison of formal communication in the 3 units and (b) comparison of formal communication by socio-cultural settings and c) comparison of formal communication by gender groups.

7.4.2 Comparisons of formal communication in the 3 units

During formal communication, the frequency of dialogues exchanged varied with the nature of the units. Familiarity and complexity of the artefacts seem to have an effect on the profile of talks during design and product communication. Bag was a simple object and an item of personal use, while windmill and puppet had more of social value connected to them. Students were more familiar with bags and puppets as compared to windmill. Making a bag and a puppet required relatively fewer skills while windmill was more complex and had many sub-parts and assemblies that needed to be worked on.

While no time limit was set, product communication lasted for a longer time as compared to design communication. Typically a design communication lasted for 3-6 minutes and a product communication for 5-6 minutes. The dialogues exchanged during design communication in bag-making and puppet units were less as compared to product communication whereas during the windmill unit, the reverse occurred and more dialogues were exchanged during design communication. In the windmill unit, time taken during design communication was more than product communication. The increase in overall talks during product communication as compared to design communication could also be explained by the fact that after making the product students were able to talk more about it rather than at the stage of designing where they were anticipating the making of product.

Of the three kinds of talks, cumulative talks were highest in all three units, followed by exploratory talk and the least frequency of talk was disputational. There was an increase in disputational and exploratory talks and a reduction in cumulative talk for product communication in all the three units. The frequency of exploratory talks was highest for windmill unit and least for the unit on puppet. While no kind of talk is considered the best or the worst, exploratory talks are the hallmark of critical thinking. An increase in exploratory talk is an indication of students' learning and critical thinking during the units.

7.4.3 Comparison of formal communication by socio-cultural settings

The frequency of talks contributed by the three settings for all the units taken together indicates that the maximum dialogues exchange occurred in the urban Marathi setting and the least in the rural Marathi setting. Similar patterns of talks with respect to socio-cultural settings were observed in bag-making and windmill units - with students of urban English contributing the most and students from rural Marathi setting contributing the least percentage of dialogues. For puppetry unit, students from urban Marathi setting exchanged most dialogues while students from urban English setting exchanged the least. Rural Marathi medium students improved in their formal communication consistently from bag-making unit, to windmill unit and to the puppetry unit.

Statistically significant differences were found between urban English and rural Marathi setting and also between rural Marathi and urban Marathi setting during product communication. For the windmill unit, the dialogues exchanged in the three settings did not significantly differ, however there were differences between urban English and rural Marathi setting and also between rural Marathi and urban Marathi setting during product communication. The puppetry unit showed a different pattern with respect to differences in settings. There were statistically significant differences between urban English and urban Marathi and also between urban English and rural

Marathi during product communication. However, during design communication in this unit, significant differences existed between urban English and rural Marathi setting and between rural Marathi and urban Marathi settings.

The profile of talks in the three settings shows that cumulative talks were highest in all the settings, followed by exploratory and disputational talks. Disputational talks were least in the rural setting and most among urban English students, and exploratory talks were highest among urban Marathi students. The differences in the profile of talks in the settings could be explained by the fact that students from urban areas have better exposure and access to media and other resources such as computers, libraries, school infrastructure, etc. as compared to students studying in rural schools and therefore are better at skills of communication. Differential home and parental experience in cities, difference in language skills and use may also be reasons for differences. The findings of this study also indicate that rural students, when given opportunities and guidance to work can improve. This was evident in their progressive improvement in the frequency of their talk from bag-making unit to the puppetry unit.

7.4.4 Comparison of formal communication by gender groups

The highest frequency of dialogues was exchanged in the single-sex boys' groups, followed by single-sex girls' groups and mixed-sex groups. The fact that students in the mixed groups contributed least number of dialogues in all the units could be an indication that in mixed-sex groups both boys and girls as a group felt restrained while talking to the cluster.

All the three gender groups did not significantly differ from each other in the frequency of dialogues exchanged during design and product communication in the bag-making and puppetry units. However in the unit on windmill statistically significant differences were found between mixed-sex group and single-sex boys' groups during design communication.

In all the gender groups, cumulative talks were most often used followed by exploratory talks and disputational talks. Disputational talks were the highest in single-sex boys' groups and least frequent in mixed-sex groups. The mixed-sex groups in both the urban schools had the least dialogues.

A reason for differences in amount of talk in boys' and girls' groups could be due to the fact that the sexes use different strategies of talking, within their groups and also in mixed groups. According to some researchers, girls' groups tend to have an egalitarian ethos, while boys learn to use strategies that raise their status (Eckert and McConnell-Ginet, 2003). Within mixed-sex groups, the styles of talking that boys and girls engage in also differs (Fishman, 1978).

7.5 Collaboration and informal communication

Informal communication and collaboration that took place among the participating students within their groups and within the cluster was analysed. We aimed to understand students' interactions and the learning that took place while they engaged collaboratively on common technological tasks. Detailed observations of the trials of the units indicated that working in teams aided students in learning to share their resources (both material and non-material), as well as skills and knowledge. The sharing and the verbal/nonverbal exchanges inevitably helped students to better understand the processes involved in reaching the goal along with developing a perspective of the points of views of others.

7.5.1 Informal communication and collaboration at the group level

Informal communication refers to the casual verbal and nonverbal exchanges that take place between members of a group and also across groups while working on a common task. Observations regarding informal communication and collaboration have been categorised under heads such as: *roles played by different members of a group, conflicts, conflict resolution and sharing of resources, nonverbal communication, and informal verbal communication*.

Students took up different *roles* while working in their groups. These roles were that of a leader, manager, assistant, writer, mediator, communicator, etc. Academic performance, physical build and possession of some specific skills such as public speaking, drawing, often helped students in taking up various roles. We observed that girls often took or were given the tasks of decoration of artefacts, drawing or sewing, while boys tended to take up tasks that required the use of tools and equipments.

In most groups there was a *sharing of resources as well as conflict over resources*. This was especially so when the resources were limited (e.g. scissors/ hammers), but there were instances of conflicts even over very small and abundant resources (e.g. needles and thread). It was observed that boys in mixed-sex groups usually exercised control over resources and girls had fewer chances to handle these. Conflicts also occurred because of unfavourable work distribution in the group or having to comply with a group decision. There were frequent debates between group members on the procedural aspects of the activity. Fewer conflicts occurred in the rural groups as compared to the urban groups.

In all the units students used their hands and facial expressions to convey messages within their groups. Thus *nonverbal communication* formed an important component of their informal communication. Students used gestures for communicating information and sharing ideas (e.g. motion of windmill) as well as for conveying emotions (e.g. victory, disapproval, etc.). Physical movements were often used for giving estimates of length and height of objects.

The *verbal communication* showed gender references in students' language use, often through explicit comments. Boys tended to use more individual centric language (such as use of 'I', 'me') as compared to girls. Girls in the mixed-sex groups often found it difficult to be heard. There were instances recorded when the boys in a mixed-sex group totally ignored the attempts of a female group member to contribute to their discussion.

With regards to informal communication in the three settings, it was observed that students from urban English setting generally communicated in Hindi within their groups. However, during formal communication they always used English. Similarly the urban Marathi students used Marathi for formal communication but within their groups they occasionally used Hindi. The rural Marathi students spoke in a dialect of

Marathi (which was different from the Marathi spoken by urban Marathi students) for informal as well as formal communication.

7.5.2 Learning through collaboration and communication at the classroom level

The analysis of collaboration in the three units focussed on the evidences of learning that occurred while students worked in groups. These evidences were categorised as: *realisation of common goals, diffusion of learning through techniques, tools and diffusion of learning facts 'while on-the-job'*. The term 'diffusion' has been used to refer to a situation where more and more members of a community/classroom use a certain resource or engage in specific practice (Roth, 1996). This study provides some evidences of these changes studied in the context of D&T units in the Indian settings. The data source for these evidences was students' informal dialogues while they worked on the units.

There were instances of learning within the smaller groups in which students worked as well as at the community or the classroom/setting level. Students who participated in our trials were not accustomed to working in groups and therefore initially faced problems. But with time they learned to work in groups *setting common group goals* and working towards them. Along with these reasons, the designing of the units also was done so as to encourage members to work together and work collaboratively.

In all our units, we planned that all the students within a setting should work together within a single classroom and this arrangement afforded a situation in which information could be easily be exchanged and students could find out about their peers' work. Students learned the use of tools, acquired new skills by engaging in tasks themselves and also by watching other members in the group. There were instances of tool-related practice being 'diffused' in the entire setting (e.g. the use of drilling machine, saw etc.). Some practices such as the use of rivets (in urban English setting), making stool-like towers (in rural Marathi setting) could be seen spreading from one group to another and then the entire setting. To become a member of a practising group, students had to find a way through their experience, to *appropriate* the use of tools and practices.

In the case of diffusion of learning through facts, it was observed that students did not use all facts that were explicitly taught to them during the units and many a times resorted to trial and error technique to learn facts on their own. Students learned a few practices and facts on-the-job. For example students learned that the key to a durable bag is the strength of the joints, base and handles. This learning could be applied in other situations also, such as in the windmill unit the base had to be strong. Thus the informal communication and collaboration indicated that D&T tasks could help students in developing new ideas and skills that will be useful to them in other areas.

7.5.3 Evaluation of products

Evaluation was an important phase of all our D&T units. Students evaluated their own products as well as those made by their peers groups using semi-formal evaluation sheets. Apart from product evaluation, students also gave comments on designs of the products to be made. These comments were generally given during design communication and the groups presenting their designs either incorporated these suggestions or justified/defended their designs.

While evaluating the products made, students tended to rate/score the objects made by their groups higher than those by other groups. The assessments made by the students of their products as well as the products made by others were guided more by aesthetics than the functionality of the artefact. Criticisms of the product and the procedure were presented respectfully to the concerned groups and the positive aspects were also genuinely appreciated.

The researcher also evaluated the products made by various groups using the same evaluation sheets. This exercise was done to see if the products made were satisfactory and met the intended aims of D&T units. The ratings given by the researcher, peers as well as self-ratings of all the products were towards the excellent end indicating that the products were made well. In the bag-making unit, most groups made paper bags and only a few cloth bags were made. Students in the urban settings used a variety of raw materials for making their products especially their windmills. For puppetry unit rural

Marathi students made a variety of props and their stage setting was innovative. Most puppets made were not very easy to handle but were aesthetically appealing.

7.6 Overall conclusions

This study indicates that D&T activities can encourage collaboration and communication among students and can also be an inclusive endeavour. The trials of the D&T units developed by us suggested that both boys and girls from rural and urban areas performed at par in terms of kinds of dialogues exchanged, learning from collaboration, as well as, the products made. The difference in communication lay in the frequency of students' talk. In formal communication, single-sex boys' groups communicated most, followed by single-sex girls' groups whereas in mixed-sex groups both boys and girls appeared restrained in communicating with others. In all the three settings (urban English, urban Marathi and rural Marathi), students exchanged *cumulative* dialogues the most and *disputational* dialogues the least. In the three settings *exploratory* dialogues, which are indicators of critical thinking, were more frequent in product communication as compared to design communication.

With regards to perceptions of Indian sixth grade students about technology, it was found that students have a positive view of technology but this view is mostly product oriented. Students were found to have stereotypical ideas of occupational suitability for males and females and gradations of technology in rural and urban areas. These ideas were similar among boys and girls and also among students from rural and urban areas.

The findings of this study support the Vygotskian view that interaction among peers has a potential to culminate in cognitive change. Although talk amongst learners has tended to have a low status in formal education, recent research provides good reasons for encouraging learners to talk and work together in educational activities. Talk is now recognized as more than a means for sharing thoughts: it is a social mode of thinking**,** a tool for the joint construction of knowledge by teachers and learners. A feature common to all the groups studied in all the settings was that group members engaged in talking with each other i.e. group members 'talked aloud'. There may be many reasons for this. One possible reason could be that it acted as another level of cohesion for the group, enabling thinking to become public knowledge so that the group's thinking could be bound together (Edwards, 2005). If so, it may be evidence for shared cognition in which knowledge is co-constructed through socially shared images, experiences, and, in this case, activities.

7.7 Limitations of the Study

The intent of this study was to investigate middle school students' ideas about technology and then develop and conduct trials of communication and collaboration centred D&T units with Grade 6 students from urban and rural settings. For investigating students' ideas about technology, questionnaires and interview schedules were prepared and tested. The use of these instruments was limited to sixth grade students in rural and urban settings who participated in the survey.

The units that we tried with the students were on an experimental basis where students (urban) volunteered to come to our Centre and participate. Therefore the results of the study are limited to students who volunteered. Though we tried to maintain situations similar to a regular Indian classroom, we were not able to cover a wide gamut of situations that exist in the real classrooms. These units need be tried in the real classroom contexts (units can be taken out of the 'laboratory').

Another limitation with this study or any other survey study is that it is limited to what people are willing to tell researchers under the conditions of data collection designed by the researcher (Fowler, 2002), so what the students said in the interviews was taken as their honest response.

The third limitation that existed but was not foreseen in the study was of the importance of informal talks within groups. We did not plan to study informal talk as a variable in the study. During the trials we realised that talk among groups members was a rich source of information about the developments within a group. Since studying informal talks was not planned within our study, we did not focus our recording equipments on any group.

The fourth limitation was a technical one and this was related to recording of data. The data recorded for informal talk was not sufficient/appropriate as we did not fix the camera on any particular group - so the data that we have was dispersed and therefore did not give a very clear picture of informal dialogues. In the rural settings due to problems of logistics, the quality as well as quantity of video data was not sufficient.

The observations and findings of this study are limited to the school settings utilized and to the students who volunteered. While the intent of this study is not to generalize the results to other schools or school settings, readers may find detailed analysis of dialogues useful in understanding how students' talks in other contexts could be analyzed. The number of units tried was limited and therefore the kinds of dialogues may vary with the nature of the units and tasks involved therein. Recording of informal conversations could have provided another dimension to the study.

7.8 Self-reflection on the research

This study involved finding out middle school students' ideas about technology through a survey questionnaire followed by interviews on a sub-sample of students. The survey used a pictorial questionnaire, which was prepared in two alternative forms. The questionnaires were pilot tested and their reliability was established using test-retest method. The reliability of Form A of the questionnaire was 0.70 and for Form B it was 0.84. Although there is no definitive standard for reliability (Pedhazur and Schmelkin, 1991), many researchers follow Nunnally's (1978) recommendation that reliability should be at least 0.70. The values of reliability with respect to survey questionnaires in this thesis signify satisfactory reliability values. The interviews gave an opportunity to understand the reasons why students considered a particular object or activity as related to technology and also the reasons why they did not consider something as technology. The survey combined with interviews helped in constructing a holistic picture of students' ideas about technology. Thus the decision to conduct interviews even on a small sample (18) proved worthwhile.

The second part of the thesis work involved development of three design and technology units and their trials with middle school students from three socio-cultural settings in India. For all the units students worked in groups of 3-5 members. Each setting had 6 groups - with 2 all girls groups, 2 all boys groups and 2 mixed-sex groups. There were two occasions planned within each unit where students needed to formally communicate - design communication and product communication. These communications were audio and video recorded.

In this thesis students' formal communication after designing (design communication) and after making the product (product communication) were studied using the categories used by Dawes et al. (1992) which included 3 kinds of talks: disputational, cumulative and exploratory. This method of verbal data analysis combines the qualitative as well as quantitative aspects and is based on Vygotsky's sociocultural approach, which views how language and social interactions are involved in the process of human development and learning.

The categories of talks based on Dawes work, does provide a broad framework for analyzing verbal data in a way that combines qualitative and quantitative aspects. A finer categorization was made only with reference to the coding of the dialogues (Appendix P). The codes for each category were fine-tuned to suit the local conditions. Besides, the coding for the three categories of talk depended on the context in which the talk had occurred. Thus the raters could not work only with the transcripts but had to go back to the video-recordings to understand the context in which something was said in order to code it accurately.

The overall framework provided a way to study collaboration and joint understanding developed over time and hence this method of analysing the data suited our purpose. Research suggests that in order to develop a joint understanding; certain qualities of discourses are necessary. These include talks in which partners present ideas clearly and are able to share relevant information effectively. Secondly members should express opinions and be able to critically examine the information being provided to them by others. According to Mercer (1996), from an observer's point of view, the shared understanding should be *visible* in the talk. Our units were designed in such a way that students needed to work collaboratively in groups and our assumption was that formal communication is not merely incidental and that it would trigger conversations. This conversational aspect was seen in the formal communication with the audience questioning the presenters who replied as best as they could.

For the coding of the verbal data, 2 raters were involved. The reliability of the data was set by inter-rater agreement or the percentage agreement between raters. The percentage agreement between raters was calculated for each unit separately based on 50% of the transcripts. This agreement ranged from about 60% to over 80%. Typically in social science research reliabilities of over 70% (or 0.70) are considered acceptable, and of over .80 are considered good (see the discussions in Pedhazur and Schmelkin, 1991). However, Nunnally (1978) does suggest that lower reliability estimates are acceptable in early stages of research. Higher reliabilities are necessary if measures are to be used for determining differences between groups. Though percentage agreement between raters is a liberal method of finding reliability, nevertheless, one cannot generalise to a large extent based on reliability measure established only by percentage agreement between raters. Since this study is exploratory and merely patterns are highlighted, I felt that this amount of percentage agreement between raters is acceptable. However better measures of reliability need to be used in order to generalise results.

In order to make judgments about the educational value of any observed talk, analysis at a cultural level is needed, because it involves consideration of educated discourse and the kinds of reasoning that are valued and encouraged in a particular culture and its institutions of formal education. Exploratory talks according to Mercer (1996, p. 370), typifies ‘language which embodies principles of accountability, clarity, constructive criticism and receptiveness to well-argued proposals.’ In this study, we observed that exploratory talks increased in product communication in all the three units, which indicates that students could reason and express themselves better after making the product. Among the three units, students exchanged maximum exploratory kind of dialogues during the windmill unit and least in the puppetry unit (Figure 5.31), which is an effect of the nature of the units. The data from the puppetry unit showed that students from the rural setting did better in this unit with respect to formal communication as well as in collaboration (in making props and putting up the puppet show) as compared to the other 2 units. Puppetry being the third unit to be tried, rural students' confidence may have increased. Also puppetry is rooted strongly in the Indian culture (especially locally) and this may have had an impact on students' communication.

If this study were to be done differently then I would try to use better methods of data recording and would record informal communication within groups as well. I would preferably focus my video camera on two or three groups in a setting and would follow these groups for the three units. Such a strategy would help me in concentrating on how the students in a group evolve in their designing and making abilities over time and then a comprehensive framework for comparison could be developed. Also, the communication patterns would be clearer and amenable to detailed qualitative and quantitative analysis. Another way that this research can be done differently is to carry out trials of one or two units in greater detail instead of three units so that we can have more parameters of observation during the trials. Yet another possibility would be to conduct the units in a regular school class (along with the limitations of time and number of students that teachers deal with) during an academic year.

I would like to develop better methods of assessment of student's understanding and progress, wherein some part of it would be objective and some part subjective. Interviewing students could help in getting closer to understand what they learned during the units. Interviewing would also help in knowing the extent of contribution of individual students to a group activity. This would give a better feel of the group dynamics. As far as research methodology of this work is concerned, a methodological triangulation, which could include detailed video data, students' interviews and daily logs, would enhance the value of the results from this study.

7.9 Recommendations

Based on our study recommendations can be made under two categories: viz, *recommendations for future research and recommendations for changes in the existing practices.* These recommendations stem mainly from our experience of conducting trials of D&T units across the three settings complemented with the survey.

7.9.1 Recommendations for future research

As noted in this study, there are some important areas for future consideration, as is the case with most exploratory research. There is a need to carry out research to find out the profile of talks during each of the phases of D&T activity. This will help in knowing the stage at which 'maximum constructive talks happen'/exploratory talks and then teachers could be trained to encourage certain kinds of talks in each of the phases so as to aid in peer learning. Another possible area of research could focus on single-sex boys' and single-sex girls' groups while they are involved in D&T tasks to find out the differences in working styles in the two groups.

Informal communication is a dominant activity while students are engaged in D&T units. In our study we did not look in detail at students' informal communication, but during the study we realised that informal communication (which adhere less strictly to rules and conventions) is also a rich source of information. Informal communication helps to achieve both social and production goals of a group (Kraut et al., 1990). Students' casual discussions and notes while they are involved in the D&T tasks could give an idea about how concepts are developed in a group and can also give more details about the kind of collaborations within the groups. Therefore a study of informal communication is a potential area of future research.

A possible way to analyse the data is at the linguistic level, where one could study the structural organization of classroom communication between students. The grammatical and pragmatic features of the discourse data could be analysed to give an idea about how students' words/messages are understood by their peers while they are engaged in teamwork during D&T activities. Another possible variation could be in the choice of D&T units, i.e., different and more or less culturally rooted units could be planned for trials and then students' communication across settings could be studied.

7.9.2 Recommendations for changes in the existing practices

Based on our study, we recommend changes in the practice of education in India in general and technology education in specific. We suggest that at the school level, students must be engaged adequately in hands-on activities. These hands-on activities should be set in real-life situations so that engagement in these activities can prepare students to respond to unpredictability of real-life events. Activities set in real-life situations will not only acquaint students in gaining procedural knowledge and skills but will also inculcate in students the culture of learning from each other.

Another recommendation that stems from other studies as well as this study is that ‘copying’/ ‘appropriation’ has a positive connotation. ‘Copying and appropriation’ as understood in the Vygotskian sense can aid learning. These involve imitation and have an element of reinterpreting one’s own behaviour in the light of another. The current Indian education system would however frown on these acts of ‘copying and appropriating.’

The educational system should encourage students to work in groups and maintain an environment in which collaborative learning is possible. For doing so, the physical layout of the classroom needs to be modified so that students can work in groups. Common worktables need to be arranged so that students can work around them. It is crucial for teachers to plan a structured range of progressive activities in advance, giving careful consideration to the concepts and the skills that need to be developed and the overall goals of the activity.

The idea of collaborative teaching or co-teaching (two or more teachers teaching one subject) should be brought into the Indian school system. For successful co-teaching, teachers need to plan their lessons together and execute them in a planned way. Such a practice will bring in academic diversity into the classrooms and give a holistic picture of a subject to students. The idea of co-teaching is common within the classrooms for children with special needs but the same practice can be successful in regular D&T classrooms as was the case in this study where two researchers facilitated classroom activities.

Appropriate assessment methods should be developed to evaluate group work. Currently in most examinations, the aim is to assess the ability of a student almost exclusively on individual basis, paying little attention to how an individual uses acquired knowledge and skills in a team. Evaluation systems must be developed to empower students to gain confidence in the skills and knowledge that they have gained during the course rather than be judged and categorized as academically poor or good students as is the practice in many schools.

In the context of technology education, students should be given a broad idea of technology and be made aware that technology is beyond objects. It includes human, technological as well as environmental factors. This idea of ‘technacy’ (Seemann, 2000) should be introduced to students at an early school age (beginning of middle school), as early adolescence is the stage when thinking begins to move from concrete to abstract, and this provides an excellent opportunity to enhance that change. Both boys and girls should be motivated to participate in the activities.

Teachers form an important component of the education system and need to be extensively trained to carry out D&T tasks in the Indian classrooms. The crafts and arts teachers along with science teachers should be trained in content and the pedagogy of conducting collaborative teaching which is specially suited for introduction of technology education in the Indian classrooms.

Technology education when introduced as a separate subject can provide a good platform for introduction of skills of teamwork teamed with technical, procedural and conceptual knowledge. This can broaden students’ concept of technology and can be helpful in forming a ‘balanced’ picture of technology in the minds of students, which can contribute to bringing about a change in the profile of human power in the area of S&T in the country. At the end we must remember that inclusion of a particular subject in curriculum is a matter of politics and logistics and therefore cooperation on the part of policy makers must be sought after.

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APPENDIX A

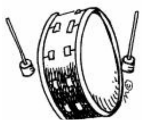
Technology-as-objects questionnaire

Name:______________________________ School:__________________________

Class:_____________ Birth date:____________________ Boy / Girl (circle one)

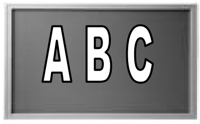
Circle the pictures that you think are related to technology


Football


Drum

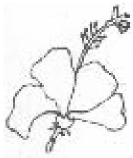

Whistle

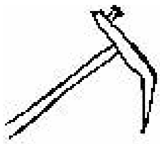

Tractor



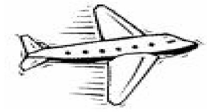
Black board


Lemon squeezer

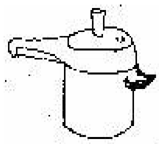

Flower

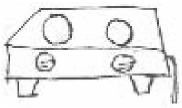

Plough

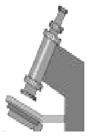

Fountain pen


Aeroplane

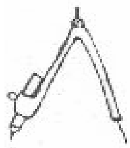

Gun

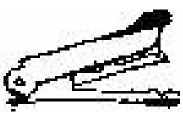

Pressure

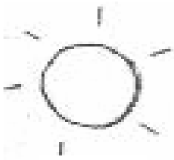

Gas

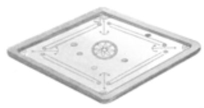

Microscope

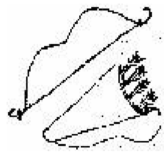

Sitar

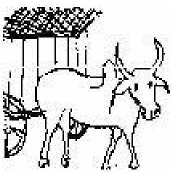

Compass


Stapler

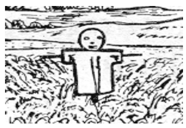

Sun

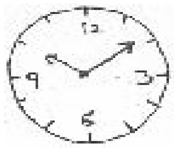

Carrom-board

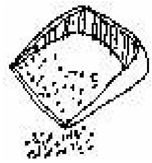

Bow and arrow

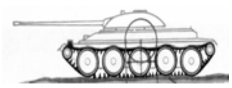

Bullock- cart


Television/T.V.

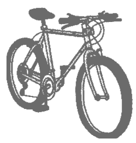

Scarecrow

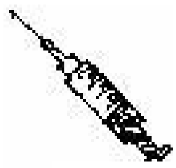

Clock

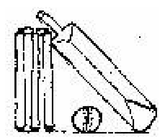

Winnowing pan


Tank


Computer


Bicycle


Syringe


Bat, ball, stumps

Name:______________________________ School:__________________________

Class:______________ Birth date:_____________________ Boy / Girl (circle one)

What would you like to become when you grow up?

____

Two of your friends, a girl and a boy, come to you for your advice on which occupation they should choose. Which occupation would you advise them to choose? Put a tick (√) in the suitable column of your choice against each career.

Occupations	**Girl**	**Boy**
Dancer		
Farmer		
Scientist		
Doctor		
Nurse		
Teacher		
Soldier		
Shopkeeper		
Cook		
Pilot		

Meeta and Suresh are friends. They have a set of jobs to be completed before they can go out to play. They distribute the jobs so that they can finish them quickly. Who would you suggest should do the following jobs? {Tick (√) **one box** for each job}

Job	**Meeta**	**Suresh**
Dusting the house		
Repairing a torn book		
Ironing the clothes		
Collecting grocery from the store		
Recording songs on a cassette		
Replacing a fused bulb		
Sorting the tool box		
Bringing firewood		
Arranging utensils (vessels) on a shelf		
Watering the plants		

APPENDIX B

Technology-as-activities questionnaire- Form A

Name: **Class:**

School: **Boy/Girl- Circle one**

Look at the pictures of the activities given below. In the box that is provided below the picture, write "T", if you think that the picture is related to technology. Write "N" , if you think that the picture is not related to technology.

Scientist working

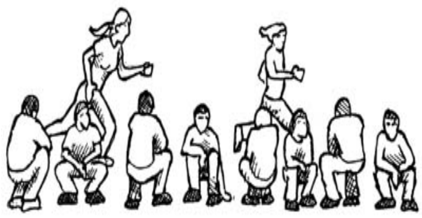
Cooking

Bird's nest

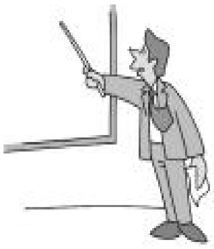
Playing *Kushti*

Dancing

Playing kho-kho

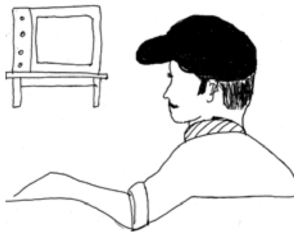


A teacher teaching



Pulling a rickshaw

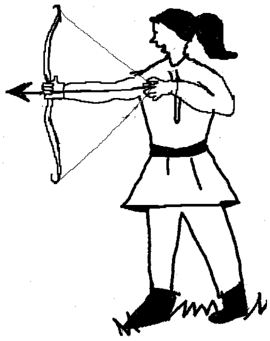
Watching TV



Driving an auto rickshaw

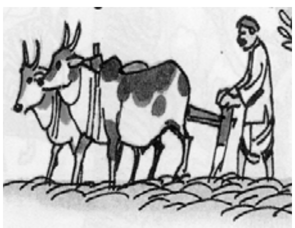
Doing Yoga

Archery

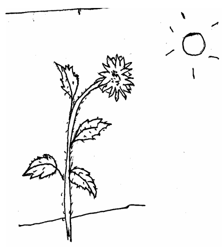


Playing sitar

Farming



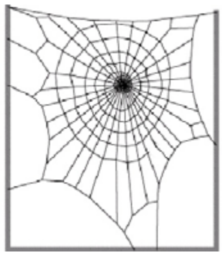
Plant turning towards light



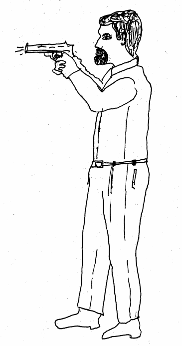
Thunder and lightning

Working on computer

Spider's web

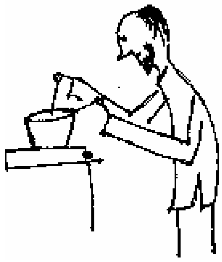


Using a gun



Talking on telephone

Cooking with gas



Playing *gilli danda*

Drawing water from well

Playing hockey

APPENDIX C

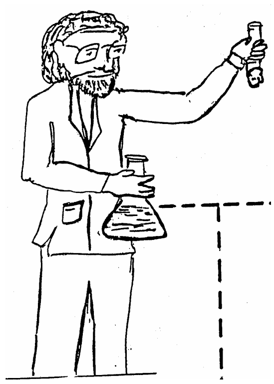
Technology-as-activities questionnaire- Form B

Name: **Class:**

School: **Boy / Girl- Circle one**

Look at the pictures of the activities given below. In the box that is provided below the picture, write “T”, if you think that the picture is related to technology. Write “N”, if you think that the picture is not related to technology.

Scientist working



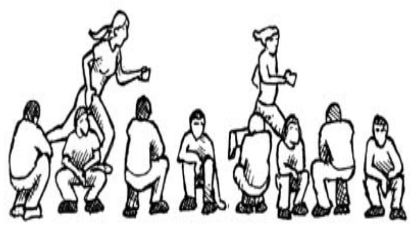
Cooking

Bird’s nest

Playing *kushti*

Dancing

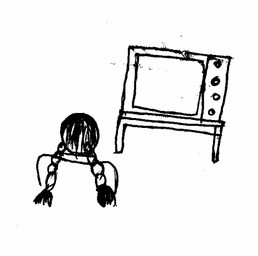
Playing *kho-kho*



A teacher teaching

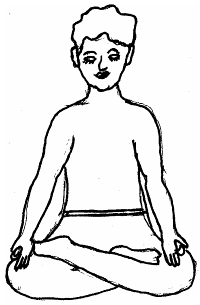
Pulling a rickshaw

Watching TV

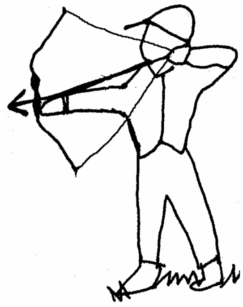


Driving an auto rickshaw

Doing Yoga

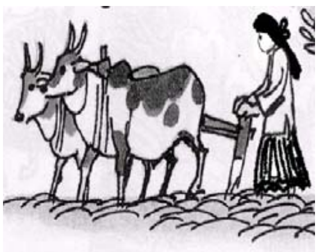


Archery

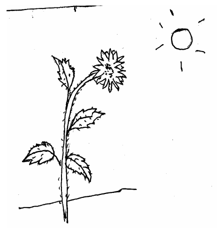


Playing sitar

Farming



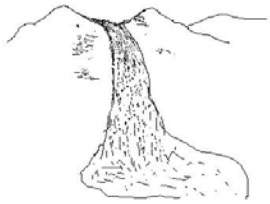
Plant turning towards light



Thunder and lightening

Working on computer

Waterfall



Using a gun

Talking on telephone

Cooking with gas

Playing *gilli danda*

Drawing water from well

Playing hockey

APPENDIX D

Interview schedule

Name:____

Date of birth:_______________ Age in completed years: ______

Boy / Girl Rural / Urban English / Marathi

Name of school: ___________________________________

Father's occupation:_________________________________

Father's education:__________________________________

Mother's occupation:_________________________________

Mother's education:__________________________________

As the child comes (**before giving the questionnaire, objects):**

School:

1. When I mention the word technology, what comes to your mind? (t)

____

____

2. Can you relate technology to any location/s?

____

3. Do ***you*** think that ***you*** use technology in your daily life?
Where, list?

____

4. Do you think that your ***mother*** uses technology?
If yes, which technology and where have you seen her use it? Elaborate. (t+w)

____

5. Do you think your ***father*** uses technology?
If yes, which technology and where have you seen him use it? Elaborate. (t+w)

____

6. Which ***people*** **according to you** are generally involved in ***using*** technology? (t)
Why do you think so/ how do you say so? (t)

____

7. Who according to you are the people who are involved in ***creating*** technologies? (t)

---

8. How do you say so/what makes you say this- where have you seen it? (t)

---

9. Do you think that technology generally involves something ***new (modern***) or it can be ***old*** also? (t+w) Why do you think so? (t)

---

10. Do you think technology is more related to ***urban areas*** than ***rural areas***? (t+w). Why do you think so? (t)

---

11. What do you think- Is technology used more by ***girls*** or by ***boys***? (t+w)
Why do you think so/what makes you say this? - elaborate (t)

---

12. Do you think, if we are using some ***materials*** like wood, metal then only we are doing technology? Or can we do technology without these? (t+w)

---

13. What is not technology? Give eg (t+w)

---

14. Would you say that there is technology in the following?
Pictures – Questionnaires of objects

Make the students do the questionnaire picture by picture.

After the child has finished the picture question: Point to each picture asking why it is/not related to technology? (t)

Football	
Drum	
Whistle	
Tractor	
Black board	

Lemon Squeezer	
Flower	
Plough	
Fountain pen	
Aeroplane	
Gun	
Pressure cooker	
Gas	
Microscope	
Sitar	
Compass	
Stapler	
Sun	
Carom- board	
Bow and arrow	
Bullock- cart	
TV	
Scarecrow	
Clock	
Winnowing pan	
Tank	
Computer	
Bicycle	
Syringe	
Bat, ball and stumps	

15. Give reasons for why you advised a particular occupation for a boy or a girl?

Boy:

Girl:

Give reasons for why you advised a particular occupation for both?

Both:

16. Give reasons for why you advised a particular task for Meeta or Suresh?

Boy:

Girl:

Give reasons for why you advised a particular task for both?

Both:

17. Give specifics of where the technology is in these activities? (t+w)

a) Is there any technology involved in cleaning vessels?

b) What about cleaning a bicycle?

c) Is any technology involved in sharpening knives?/on stone

d) What about sharpening pencils?

e) Is there any technology involved in farming? (ploughing)

f) What about sowing?

18. If there is an opportunity for only one person to go to space on a shuttle- who should go- a boy or a girl? Why?

20. Make the students do activity questionnaire (Form A+B) - if they have not already done it or if they have done it, take out their sheets and ask them pointing to a few pictures, why they considered it tech or not tech- on what basis. (as done for object quest)- (t)

Form A:

Pictures	
Scientist working (f)	
Cooking (m)	
A teacher teaching (m)	
A *kushti* competition (f)	
Dancing (m)	
Playing kho-kho (b)	
Weaver bird nest (n)	
Pulling a rickshaw (f)	
Playing *gilli danda* (f)	
Driving auto rickshaw (m)	
Doing yoga (f)	
Drawing water from the well (m)	
Playing sitar (f)	
Farming (m)	
Playing hockey (f)	
Thunder and lightning (n)	
Working on computer (f)	
Spider web (n)	
Using a gun (m)	
Talking on telephone (f)	
Cooking with gas (m)	
Watching TV (m)	
Archery (f)	
Plant turning towards light (n)	

Form B:

Scientist working (m)	
Cooking (f)	
A teacher teaching (f)	
A *kushti* competition (m)	
Dancing (f)	
Playing kho kho (b)	
Weaver bird nest (n)	
Pulling a rickshaw (m)	
Playing *gilli danda* (m)	
Driving auto rickshaw (f)	
Doing yoga (m)	
Drawing water from the well (f)	
Playing Sitar (m)	
Farming (f)	
Playing hockey (m)	
Thunder and lightning (n)	
Working on computer (m)	
Bee-hive (n)	
Using a gun (f)	
Talking on telephone (m)	
Cooking with gas (f)	
Watching TV (f)	
Archery (m)	
Plant turning towards light (n)	

APPENDIX E

Letter to school principal

To,
The Principal,

Mumbai.

Subject: Permission for students to come to HBCSE for activity based learning unit

Dear Sir,

Homi Bhabha Centre for Science Education (HBCSE), TIFR, Mumbai, is a National Centre for research and development in science and mathematics education. It conducts a variety of field programmes for students and teachers from primary school to introductory college levels. It also conducts research in education and student's ideas about science and technology.

We are developing units on technology education for school students in a project at the Centre. The attitudinal survey that we carried out with your students was a part of this project. We are now at a stage where we would like to try out some on the technology education units, which we have developed. We would be grateful if we could do this in collaboration with your school. We have already tried out one of our modules with your students. For this camp, we would prefer to have the same set of students who had attended the previous camp. We need to interact with about 20-25 students (preferably equal number of boys and girls) from Standard VI (going to std VII) who can come to the Centre during vacations.

The second and third technology education unit trials are expected to be carried out in 5 sessions (5 +5 days) of about 1 -1.5 hours each. During this time the students will be engaged in a variety of activities of planning, designing and making a usable product. This unit will benefit students in gaining hands-on experience at technological tasks involving science concepts.

HBCSE has a long history of collaboration with (school name), which has been of mutual benefit. We hope to continue this tradition of association. Therefore we request you to kindly help us choose the students to participate in our design and technology project. The tentative schedule of the camp is attached. We will be contacting at a later time for more help with activity based learning units.

Thank you very much for your co-operation in this regard and look forward to interacting with your students.

Thank you.

Yours truly,

Swati Mehrotra   Ritesh Khunyakari

APPENDIX F

Letter of consent to parents

HOMI BHABHA CENTRE FOR SCIENCE EDUCATION
TATA INSTITUTE OF FUNDAMENTAL RESEARCH
National Centre of the Government of India for Nuclear Science and Mathematics
V. N. Purav Marg, Mankhurd, Mumbai 400 088.

Tel : 2555 5242, 2558 0036 Fax : 091-22-2556 6803
E-mail: hbcadm@hbcse.tifr.res.in

Sub: Note to Parents/Guardians seeking permission for their ward to participate in Design and Technology Tasks at the Centre

Dear Parent/ Guardian,

Homi Bhabha Centre for Science Education, TIFR, Mumbai is a national Centre for research in science, mathematics and technology education. The Centre collaborates with teachers and students of a variety of schools in its educational activities.

One of our interests is the development of Technology curriculum for school students. We develop design and technology tasks suitable for school students that engage students in active learning through planning, designing, making and evaluating objects and systems. It is expected that these activities will use knowledge from subjects like science, mathematics and art, and link them in meaningful contexts.

During the development of such tasks, we seek the participation of a group of students **passing from Std. VI** of Atomic Energy School. This letter is to seek your permission to consider your ward for **possible selection** in the project group. **If selected**, your ward will participate in the summer camp to be held during May, 2004 at our Centre.

The schedule for the activity sessions is as follows:

Duration: 03.05.04 to 22.05.04 (Except Sunday)
Venue: Homi Bhabha Centre for Science Education located near Anushakti Nagar Bus Depot, opposite Children's Aid Home.
Time: 10.00 am to 12.30 pm
No fee is charged for participating in the project.

Kindly fill the attached form and send it to the school. We can admit only 20-25 students in our project, including nearly equal numbers of boys and girls. The selected students will be informed by the school.

You may contact the undersigned at the phone numbers given above for any clarifications.

Thanking you,

Yours sincerely,

Swati Mehrotra and Ritesh Khunyakari
Researchers, Science-Technology-Society Project, HBCSE (TIFR)

APPENDIX G

Form for admission to D&T development project

FORMS FOR ADMISSION TO

DESIGN & TECHNOLOGY TASKS DEVELOPMENT PROJECT

(Please fill this form and submit it to the school within **3 days**)

I have no objection to send my daughter/son/ward________________________
(Name)
studying in ______ Std. _____ section in school _____________________________ to
(School name)
participate in the programme.

My residential address is:

And contact phone is:

I shall take the responsibility to ensure that my ward attends the camp on all the days.

Signature of the Parent/ Guardian and date:

Name of the Parent/ Guardian:

Is your ward likely to be absent on any day during the camp period?
If yes, please give the likely dates s/he is will be absent________________

Dates/ Period that you are likely to be out of station:

Schedule of the camp: May 3 to May 21, 2004, 10-12.30 hrs

APPENDIX H

Students' self information form

Self-Information

Name:____

School:____

☐ Girl ☐ Boy

Age: _______________Years Date of birth: ________________

What was your percentage marks in the last examination? ________________

Father's work:____

Mother's work:____

Your favourite subject:____________________________________

The subject that you like the least:______________________________

What do you like to do when you are not at school?

____

____

Do you like making things?

Yes ☐ No ☐

If "Yes" then what are the things that you like to make?

____

____

What are your hobbies?

____

____

APPENDIX I

Form for evaluation of own group's bag

Information about your bag

1. Name: ____

2. Name of your group: ____________________________________

3. (i) Now you have made a bag! It may be a little different from what you had planned. Observe your bag carefully and state how your bag is different from the one you had planned. Compare with your plan in your file

(a) **Size**
In your plan: ____

Of your bag: ____

(b) **Shape**
As planned: ____

Of your bag: ____

(c) **Weight it can carry**
As planned: ____

Of your bag: ____

(d) **Time it will last**
As planned: ____

Of your bag: ____

(e) **Materials used**
In your plan: ____

In your bag: ____

(f) **Decoration**
In your plan: ____

In your bag: ____

(g) Any other changes you have made

____

(ii) While *designing* your bag what tasks did you do as a group?

- Made drawings Yes/No
- Listed materials needed Yes/No

- Distributed work within your group Yes/No

- Any other task not listed above ____

Of the above listed tasks (drawing, listing materials needed, work plan, distribution of work), which were helpful for making the bag and in what ways?

Task	**How it helped**

(iii) What was the cost of making your bag? List the materials used and their cost in the table below. Be sure to include the cost of all materials.

Materials and its quantities	***Approx. cost (Rupees)***	***Sub- totals***
Things that are used up		
Things that can be used again and again		
Other expenses		

Total cost for making the bag:
Rs___________

For how much would you like to sell this bag? ______________________________

If someone else sold this bag to you, how much would you pay for it?

____

If you had to make a similar bag again, how much time will you take?

____

(iv) If I want to make a bag like yours, what points should I keep in mind? What advice will you like to give me?

____

(v) How would you rate your bag? (Mark a tick ☐ under your option)

(a) Looks

Very Good	Good	Fair	Bad	Very Bad
☐	☐	☐	☐	☐

(b) Strength

Very Strong	Strong	Fair	Weak	Very Weak
☐	☐	☐	☐	☐

(c) Durability (How long will it last?)

Highly durable	Durable	OK	Less durable	Not durable
☐	☐	☐	☐	☐

(d) In which season, do you think your bag *cannot* be used?

Summer	Monsoon	Winter
☐	☐	☐

OR Can be used throughout the year

☐

(e) How useful is your bag for the purpose for which it is made (to carry 5 books of different sizes)?

Very useful	Useful	Neither useful nor useless	Less useful	Useless
☐		☐	☐	☐

(f) Now that your bag is complete. Can you see that it could have been made in some better way? List the changes in *making* that you realise now.

____

(g) List the ways in which your bag can be used

____

APPENDIX J

Form for evaluation of peer group's bag

1. Name of your group____

2. Name of other group whose bag you are evaluating___________________________

3. The bag made by the other group has the following features- (Mark a tick ☐ under your option)

(a) Looks

Very Good ☐ Good ☐ Fair ☐ Bad ☐ Very Bad ☐

(b) Strength

Very Strong ☐ Strong ☐ Fair ☐ Weak ☐ Very Weak ☐

(c) Durability (How long will it last?)

Highly durable ☐ Durable ☐ OK ☐ Less durable ☐ Not durable ☐

(d) In which season, do you think the bag *cannot* be used?

Summer ☐ Monsoon ☐ Winter ☐

OR Can be used throughout the year ☐

(e) How useful is their bag for the purpose for which it is made (to carry 5 books of different sizes)?

Very useful ☐ Useful Neither useful nor useless ☐ Less useful ☐ Useless ☐

List all the ways in which the other group's bag can be used

____

How much would you pay to buy this bag?

____

Is there anything special about their bag?

____

What other qualities or features would have made their bag better? (Suggest improvements needed)

____

APPENDIX K

Form for evaluation of own group's windmill

Name of your group ______________________________

1. Please rate your windmill in terms of the following-
   (**Tick** in the circle that you feel is the right choice)

(a) Neat and tidy

Neat　Okay　Untidy

(b) Sturdy

Strong　Okay　Delicate

(c) How would you describe your windmill?

(i) Tall　Medium　Short

(ii) Broad　Medium　Slim

2. What changes can make your windmill **look** better? (Circle one)

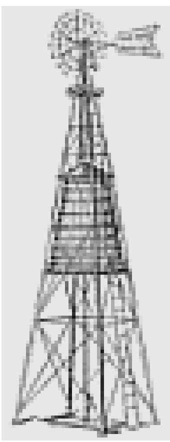
(a) Changes in materials　Yes / No
List the changes

____

____

(b) Changes in design　Yes / No
List the changes

____



(c) Changes in finishing touches　Yes / No
List the changes

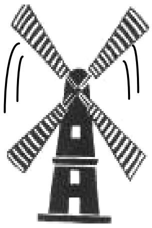
____

3. (a) How many blades does your windmill have? __________

(b) **Dimensions of the blades:**
Length = 　　cm; Breadth = 　　cm;
Thickness = 　　cm

(c) Length of the shaft = __________ cm

(d) Total height of the tower = __________ cm



4. (a) How smoothly does the shaft rotate? (Circle your choice)

Smoothly	Neither smoothly nor haltingly	Haltingly
1	2	3

(b) What can be done to make the shaft rotate more smoothly?

____

____

5. (a) Can the windmill be made using other materials? (Tick one)

Yes   No

(b) If "yes", list the names of other materials that can be used. Also mention which parts they will be used for.

Sr. No.	***Materials***	***Parts***

6. (a) Does the finished windmill look like your plan drawing?   Yes / No

(b) If "no", in what ways is it different from your plan drawing?

____

____

7. If you were to make your windmill again, what might you do differently?

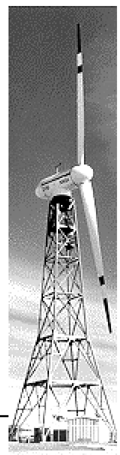
____

____

8. Did making this windmill teach you interesting things? List them.

____

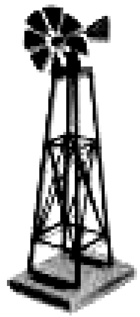
____



9. (a) How much time did you take to make your windmill? ____________________

(b) To make a similar windmill again, how much time will you will take? ____________

10. What is the estimated cost of your windmill?______________________________



11. What else can your windmill do besides lifting some weight?

____

____

12. Under what conditions will a windmill **not** work?

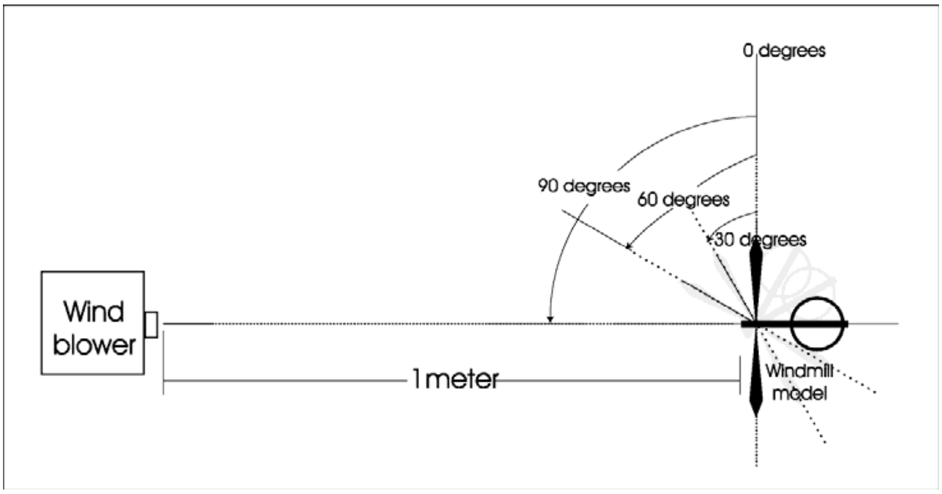
____

____

13. Using a blower and stand arrangement in the Test Room, test your windmill for its working.

Materials: Wind blower, stopwatch, stands, weights, protractor, scale, pencil, thread

a) At what angle does your windmill work best?
Count the number of rotations of the blades for 1 minute at angles **0°, 30°, 60° and 90°** for a distance of 1 metre from the blower. (See Figure below)



Number of rotations of blade for 1 min.	*At **0°** angle*	*At **30°** angle*	*At **60°** angle*	*At **90°** angle*

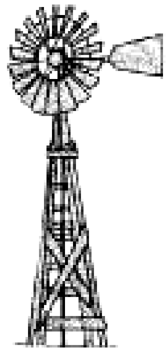
b) Your windmill performs best at __________ angle.

c) Place your windmill at best angle at different distance from the blower and count the number of rotations of the blade.

Distance of the windmill from the blower	***Number of rotations per minute***
1 metre	
1.5 metre	

d) Attach different weights to your windmill placed at 1 metre distance from the blower and measure the number of rotations in 1 minute.

Weight attached	***Number of rotations***
0 gms.	
5 gms.	
10 gms.	
15 gms.	
20 gms.	
30 gms.	



14. What changes can make your windmill **work** better? (Circle one)

(a) Changes in materials Yes / No
List the changes

____

____

(b) Changes in design Yes / No
List the changes

____

(c) Changes in finishing touches Yes / No
List the changes

____

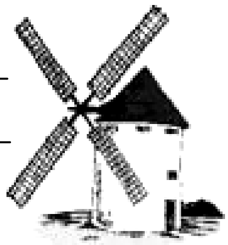
15. What do you like the most about your windmill?

____

16. One group of students made a windmill. It did not work at all. What could be the possible reasons?

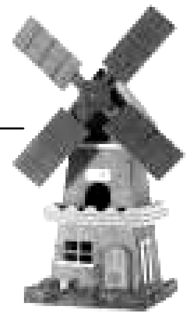
____

____



APPENDIX L

Form for evaluation of peer group's windmill



Name of your group ______________________

Name of the group whose windmill you are evaluating ______________

1. Please rate the other group's windmill in terms of the following- (**Tick** in the circle that you feel is the right choice)

(a) Neat and tidy

Neat   Okay   Untidy

(b) Sturdy

Strong   Okay   Delicate

(c) How would you describe the windmill?

(i) Tall   Medium   Short

(ii) Broad   Medium   Slim

2. What changes can make the other group's windmill **look** better? (Circle one)

(a) Changes in materials   Yes / No
List the changes

____

____

(b) Changes in design   Yes / No
List the changes

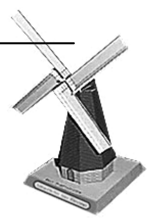
____

____

(c) Changes in finishing touches   Yes / No
List the changes

____

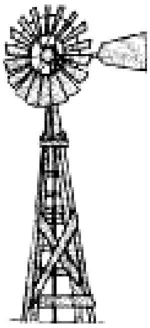
____



3. (a) Will the changes that you have given above make the windmill **work** better? (Circle one)   Yes / No

(b) Explain in a few lines

____



4. (a) How many blades does the windmill have?___________

Dimensions of blade:

Length = cm;
Breadth = cm;
Thickness = cm;

(c) Length of shaft = _________ cm

(d) Total height of the tower = _________ cm

5. (a) How smoothly does the shaft rotate? (Circle your choice)

Smoothly	Neither smoothly nor haltingly	Haltingly
1	2	3

(b) What can be done to make the shaft rotate more smoothly?

____

____

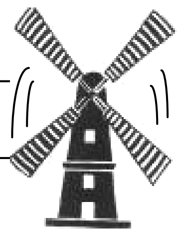
6. (a) Can the windmill be made using other materials? (Tick one)

Yes No

(b) If you ticked "yes", list the names of other materials that can be used. Also mention which parts they will be used for.

Sr. No.	**Materials used**	**Parts**

7. What is the thing that you liked the most in the other group's windmill?



____

____

____

APPENDIX M

Form for evaluation of own group's puppet

1. Your Group's name

____

2. Name and character of your puppet character

____

3. Kind of puppet/Human figure that your group has made (Tick one)

Glove/Hand puppet Rod puppet

String puppet Finger puppet

4. How many parts of the puppet can you move? (Circle one)

None (0) One (1) Two (2) Three (3) Four (4) Five or more (5)

5. Name the parts that can move in the puppet?

____

6. Movement of body parts

Head **(Tick one)**

- Cannot move (0)
- Moves in one direction (1)
- Can move in two directions (2)
- Can move freely in all directions (3)

Hands **(Tick one)**

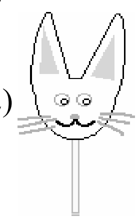
- Cannot move (0)
- Entire hand moves (1)
- Moves in more than one direction/Sub-parts/Joints move (2)

Legs **(Tick one)**

- Cannot move (0)
- Entire leg moves (1)
- Moves in more than one direction/Sub-parts/Joints move (2)

7. How easy is the puppet to handle? (Tick one)

♦Difficult (0) ♦Ok (1) ♦Very easy (2)



8. Is the puppet (Circle one)

♦Girl/Woman ♦Boy/ Man ♦Not clear

9. The finishing of the puppet is (Tick one)

♦Poor (0) ♦Satisfactory (1) ♦Very good (2)

10. To which place/region does the puppet character belong?

____

11. The puppet represents the character of the story (Tick one)

♦Poorly (0) ♦Satisfactorily (1) ♦Very well (2)

12. To make the puppet look like the character of the story what has been stressed? (Tick as many)

- Costume_______________________________
- Accessories_____________________________
- Colour_________________________________
- Features_______________________________
- Proportions_____________________________
- Any other______________________________

13. List the materials that you have used for making your puppet very much look like the character

____

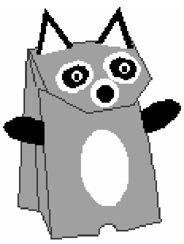
14. Is there any difference between the puppet that you have made and the puppet you had planned? (Circle one)

Yes No

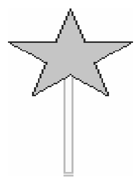
If "yes", list the differences

____

15. Are the changes more in terms of (Tick as many as necessary)



- Look/Finish ____________________________
- Materials-
  - Quantity ____________________________
  - Quality______________________________
- Measurements __________________________
- Any other (Specify)______________________



16. List the materials that you have used in making puppets but these materials can be used for other things/purposes

Materials	**Cost (Approx.)**
Scissors	

17. List the materials that you have used in making puppets but these materials **cannot** be used for other things/purposes

Materials	**Cost (Approx.)**

8. What do you think is the cost of your puppet? (Cost Price)

____

19. How much would you sell your puppet for? (Selling Price)

____

20. Calculate difference between selling price and cost price (Profit/Loss)

Selling Price – Cost Price

=______________________________

21. Did your puppet make a profit or a loss (Tick one)

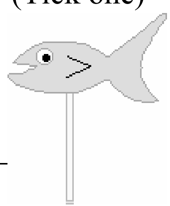
♦ If there is a Profit (1)   ♦ If there is a loss (0)

22. Are you sure that people would buy the puppet for this selling price

♦ Very sure   ♦ Do not know   ♦ Not sure

23. If you had to make this puppet cost a little less then what would you do? (Tick one)

- Use different materials (List materials___________________)
- Change the size of the puppet
- Any other way (Please mention)



____

24. If you wanted to add more movements-facial expression etc what would you do?

25. Any concept/s that you learned in school and also used in puppet making

26. How much time did you spend in making the puppet?

27. If you had to make a similar puppet again, how much time would you take?

28.Out of 10 how many marks would you give the puppet on the following?

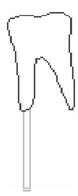
(a) Resemblance to the character in the story _____/10

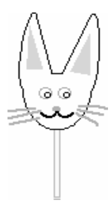
(b) Finish/Workmanship _____/10

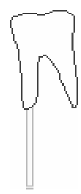
(c) Ease of handling _____/10

(d) Made with right materials _____/10

29. Now looking back, what do you think you should have done differently to make your puppet resemble the character?

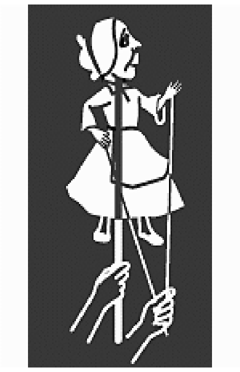






APPENDIX N

Form for evaluation of peer group's puppet



Name of your group ______________________________

Name of the group whose figure/puppet you are evaluating___________________

The following information is to be given for the other group's puppet/human figure

1. The Character of the puppet you are evaluating_______________________

2. What kind of puppet is it? (Tick one)

- Glove/Hand
- Rod
- String
- Finger
- Any other

If any other, please explain it________________________

3. How many parts of the puppet can you move? (Circle one)

None (0) One (1) Two (2) Three (3) Four (4) Five or more (5)

4. Name the parts that can move in the puppet

____

5. Movement of body parts

Head **(Tick one)**

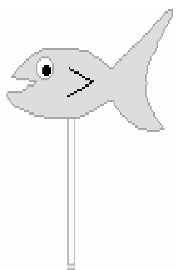
♦Cannot move (0) ♦ Moves in one direction (1)
♦Can move in two directions (2) ♦Can move freely in all directions (3)

Hands **(Tick one)**

♦Cannot move (0) ♦Entire hand moves (1)
♦Moves in more than one direction/Sub-parts/Joints move (2)

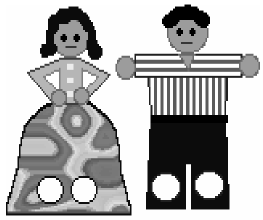
Legs **(Tick one)**

♦Cannot move (0) ♦Entire leg moves (1)
♦Moves in more than one direction/Sub-parts/Joints move (2)



6. How easy is the puppet to handle? (Tick one)
♦Difficult (0) ♦Ok (1) ♦Very easy (2)

7. Is the puppet (Tick one)
♦Girl/Woman ♦Boy/ Man ♦Not clear



8. The finishing of the puppet is (Tick one)
♦Poor (0) ♦Satisfactory (1) ♦Very good (2)

9. To which place/region does the puppet character belong?_____________________________________

10. Does the puppet represent the character (Tick one)

♦Poor (0) ♦Satisfactory (1) ♦Very well (2)

11. To highlight the identity of the puppet what has been focussed? (Tick as many)

- Costume______________________________________
- Accessories___________________________________
- Colour_______________________________________
- Features______________________________________
- Proportions___________________________________
- Any other_____________________________________

12. List the materials that make the puppet that make it look very much like the character in the story ____

13. This puppet was made in 1.5 to 2 hours. If you all had to make a similar puppet again, how much time would it take?

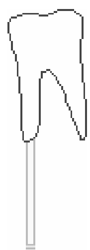
____

14. Suppose you buy this puppet, how much are you ready to pay for it?____

15. How much would you sell this puppet for?________

16. If you had to make this puppet cost a little less then what would you do?

- Use different materials (List materials_________________________)
- Change the size of the puppet (_________________________________)
- Any other way (Please mention) (______________________________)

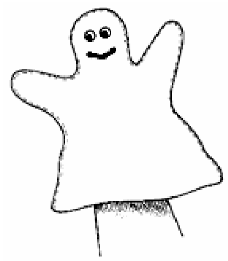


17. If you had to make the same puppet how would you like to improve it?

____

18. Out of 10 how many marks would you give the puppet on the following

(a) Resemblance to the character in the story _____/10
(b) Finish/Workmanship _____/10
(c) Ease of handling _____/10
(d) Make with right materials _________/10



APPENDIX O

Stories for the puppet shows in the three settings

Urban Marathi setting

The story that was chosen for the puppet show by these students was based on a traditional Indian tale that is also included in school text books. It was titled ‘Trees are our friends’ and the moral of the story was that trees should not be cut senselessly. This story inspired by the Chipko movement (a movement in India against the destruction of forests during 1970's and 1980's) was set in a tribal locale. The characters of this story were: a queen, 2 soldiers (males), a forest goddess (*Vandevi*- meaning a forest deity), a middle-aged tribal male and a middle-aged tribal female. In all, there were 3 male and 3 female characters. *Vandevi* was supernatural character or a fantasy character.

Story: A queen wants to make a new palace for which she wants specific kind of wood. She orders a part of the forest in her kingdom to be felled for wood to build her new palace. Her soldiers go to the forest and just as they are about to hack the trees, a few tribal men and women stop them from cutting trees. They tell the soldiers that their forest goddess resides in the trees and they want to protect her and so they should not cut the trees. That night the queen has a dream in which the forest goddess appears and tells her not to cut the trees for her luxury and also tells her the many benefits of trees. The queen feels sorry and the next morning she calls her soldiers back from the forest and changes her plan about her new palace.

Urban English setting

This was the second setting with whom we tried the puppet activity. This was the only group whose story was based on a western theme and was an adaptation of the story Snow White and Red Rose. They titled their story as ‘The three months’ and its moral was that jealousy and desire leads to trouble. There were 6 characters in the story which included: Mary - mother of two young daughters, Rose Red and Snow white. The male characters of the story were the three months- December, January and May. The three months were fantasy characters.

Story: Mary had two daughters- Red Rose and Snow White, who stayed in London. She was partial towards Red Rose and always scolded Snow White and made her do various tasks. One day in the month of May she ordered Snow White to get roses for her from anywhere. Snow White tells her that roses are not available in this month and that it would be difficult to get them. Mary gets angry at the excuse and commands Snow White to get the roses anyhow. Snow White then goes to the forest to search for roses. While in the forest, she gets tired and sick due to the scorching heat and falls down. The three months, December, January and May who reside in the forest find Snow White lying down. They take care of her and ask her about her problem. She tells them that her mother wants roses in this season and that she had come to the forest to search for them. The three months take pity on her and provide her roses. Seeing Snow White get roses for her mother, Red Rose is surprised and she asks her sister how she managed to get the roses. Snow White tells her about her visit to the forest and her meeting with the three months. Red Rose also decides to go to the forest and ask the months for roses. She goes to the forest and meets the three months and commands them to get her roses and other things. The three months get angry and curse her so that she would fall sick when she reaches home. As Red Rose reaches home, she is very sick. Her mother and her sister are worried. She then tells them about her visit to the forest and about the curse of the three months. Snow White then prays for her sister to get well. After sometime Red Rose recovers and she pledges to improve her behaviour.

Rural Marathi setting

This was the third and the final cluster with which the unit was tried. The story selected by this setting was an adaptation of the story Wolf! Wolf! The title of their story was 'A monster is coming!' The story is set in a village. Its moral was not to tell lies or cry wolf. The story had 3 male and 3 female characters and these were: Swati (a school girl), Gungya (a monster- Male), Pratap (an adult male farmer), Meher (an adult female farmer), Pandu (an adult male farmer) and Shantaben (an adult female farmer). The fantasy character in the story was Gungya.

Story: In the village of Bhinar, there was a young girl called Swati. Swati was very naughty and often played pranks with the people of her village. One day while returning home from school, Swati began to scream for help, 'A monster has come, a monster has come!! Please help and save me!' On listening to her screams, the villagers leave their work and go to save her from the monster. When they reach her, she laughs at them and tells them that she has fooled them. The villagers are irritated and go back. The next day, once again she screams for help and the villagers leave their work and run to her to help but she once again ridicules them. The next day, while Swati is coming back from school, she has an encounter with a real monster and cries for help. But this time, the villagers hear her scream and ignore it thinking that she must be just fooling around like other days. No one comes to Swati's help and the monster hurts her.

APPENDIX P

Code categories

Initial characterisation of code categories from Dawes et al, 1992, used for percentage agreement between raters

Category of talk	Description
Disputational	Propositions
	Instructions
	Challenges
Cumulative	Uncritical additions
	Initiations accepted
	Superficial amendments
	Active engagements
Exploratory	Counter challenges
	Alternative hypothesis
	Joint acceptances

Code descriptions that were finally developed by the two raters and are adapted from the above scheme

Category	Description
Disputational	
Challenge	Make a rival claim/do something that one thinks will be difficult
Disagreement	Not agreeing with what has been said/done
Rejection	Not accepting what has been said/done
Evaluative/judgmental	Critical
Cumulative	
Information	Facts/add of facts
Elaborate	Adding information to what has been said for clarification/making it more explicit
Filling statements	Statements made to take communication ahead/bridging purpose
Amendment (surface)	Making changes to the existing feature/product/idea
Confirmation	Reinforce someone in opinion/ belief/feelings (seeking or giving)
Exploratory (conceptual)	
Justification	Giving rationale
Reflection	Thinking about what has been done/said
Initiation/ Focusing	Sentences for drawing attention to what is important but has not been talked of
Amendment (deep)	Making changes to the existing feature/product/idea
Evaluative/judgmental	Critical

APPENDIX Q

Frequency of talks during the 3 units

Frequency of talks during Bag-making unit in the 3 settings for the 3 gender groups during design and product communication

Design Communication						Product Communication			
		D	C	E	Total	D	C	E	Total
Urban English	Single Sex Girls -1	1	17	1	19	6	7	13	26
	Single Sex Girls -2	1	20	7	28	12	11	17	40
	Single Sex Boys-1	5	53	10	68	10	36	26	72
	Single Sex Boys -2	9	27	6	42	19	17	19	55
	Mixed Sex-1	0	20	2	22	5	12	13	30
	Mixed Sex-2	3	23	8	34	12	11	17	40
	Total	19	160	34	213	64	94	105	263
Urban Marathi	Single Sex Girls -1	0	6	3	9	15	30	36	81
	Single Sex Girls -2	0	10	0	10	12	8	20	40
	Single Sex Boys -1	0	15	4	19	6	24	34	64
	Single Sex Boys -2	1	7	2	10	6	20	20	46
	Mixed Sex-1	0	15	5	20	12	10	17	39
	Mixed Sex-2	2	15	0	17	7	18	12	37
	Total	3	68	14	85	58	110	139	307
Rural Marathi	Single Sex Girls -1	0	21	0	21	0	9	2	11
	Single Sex Girls -2	0	14	0	14	1	19	4	24
	Single Sex Boys -1	0	28	3	31	1	11	3	15
	Single Sex Boys -2	0	13	1	14	1	9	3	13
	Mixed Sex-1	0	16	2	18	1	7	3	11
	Mixed Sex-2	0	15	4	19	0	12	0	12
	Total	0	107	10	117	4	67	15	86

Frequency of talks during Windmill unit in the 3 settings for the 3 gender groups during design and product communication

Design Communication						Product Communication			
		D	C	E	Total	D	C	E	Total
Urban English	Single Sex Girls-1	0	21	3	24	7	13	15	35
	Single Sex Girls -2	2	31	5	38	10	19	24	53
	Single Sex Boys -1	4	27	4	35	4	11	14	29
	Single Sex Boys -2	6	31	11	48	12	29	27	68
	Mixed Sex-1	0	23	5	28	5	11	16	32
	Mixed Sex-2	2	13	4	19	8	8	14	30
	Total	14	146	32	192	46	91	110	247
Urban Marathi	Single Sex Girls -1	3	18	6	27	5	12	10	27
	Single Sex Girls -2	2	47	3	52	0	29	7	36
	Single Sex Boys -1	3	22	11	36	3	19	13	35
	Single Sex Boys -2	4	26	14	44	3	41	23	67
	Mixed Sex-1	0	21	3	24	2	13	11	26
	Mixed Sex-2	0	24	2	26	2	16	13	31
	Total	12	158	39	209	15	130	77	222
Rural Marathi	Single Sex Girls -1	2	23	6	31	0	7	10	17
	Single Sex Girls -2	2	22	2	26	1	15	11	27
	Single Sex Boys -1	1	28	4	33	2	9	10	21
	Single Sex Boys -2	0	45	0	45	2	14	10	26
	Mixed Sed-1	4	31	2	37	0	12	7	19
	Mixed Sex-2	4	31	6	41	1	9	5	15
	Total	13	180	20	213	6	66	53	125

Frequency of talks during Puppetry unit in the 3 settings for the 3 gender groups during design and product communication

		Design Communication				Product Communication			
		D	C	E	Total	D	C	E	Total
Urban English	Single Sex Girls -1	0	9	0	9	7	16	15	38
	Single Sex Girls -2	0	12	0	12	3	8	16	27
	Single Sex Boys -1	0	7	0	7	10	18	13	41
	Single Sex Boys -2	0	1	0	1	4	18	13	35
	Mixed Sex-1	4	10	9	23	7	11	17	35
	Mixed Sex-2	0	10	1	11	3	5	5	13
	Total	4	49	10	63	34	76	79	189
Urban Marathi	Single Sex Girls -1	0	9	0	9	3	20	16	39
	Single Sex Girls -2	0	12	0	12	3	30	22	55
	Single Sex Boys -1	0	10	1	11	6	36	21	63
	Single Sex Boys -2	0	17	0	17	0	57	31	88
	Mixed Sex-1	0	7	0	7	8	26	31	65
	Mixed Sex-2	0	24	1	25	1	13	9	23
	Total	0	79	2	81	21	182	130	333
Rural Marathi	Single Sex Girls -1	2	45	0	47	1	18	1	20
	Single Sex Girls -2	3	43	2	48	1	20	2	23
	Single Sex Boys -1	0	44	0	44	0	14	0	14
	Single Sex Boys -2	1	39	0	40	2	24	2	28
	Mixed Sex -1	0	45	0	45	1	10	3	14
	Mixed Sex -2	3	28	0	31	0	26	3	29
	Total	9	244	2	255	5	112	11	128

Key: D=Disputational talks, C= Cumulative talks, E= Exploratory talks

APPENDIX R

Synopsis

1. Introduction

The thesis begins by examining Indian middle-school students' (age 11-14 years, Grade 6) ideas about technology. On the basis of this study of students' ideas, an attempt was made to develop design and technology education units to engage boys and girls from rural and urban areas. The units developed were communication and collaboration centred and based on the premise that interactions play an important role in bringing about changes in students' thoughts and behavior and that contextualization of tasks is critical for students' engagement. The trials of three units developed were carried out in three different socio-cultural settings. Students' communication during the trials of the units was studied. The thesis presents an analysis of students' communication while they worked in groups during the trials, focusing especially on socio-cultural and gender aspects.

1.1 Background and motivation

The term 'technology' conjures up multiple meanings and images in differing contexts and these meanings have evolved over time. According to MacKenzie and Wajcman (1999), technology has three layers of meaning. At the first level, technology refers to physical objects – cars, refrigerator, computers; on the second level it includes human activities – that is, the use of the physical objects; and the third level is the "know-how" – the information required to use, repair, design and produce the physical objects. The various levels of meanings of technology give an indication of the complex nature of technology. Apart from multiple meanings of technology, there is an issue of unequal representation of women and people from rural areas in the field of technology.

It is generally accepted that science, technology, and education are critical ingredients for national, economic and social development. The growing importance of technology in all spheres of life has made it imperative that we have a formal program of study introduced for children at a young age. The New Policy on Education (NPE, 1986) recognized the importance of technology for personal and social development. This led to the National Curriculum Framework (NCF, 2000) introducing 'Science and Technology' textbooks at the secondary school level. These books presented technology in the paradigm of applied science which could have negative consequences for meeting specific learning objectives of both science and technology (Ramadas, 2003).

The complexity of technology and its multiple meanings are evident in the way people have different ideas about technology and relate to it differently. Worldwide there have been attempts at understanding students' ideas about technology through the PATT (Pupils' Attitudes Towards Technology) studies (USA, Netherlands, HongKong etc.) and a few efforts have been made in India at understanding students' ideas of technology (Rajput et al., 1990; Bhattacharya, 2004). But there is a need for more in-depth studies. Since Indian schools do not have formal technology education, student's ideas of technology are more likely to be influenced by factors other than school learning.

Our motivation for the study of students' ideas about technology came from our earlier work wherein urban students (about 10-15 years old) drew technology as a collection of objects when asked to draw their 'Image of technology'. Their conception of technology was limited and restricted to products related to communication and transport such as television, satellite, mobile phone, cars airplane etc. (Mehrotra et al., 2003). We were interested to know whether this product-centric view of technology existed among other boys and girls from rural and urban areas. To explore these questions, questionnaires were developed for students of middle school. The survey served as a precursor and provided inputs to the research and development of design and technology education units at the Homi Bhabha Centre for Science Education, Mumbai.

1.2 Gender and technology

Technology being a social endeavour involves both men and women. There is a disproportionately low involvement of females at all levels of technology (Weber & Custer, 2005) and the contribution of women to the field of technology is by and large invisible. Layton (1993, p.33) suggests that "…'gendering' of experience is nowhere more obvious than in technology". Technology is often seen as complicated and "high-tech", and unsuitable for women. Engineering, just as science and mathematics, is seen as a masculine profession (Chunawala & Ladage, 1998; Rosser, 1992; Harris, 1997). Women's traditional involvement in technologies, such as, horticulture, cooking, sewing and child-care have been accorded low status (Wajcman, 1991). Even today women form a small part (about 22% at graduate level) of the technology/engineering community in India (INSA report, 2004) and of those who clear their engineering examination over 30% remain unemployed (Parikh & Sukhatme, 2004).

Science and technology are intertwined with gender through the medium of language. Several researchers (Gurer & Camp, 1998) working in the area of gender, technology and language have pointed out that the language use in technology is 'gendered'. Cohn (1987) analysed the language used in technology related teaching courses and found it laden with gendered imagery.

Technology education in the school curriculum (where this subject exists) is disproportionately attentive to male perspectives on technology. Studies indicate that the content taught in technology education courses is derived keeping in mind the majority of students who take up this subject, that is males, who value abstraction and competition (Welty, 1996), whereas females tend to value and perceive technology as a means of facilitating collaboration, communication, and linkages between people (Gilligan, 1982; Honey et al., 1991). Various ways have been suggested by technology educators to overcome the problem of alienation of girls in technology. Some of them involve restructuring of subject matter, revising language by paying closer attention to explanation and context, creating humane classroom environment and valuing a variety of ways of knowing, expressing and working, integrating cognitive and affective learning and discussing values related to technology (Zuga, 1999). Attempts at making technology education inclusive motivated the development of our collaboration and communication centred design and technology units for middle school students.

1.3 Collaboration and communication for inclusive technology education

Humans naturally have a tendency to work in groups and in our social interactions with others, we communicate - attempt to transmit our ideas, thoughts and emotions to others through verbal and non-verbal ways. Vygotsky (1978) has emphasized social context and the role of language in his theory of development of cognitive functioning. According to this theory, jointly undertaken, goal-oriented activities are important for learning and language is a major psychological and cultural tool for representing ideas, interpreting and evaluating events and experiences, and constructing explanations. Ability to use language is central to an individual's overall development and especially in developing technological capability (Rowell, 2002).

Collaborative learning is based on the premise that learning is best achieved interactively rather than through individual or one-way transmission process (Haller et al., 2000). In collaborative learning, learners work together by communicating whereby they are, stimulated to discuss, negotiate and, ultimately, create new constructed knowledge (Baker et al., 1999; Medway, 1994). By verbalizing and proposing new ideas, asking questions, (Chi et al., 1989) or giving explanations in an elaborate manner, learners exchange ideas and, thereby externalize their thoughts (Wegerif & Mercer, 1996; Weiss & Dillenbourg, 1999).

Despite the demonstrated importance of communication, socialization and teamwork for all-round development, there is limited appreciation that skills needed for collaboration need to be deliberately fostered in the context of classroom activities. There have been few studies done in the classroom environment that focus on communication and collaboration aspects (Edwards, 2005). Some studies have encouraged pupils to talk rather than focus on sharing thoughts and decision-making (Henessey and Murphy, 1999). There is a need for research in classroom contexts with students engaged collaboratively in meaningful tasks.

Design and technology activities provide a potentially rich environment for fostering collaborative learning – both, for expression and accommodation of individual perspectives as well as opportunities for group work. In design and technology, the ideas conceived in the mind need to be expressed in concrete form before they can be examined to see how useful they are (Kimbell et al., 1991). Researchers have pointed the need to link technology with its social implications, since in the enterprise of technology various groups of people are involved – the clients, designers, makers and users – who form a community of practice (Wenger, 1998). Cognitive activity is tied to the social context in which it occurs (Natarajan, 2007) and therefore classroom activities need to be contextualized in order to make them inclusive. Research has shown that students from rural and urban areas and girls and boys have different learning styles with rural students tending to be more 'serious analytical learners and active practical learners' as compared to urban students (Cox et al., 1988) and girls preferring collaboration over competition (Honey, 1996). Contextualizing activities provides all groups of students irrespective of their social and educational setting access to a wide and empowering range of knowledge, skills and values. Technology education activities offer opportunities to all groups to visualise and redesign their environment, and hence can be meaningful to all.

1.4 Theoretical framework of analysis used in the study

The structure of the units, classroom organisation and the sequence of trials were all broadly located in socio-cultural theory (Vygotsky, 1986) wherein learners are considered active agents, responsible for their own learning, enhanced by their interactions with peers, family and their environment, including the objects around them. The term 'socio-cultural' is associated with research that draws explicitly on the developmental psychology of Vygotsky. In our study the context of design and technology units engaged groups of students in designing and making an artefact as a solution to a problem situation. The sequence of classroom activities during the trials of the units integrated formal communication at two stages: one where students communicate their design ideas and another, after their product evaluations. The formal communication was analysed using the socio-cultural discourse analysis method, while informal communication was studied in terms of the group dynamics and evidences of collaboration during the design and technology units.

Analysing verbal data

Verbal data in educational contexts have been analysed qualitatively as well as quantitatively and have involved techniques like 'Conversational analysis', 'Protocol analysis' and 'Discourse analysis'. These different techniques emerge from different disciplines. For example, 'Protocol analysis', also called the 'think-aloud' method is informed by the information processing approach and is a rigorous methodology for eliciting verbal reports of thought sequences. 'Conversational analysis' focuses on natural settings and aims to understand social interactions such as power relations through everyday talk and non-verbal communication.

Discourse analysis considers linguistic and/or socio-cultural dimensions in order to determine how meaning is constructed (Barsky, 2002). While linguistic discourse analysis focuses on the language itself rather than its functions, socio-cultural discourse analysis drawing on the work of Vygotsky focuses less on the organisational structure of talk and more on the content, function and the ways in which talk serves to develop shared understanding (Mercer et al., 2004). Through the socio-cultural analysis of students' talk it is possible to recognise that students do not just speak words but instead draw on various factors connected with their diverse social, historical, cultural and institutional relations (Wertsch, 1991).

In our study, the data from formal communication in the trials of the units were more amenable to socio-cultural discourse analysis. A scheme for analysing classroom talk, developed by Dawes et al. (1992), based on socio-cultural discourse analysis was used by us to analyse the formal communication of students. This scheme analyses discourse as 'social modes of thinking' and categorizes talk as, disputational, cumulative and exploratory. It provides a way in which qualitative and quantitative methods can be combined to ascertain how girls and boys in different socio-cultural settings, working in different kinds of gender groups contribute to design and technology tasks. In our analysis we examined patterns of talk and differences across groups rather than attempting to isolate variables responsible for observed patterns.

2. Research objective and Research questions

The broad aim of the research was to develop and conduct trials of design and technology education units among middle school students in India in differing socio-cultural contexts and analyse the communication among students. The main research questions were:

2.1 Research questions

The three main research questions addressed in this study are:

1 What are students' ideas of technology?

2 How do students engage in design and technology units that are collaboration and communication centered?

3 Are there differences in the ways students from various socio-cultural settings and genders communicate while they are engaged in design and technology units?

2. 2 Sub-questions asked were:

Students' ideas of technology

1a What kinds of objects/ artefacts do students associate with technology?

1b What activities are considered technological?

1c Does the perception of an activity change when depicted as being done by males or females or by a person in an urban or rural area?

1d Are there gender differences in students' perceptions of objects and activities as technological?

1e What gendered stereotypes do students hold with respect to technological careers?

Collaboration

2a What are the evidences for collaborative learning in design and technology units?

2b What kinds of informal communication occur in design and technology tasks?

Communication

3a What is the nature of students' talk at the design stage and after making the product?

3b What are the differences in the talks of students from different socio-cultural settings at the design stage and after the making of the product?

3c What are the differences in talk between boys', girls' and mixed-sex groups at the design stage and after making the product?

3. Methodology

3.1 Our study

In view of introducing Indian middle school students to technology, we developed three technology education units that were collaboration and communication centred and followed the modified form of Design-Make-Appraise approach as suggested by Kimbell (1994). Our study was conducted in 3 phases and these are as follows:

Phase 1: Survey of students' ideas about technology. Before developing the units, we wanted to know students' conceptions of technology. We developed survey questionnaires to identify students' ideas about technology and conducted interviews on a sub-sample.

Phase 2: Development and trials of three design and technology units that were collaboration and communication centred, and which were situated in the real life experiences of the students and the contexts they came from, i.e. all the units were contextualized in such a way that students in different socio-cultural settings could associate themselves with it. Trials of the units were conducted in 3 socio-cultural settings – the urban English, the urban Marathi and the rural Marathi medium settings. In each of the three settings, the units were tried at different times. The trials in each setting were learning experiences for researchers and the tasks in the units were modified based on the experiences of our trials.

Phase 3: The analysis of communication, both formal and informal, and collaboration that occurred while students were engaged in design and technology tasks was carried out. The analysis of formal communication focussed on students' dialogues during two stages in the units: the design stage and after making the product.

3.2 Details of Phase 1(Survey of students' ideas of technology)

Sample description

Phase 1 of the study was carried out in 9 schools. The criteria for selecting the schools were based on our need to have a representative data of urban and rural/tribal population, a fair and balanced representation of boys and girls and a reasonable physical proximity of the schools. Table 1 gives details of the survey sample, in terms of the urban-rural and male female distribution for the two questionnaires and the interviews.

Table 1: Sample composition of the survey of Grade 6 students

Technology-as-objects (TAO)			
	Urban	**Rural**	**Total**
Girls	88	73	161
Boys	126	56	182
Total	214	129	343
Technology-as-activities (TAA)			
Girls	65	49	114
Boys	60	27	87
Total	125	76	201
Interviews			
Girls	5	5	10
Boys	6	2	8
Total	11	7	18

The rural schools were situated at a distance of about 60 kilometers from our research institute in the adjoining Thane district. All the six urban schools were mixed-sex schools, three of which had English as the medium of instruction and three had Marathi (the official language of the state of Maharashtra) as the medium of teaching-learning. Urban schools catered to students that belonged to middle socio-economic groups. The three rural schools (*Aashramshalas*) were all Marathi medium, and one of the three was a single-sex girls' school. All these schools were administered by the Tribal Welfare Department, Government of Maharashtra. The students in the rural schools were largely tribal, and came from lower socio-economic groups.

Instruments used in Phase 1 of the study

Survey instruments were developed to learn about students' ideas of technology. This part of our work was inspired by the PATT studies carried out by Raat and de Vries (1986) that aimed at measuring students' attitudes towards technology. The instruments developed for Grade 6 students were derived from a questionnaire developed earlier for Grade 8 students (Khunyakari et al., 2003). However, as we were dealing with younger children we developed 2 largely pictorial questionnaires for use with Grade 6 (11-14 years) students. One questionnaire focused on *technology-as-objects (TAO)* and the other on *technology-as-activities (TAA)*. The *TAO* questionnaire was patterned after the instruments used by Rennie and Jarvis (1994) but modified to suit the local contexts. Our questionnaires were initially prepared in English and later translated to Marathi for use in Marathi medium schools.

Interviews of some students followed the questionnaires and were aimed at a detailed exploration of the reasons for associating objects and activities to technology. The interviews focused on aspects covered in the questionnaires, such as, users/creators of technology, temporal aspects of technology, locales of technology, gender and technology, what is 'not technology', and words, objects and activities associated with technology.

a) Technology-as-objects (TAO): This questionnaire consisted of 30 pictures of objects associated with ten categories: sports, agriculture, school, music, household, workplace, transport, communication, warfare and natural objects. Our selection of categories and the pictures in the categories was guided by the fact that our sample would have rural and urban students as well as girls and boys. Each category had pictures that focused on aspects of 'time' or tradition/modernity. The *TAO* sub-part was used in our earlier work with Grade 8 students and a reliability score 0.9 (Correlation coefficient) had been established. The *TAO* questionnaire also had situational questions aimed at learning students' gender stereotypical thinking with respect to jobs and occupations (Khunyakari et al., 2008).

b) *Technology-as-activities (TAA)*: This questionnaire depicted activities related to categories in the *TAO* questionnaire. Most pictures showed humans involved in an activity and there were a few pictures without humans (waterfall, spider making its web, sunflower turning towards sun) and one picture with both males and females (neutral category). Two alternate forms (A and B) were developed, with 24 pictures in each. Both forms had some activities being done by males and some by females. If an activity in form A was shown as being done by a male then in the alternate form it was depicted as being done by a female. Students were asked to write "T", if they thought that a picture was related to technology, and "N", if they thought that the picture was not related to technology. This questionnaire was aimed at eliciting students' ideas about technology in activities and gender stereotypes, if any. Test-retest reliability was established separately for Form A and Form B of *TAA* and was found to be 0.70 for Form A and 0.84 for Form B (Spearman-Brown coefficient correlation).

3.3 Details of Phase 2 (Development and trials of Units)

Sample

These units were tried with 20-25 Grade 6 students (11-14 years of age) in each of the three settings: a rural Marathi medium, an urban Marathi medium and an English medium school. It was ensured that the number of boys and girls participating in the trials were about the same. To a large extent the same students participated in all the three units. A few dropped out due to unavoidable reasons.

Development of the 3 units

The project of development of design and technology education units for middle-school students in India began in the year 2002-2003 at the Homi Bhabha Centre for Science Education. Three units developed through trials were: making a bag, making a working model of a windmill and making a puppet and putting up a puppet show. The 3 technology education units that we developed had the following broad aims – (a) building a collaborative working environment in the classroom, (b) situating the goals in the context of students/authenticity, (c) teaching technology with design at its core and (d) making the unit inclusive i.e. suitable for boys and girls from urban and rural settings.

In our units, collaboration was introduced by asking students in a setting to work in groups. The task to be performed or the problem to be solved was given to the entire setting and then each group within that setting had to engage independently in the task and solve it.

The 3 units were situated in real-life contexts, and we tried to make the units personally authentic to the participating students. Along with personal authenticity, cultural authenticity of the units was considered during their planning. This was done to ensure that students from both rural and urban areas and boys as well as girls could connect to the tasks. We also tried to contextualize the units in such a way that the skills gained could be transferred out of these 'contexts' to other classroom activities and real world contexts.

Designing involves thinking creatively and begins with hazy, speculative ideas that become clearer and better formulated as they are refined and shared with others (Ritchie, 2001). In the context of design and technology activities, designing involves the process of generating, developing and communicating ideas relating to outcomes, which may be made. Each of the stages in our units was open-ended. Drawing/sketching was an important aspect of students' designing. Students were free to draw their designs or make models or prototypes of the products/artefact. We incorporated design in our units in a 'vernacular way', where the designer and maker of the product were the same unlike a modern designer who may design the product without having to make it (Lawson, 2005)

The assessments of the design/products or the teams participating in the same were not formal. Harding (as quoted in Armstrong & Leder, 1995) suggests that to encourage girls to participate in technology tasks, open-ended and informal rather than objective type questions are helpful. All the units had scope for using skills that were appealing to or possessed by both boys and girls.

The units were selected on the basis of increasing order of complexity of tasks and intra and inter group collaboration. The *bag making* unit viewed technology as a product (artefact) and could be done by an individual, though a group was involved in the process. The *windmill* unit required students to make a working model of a windmill to lift weights and test it. This activity was more complex, having many sub-parts and needing more mental and physical work. The third unit on *puppet making and putting up a puppet show* was based on a systems approach of technology. In the puppetry unit each group had to make a puppet and all the puppets made by them were needed to put up the show, so a second level of collaboration (with the entire cluster collaborating) was introduced (Mehrotra & Khunyakari, 2007).

Trials of the units

The trials of the all the units were conducted in the 3 settings and in each setting about 20-25 students worked in teams of 3-4 members. Three kinds of gender groups were made in each setting, 2 groups of boys called single-sex boys groups, 2 groups of girls called single-sex girls groups and 2 groups with both boys and girls, called mixed-sex groups. The language used by the researchers was the same as the medium of instruction in each of the settings. Trials were conducted during the period August 2003 to September 2004. Video records, audio records, students' writings, students' drawings, daily logs and questionnaires served as our sources of data. The different stages in each unit are presented in a model (Figure 1) put forward by Choksi et al. (2006).

Figure 1: Collaboration and communication centred Design & Technology education model for the Indian school context

Participation in the units was expected to help students to figure out the 'process of design' and become aware of the underlying concepts, such as, exploration, design, evaluation. For each unit, students worked for about 15 hours in 5 sessions. Table 2 presents the general structure of the design and technology units.

Table 2: General structure of the units: Elaboration of activities in each stage

Stages	Elaboration of activities
Day 1 Investigation & Motivation	Introduction of various kinds of bags/windmills/ puppets by researchers Writing words for the artefact/ system in various languages by students
Day 2 Designing	Technical/academic inputs related to the units provided by researchers Designing the artefacts to be made by students Technical drawing of the artefacts by students
Day 3 Planning & Communicating	Procedural map of the artefact by students Materials needed for making and their quantities listed by students Work distribution within groups listed by students Communication of design to the entire cluster by students
Day 4 Making	Actual making of the artefact by students
Day 5 Evaluation & communication	Students critically evaluate own products as well as those made by others Students formally communicate their evaluation to the entire cluster

3.4 Details of Phase 3 (Analysis)

Phase 3 of the study involved analysis of communication and collaboration that occurred while students were engaged in design and technology units. There were activities planned in our units called 'structured communication', which explicitly required students to communicate, both orally and in writing. Studies have suggested that structuring of dialogues helps students engage in more frequent higher-level elaborations and makes the process of knowledge construction in individuals more effective (Van der Meijden & Veenman, 2005). Activities within structured communication included:

- Suggesting different words for the object/artefact to be designed, in any language,
- Writing poems/ descriptive paragraphs on the activity/artefact,
- Making sketches of the conceived artefacts as well as drawing step-by-step procedures for making it (Khunyakari et al., 2007),
- Formally communicating the group's designs to the cluster (*design communication*),
- Formally communicating about the product made by the group after the product is made and evaluated by the group (*product communication*).

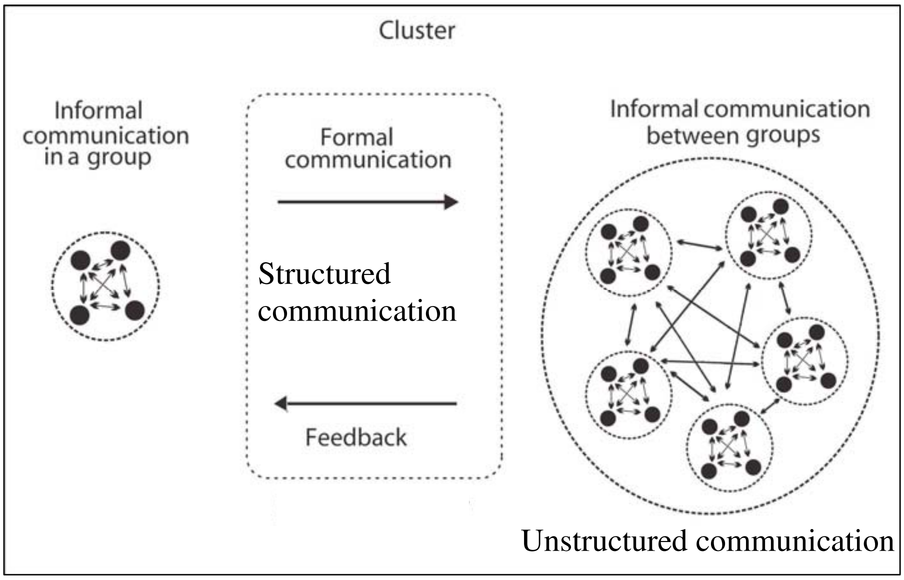
During formal communication all the members of a group came to the front of the classroom and presented their work orally to other groups in the cluster. A scheme developed by Dawes et al. (1992), that categorizes talk as, disputational, cumulative and exploratory was used for analysing the formal communication. These categories are elaborated as:

- *Disputational talk* is characterized by disagreements, challenges, direct rejections and individualized decision-making. There are few attempts to pool resources or to offer constructive criticisms.
- In *cumulative talk*, students construct uncritically, a common knowledge by accumulation. It maintains group cohesion through confirmations, but does not produce critically grounded knowledge.
- During *exploratory talk,* students engage critically but constructively with others' ideas, reflect on their work, make suggestions for joint understanding, justify challenges, and offer alternative hypotheses. Exploratory talk is considered an embodiment of critical thinking (Mercer, 1996).

Audio and video records of students' formal communications were analysed. Formal communication was analysed at 2 stages during each unit – design communication (after making the design) and product communication (after making the product). The unit of analysis was taken to be a complete or incomplete sentence uttered by a student during formal communication. Reliability was established by calculating the percentage agreements in coding of dialogues between two raters (percentage agreement between the raters) on 50% of the data and was found to range between 60%-82%.

We use the term 'informal communication' to refer to the myriad occasions when students engaged in talking/gesturing to their group members and also to members of other groups during the trials of the design and technology education unit. While informal communication between group members helps in gathering information, generating ideas and sharing these along with other affective aspects with members in the group, formal communication provides an opportunity for sharing ideas with the entire cluster and getting their feedback to improve the design and the product (Mehrotra et. al., 2007b). Figure 2 presents a depiction of formal and informal communication.

Figure 2: Pictorial representation of formal and informal communication within and across groups in a setting



Other analyses focussed on students' collaboration, by observing the ways in which knowledge spread in groups in a setting through various means such as tools, practices and facts. Table 3 presents the details of the criteria by which analysis has been carried out with reference to communication and collaboration in this thesis.

Table 3: Criteria used for analyses of formal communication, informal communication and collaboration

Parameters	Data sources	Analysis categories/criteria
Formal oral communication	Video/ audio records, Students' writings	Coding scheme developed by Dawes et al., (1992)
Informal communication	Video /audio records	Observed through: • Roles and responsibilities taken by various members in a group • Conflict, conflict resolution and sharing of resources • Informal communication through gestures
Collaboration	Video /audio records	Observed through: • Realisation of common goals • Diffusion of learning through techniques, tools, facts

4. Results

4.1 Results of survey - Phase 1

Most of the results of the survey have been presented at PATT 18 conference held at Glasgow in July 2007 (Mehrotra et al., 2007a). The responses to the *TAO* and *TAA* questionnaires are discussed below along with results from the interview.

Objects and activities associated with technology: Of the 30 pictures used in the *TAO* questionnaire, on an average, students circled 14 pictures as related to technology. It was found that students associated technology with objects over a broad spectrum of categories. Table 4 presents the objects within each category of the *TAO* questionnaire and the percentage of students who stated that the objects were related to technology.

Table 4: Percentage of students relating objects to technology

Category	Objects	Percentage
Communication	Computer	89
	Television	54
Transport	Airplane	87
	Tractor	83
	Bicycle	61
	Bullock-cart	27
Workplace	Stapler	59
	Clock	70
	Syringe	55
	Microscope	79
School	Compass	55
	Blackboard	31
	Pen	64
Household	Gas-stove	73
	Lemon-squeezer	36
	Pressure cooker	55
	Winnowing pan	24
Warfare	Gun	65
	Tank	49
	Bow and arrow	29
Music	Sitar	35
	Drum	33
	Whistle	43
Natural Objects	Flower	23
	Sun	42
Sports	Bat, ball and stumps	29
	Football	35
	Carrom-board	26
Agriculture	Scarecrow	23
	Plough	40

Categories of *household, sports and agriculture* were related to technology by less percentage of students while more students related objects and activities in the categories of *communication, transport* and *workplace* to technology. It is interesting that in an agricultural economy like India, only a minority of students considered agricultural objects (plough, bullock-cart) as technological. Students considered *natural objects (sun)* and *activities in nature (plant turning towards light)* to be related to technology, while this was interesting in itself, it was notable that such objects and activities were considered by more students as related to technology than objects in the category of agriculture and sports. When probed about this aspect in the interviews, one reason given by students for considering natural objects or activities to be technological was that they had read about these objects and activities in their science books.

Table 5 presents students' responses to the two alternate forms of the *TAA* questionnaires. The table shows the percentage of students who associated pictures in Form A and B with technology, and presents their significance values (paired t-test).

Table 5: Percentage of students relating an activity to technology

Category	Activities	Female Picture	Male Picture	t-test significance
Communication	Working on computer	96	93	0.65
	Watching television	31	31	0.88
	Talking on phone	81	81	0.86
Transport	Driving a cycle rickshaw	69	56	0.04*
	Driving auto rickshaw	61	69	0.40
Workplace	A scientist working in the laboratory	96	88	0.02*
School	Teacher teaching on blackboard	29	24	0.74
	Doing yoga	55	53	0.58
Household	Cooking on gas-stove	68	62	0.12
	Cooking on *chulha* (fireplace)	53	51	0.46
	Drawing water from well	51	64	0.07
Warfare	Using a gun	69	66	0.23
	Using bow and arrow	78	64	0.01*
Music	Playing sitar	46	46	0.90
	Dancing	32	30	0.47
Natural Objects	Lightening	54-63		NA
	Waterfall	22		NA
	Spider weaving a web	19		NA
	Flower turning to light	50-53		NA
Sports	Playing hockey	76	68	0.01*
	Playing *gillidanda* (an Indian sport)	56	65	0.06*
	Kushti (wrestling)	27	33	0.32*
Agriculture	Using a plough	57	63	0.27
Neutral	Playing *Kho-kho* (an Indian sport)	48-51		NA

*= statistically significant difference, NA= not applicable

Of the total of 48 activities (in both forms), students on an average tended to relate 27 pictures to technology. Activities like *working on computer*, *talking on phone* and a *scientist working in laboratory* were related to technology by most students. On the other hand, activities perceived as more dependent on skills than equipment, like *wrestling*, *teaching* and *dancing* were considered as technological least often. An exception was 'yoga' which was associated with technology by over half the students. Students' responses indicate that objects when presented along with humans tend to be associated with technology more often than humans presented in an activity without equipment, or when objects are presented alone. This finding is in contrast with de Klerk Wolters (1989) and Rennie & Jarvis's (1995) studies where pupil's drawing on technology were mostly without humans indicating that humans were not an essential element of technology.

People who use/ create technology: Most students said that all people use technology. A few students stated that children or those staying at home do not use technology. This is consistent with household objects being related to technology only by half the students in the survey. Regarding who creates technology, most students believed that scientists and researchers working in laboratories or special centres created technology as they are *'engaged in experiments'*.

Temporal and locale aspects: All the students interviewed thought that technology involved something new and that it came into existence in the recent past, rather than in ancient times. Some students stated that technology began before or after some specific event, such as, 'discovery' of light / fire / steam engine / electricity / Indian Independence. One student said that *'science was discovered before technology'* and other students specified the years when technology came to being, for example, 'B.C.', '100 years', 'one million years'. A gradation in technology level was also seen. Some students stated that in ancient times there was less technology as compared to now. They also thought that there was more technology in urban than in rural areas. The students in this study thought that technology essentially had an evolving nature, was present in the ancient periods in limited ways and is now used by everyone.

Gender comparisons: There were significant differences in students' responses to the same activity depicted by a male/female for seven activities. Of these, 4 activities were considered technological when done by a female, namely, *driving a cycle rickshaw, scientist working in* *a laboratory, using a bow and arrow, playing hockey.* The other three activities were considered technological more often when depicted as being done by a male: *drawing water from a well, playing gilli-danda and Kushti (wrestling).* Students' responses to the situational questions confirmed their gender-stereotypic ideas about occupations and jobs/chores.

In a situational question, students were asked, *"Two of your friends, a boy and a girl, come to you for your advice on which occupation they should choose. Which occupation would you advise them to choose?"* Table 6 presents students' responses regarding whether they considered an occupation suitable for girl, boy or for both.

Table 6: Students' responses in connection with gender occupational suitability

Occupations	Suitable for a girl (%)	Suitable for a boy (%)	Suitable for both (%)
Dancer	31	4	48
Farmer	7	54	32
Scientist	7	36	48
Doctor	8	25	66
Nurse	69	4	17
Teacher	22	5	68
Soldier	3	74	18
Shopkeeper	3	50	39
Cook	65	2	28
Pilot	6	56	29

Most students felt that teaching was a profession that was suitable for both boys and girls, followed by a doctor, dancer and scientist. The careers that were *least advised for boys* were that of a cook, nurse and dancer and *the most recommended* ones for boys were soldier, pilot and farmer. Similar findings have been reported by Chunawala (1987). On the other hand careers that were *most advised for the girls* were nurse and cook and the *least advised for girls* were shopkeeper, soldier and pilot. It was observed that occupations that were considered more suitable for males (such as, soldier and pilot) generally involved objects such as, gun (65%) and airplane (87%) that had also been considered related to technology by a high percentage of students.

In another situational question, respondents were asked who (a boy or a girl) should do which job, given a time constraint. The question was framed as: *"Meeta (girl) and Suresh (boy) are friends. They have a set of jobs to be completed before they can go out to play. They* *distribute the jobs so that they can finish them quickly. Who would you suggest should do the following jobs?"* A list of 10 jobs followed the question and of these ten jobs, according to the students only three, namely, ironing clothes, collecting grocery from store and bringing firewood were jobs that could be done by both that is, either Meeta or Suresh. For the remaining chores, there were significant differences in job allocation between Meeta and Suresh. Most students assigned jobs that required dealing with appliances or tools and outdoor jobs to Suresh, and domestic jobs were assigned to Meeta. Table 7 indicates students' responses for division of work between Suresh and Meeta along with Chi-square significance values.

Table 7: Students' division of work between Meeta and Suresh

Jobs	Suresh (%)	Meeta (%)	Chi-square
Dusting the house	4	85	0.00*
Repairing a torn book	69	20	0.00*
Ironing clothes	46	42	0.45
Collecting grocery from store	48	40	0.10
Recording songs on a cassette	59	29	0.00*
Replacing a fused bulb	80	11	0.00*
Sorting the tool box	57	33	0.00*
Bringing firewood	48	42	0.21
Arranging utensils on a shelf	3	90	0.00*
Watering the plants	30	55	0.00*

* statistically significant difference

Our findings suggest that students' ideas of technology though varied, lacked depth. Their view of technology was rooted in science either as its applications or as its object of study. Students gave consistent reasons for associating a particular object or an activity to technology. These were mostly to do with the benefits derived from using technological artefact such as having to use less physical strength, doing work faster, being made by humans and being dynamic. Students who related technology to natural categories stated that plants, waterfall, thunder and lightening had motion and life and therefore were related to technology and also they had studied these in their science books. Reasons for considering something as 'not technology' were that it "did not have a machine," was "not related to science," or was "something found in nature."

Students had stereotypical views of careers and jobs suitable for males and females. The survey suggests a need to introduce the study of technology at the school level as a subject with distinct knowledge and skill requirements to broaden students' ideas about technology. Teachers and educators need to be conversant with the multiple perspectives of technology so that in their classrooms they may be able to make appropriate linkages of technology with science and society as well as with other school subjects.

4.2 Results of formal communication - Phase 3

A part of the results related to the analyses of formal communication in the unit on puppetry, were presented at epiSTEME-2 conference, Mumbai, February 2007 (Mehrotra et. al., 2007c). This section reports on the analyses of formal oral communication between students in the 3 units during the stages of design and product communication. Students' talks during formal communication were analysed using the scheme of Dawes et al. (1992), according to which there are 3 categories of students' talk 1) Disputational, 2) Cumulative and 3) Exploratory. Table 8 provides examples of the classification of the kinds of talk.

Table 8: An excerpt of dialogues between an Urban Marathi mixed-sex group and the audience during product communication in puppetry unit

Audience:	What have you done to make her [the puppet] look like a queen?	**Challenge (D)**
Audience:	What is her name?	**Information (C)**
P1:	(Ignoring the question, continues to read from his file, pointing to the puppet) Features of the puppet are- its face is loving [pleasant]	**Information (C)**
P2:	(answering the first question) [We have given her] crown, as she is wearing a green saree, she looks like a vandevi (forest deity)	**Justification (E)**
P3:	And she has long hair made of cloth First we had made hair with wool, then it was not looking long so we made it with cloth	**Information (C)** **Reflection (E)**
P2:	We had difficulties with the saree There were problems in sewing I sewed it but it opened quickly	**Reflection (E)** **Reflection (E)** **Reflection (E)**

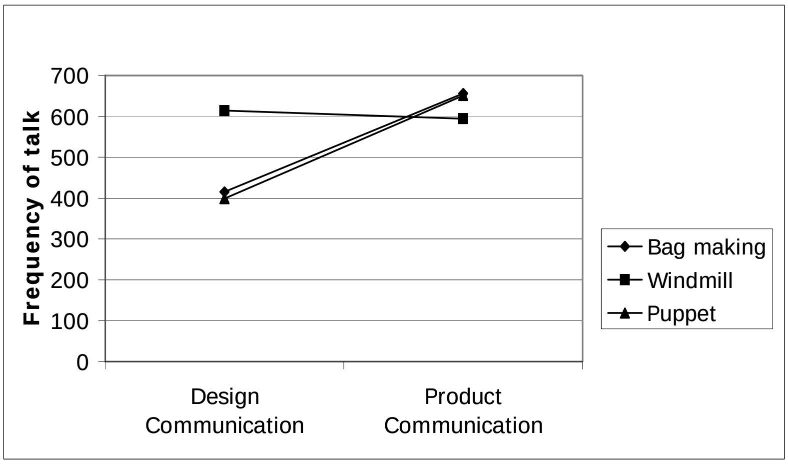
Key: C= Cumulative talk, D= Disputational talk, E=Exploratory talk, P= Presenters

The results are first presented according to the units, then by socio-cultural settings and finally by gender. In the three units a total of 3328 sentences occurred in dialogues during design and product communication. Overall the frequency of talks was the highest in the windmill unit (1208), followed by the bag-making unit (1071) and the puppetry unit (1049).

Comparisons of formal communication in the 3 units: Formal communication that took place in the 3 units during design and product communication stages indicated the following.

- The units of bag making and puppetry had a similar profile of talks – there were more dialogues in these units during product communication (which occurred after making) than during design communication. In the windmill unit, the opposite occurred – more dialogues occurred during design communication than during product communication (Figure 3).

Figure 3: Comparison of 3 units for design and product communication



The possible reasons for the observed differences in the frequency of talks could be that:

- The bag making and the puppetry units involved elements of personal use and students had *greater familiarity to these artefacts*. The windmill unit was a novel experience for students. Students were more *acquainted with the materials and the tools* required for making bags and puppets as well as some part of *the making procedure*. Making a windmill that could lift some weight was a problem that was not at the same level of familiarity as bag making and puppetry.
- With respect to the *level of technical complexity* involved, bag and puppet were relatively simple artefacts that required relatively fewer skills in making unlike the model windmill.
- Reporting of 'empirical' kind of data/observations (i.e. reporting the performance of the windmill, number of rotations made per minute, weight it could lift, angle at which it moved most smoothly) was required during product communication in the windmill unit.

The increase in overall talks during product communication (1900) as compared to design communication (1428) could be explained by the fact that after making the product students were able to talk more about it rather than at the stage of designing where they were anticipating the making of product. Teasley (1995) suggests that when talking to someone else, knowledge becomes more elaborate because communication implies the need to be understood by the other, which results in more coherent explanations/talks.

Of the 3 kinds of talks, cumulative talks were highest (1191+928=2119 sentences) in all 3 units, followed by exploratory talk (163+719=882 sentences) and disputational talks (74+253=327 sentences). As can be seen from the last row in Table 9, cumulative talk though having the highest frequency, decreased during product communication while disputational and exploratory talks increased. The increase in exploratory talk was more than the increase in disputational talk. The increase in exploratory talks was more than that of disputational talks. According to Mercer (1996), exploratory talk is more valuable for learning because there is no automatic consensus (as with cumulative talk) or unproductive dispute (as with disputational talk), but rather, productive argument, questioning and exploration.

Table 9: Profile of talks in the 3 units for design and product communication

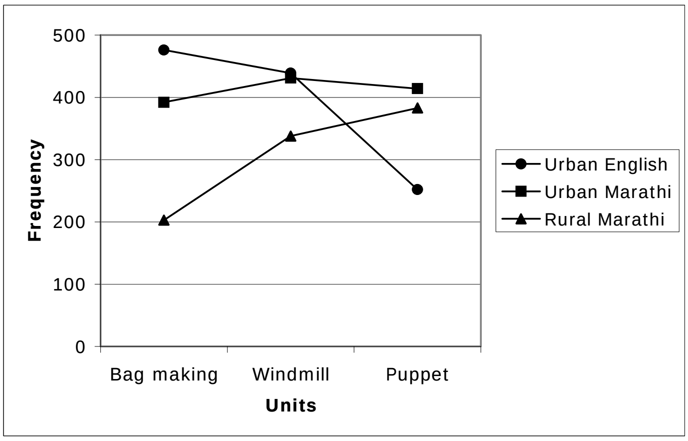
Kinds of talk	**Bag-making**		**Windmill**		**Puppet**		**Total**
	Design	**Product**	**Design**	**Product**	**Design**	**Product**	
Disputational	5 (22)	19 (126)	6 (39)	11 (67)	3 (13)	9 (60)	10 (327)
Cumulative	81 (335)	41 (271)	79 (484)	48 (287)	93 (372)	57 (370)	64 (2119)
Exploratory	14 (58)	39 (259)	15 (91)	40 (240)	4 (14)	34 (220)	27 (882)
Total	12 (415)	20 (656)	18 (614)	18 (594)	12 (399)	20 (650)	(3328)

**Figures in brackets indicate the frequency of talks*

Comparisons of formal communication between the 3 socio-cultural settings: The frequency of talks contributed by the 3 settings for all the 3 units taken together indicates that the maximum dialogues occurred in the urban Marathi setting (1237, 37%) and the least in the rural Marathi setting (934, 28%).

Figure 4 indicates that in bag making and windmill units, most dialogues occurred among the urban English group followed by the urban Marathi, and least dialogues occurred in the rural Marathi setting.

Figure 4: Comparison of frequency of talks in the 3 units across the 3 settings



Both the groups from urban area were closer to each other than to the rural group. On the other hand for puppetry, an interesting change was seen in the pattern of frequency of dialogues in the 3 settings. While most talk was observed in the urban Marathi setting, this was followed by rural Marathi. Urban English students had the least talks in the puppetry unit. Figure 4 suggests that the frequency of talks progressively increased from one unit to the next among the rural Marathi students.

The profile of talks in rural and urban settings is presented in Table 10. The table indicates that cumulative talks were highest in all three settings, followed by exploratory and disputational talks. Disputational talks were least in the rural setting and most among urban English students, and exploratory talks were highest among urban Marathi students.

The differences in the profile of talks could be explained by the fact that urban students have greater exposure to complexity and diversity (Weisner, 1976). Bernstein (1971) suggests that differences in communication can be traced to socio-economic backgrounds. The differences between students from rural and urban areas can be explained in terms of the ‘restricted’ codes of communication used by students from rural Marathi medium setting. Most students from rural Marathi setting were tribals, and socio-economically disadvantaged whereas students from the urban areas were mostly from middle class families and were accustomed to ‘elaborate’ codes during formal communication in the class. Tizard et al. (1983) have argued that setting has a marked effect on the language of working class girls and this effect is more in terms of language style than language deficit. According to them the language style of girls from working class families changed more between home and school than that of the middle class girls. Differential home and parental experience in cities, difference in language skills and use may also be reasons for differences.

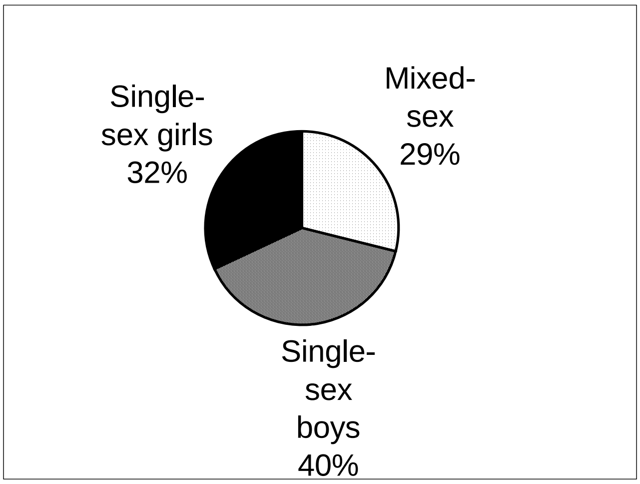
Table 10: Profile of talks in 3 settings for design and product communication

Kinds of talk	% Dialogues in Urban English	% Dialogues in Urban Marathi	% Dialogues in Rural Marathi	%Total
Disputational	16 (181)	9 (109)	4 (37)	10 (327)
Cumulative	53 (616)	59 (727)	84 (776)	64 (2119)
Exploratory	32 (370)	32 (401)	12 (111)	27 (882)
Total	35 (1167)	37 (1237)	28 (924)	(3328)

**Figures in brackets indicate the frequency of talks*

Comparisons of formal communication based on gender: Figure 5 presents the overall frequency of talks in the 3 gender groups during design and product communication. Most dialogues were exchanged by the single-sex boys' groups (1325), followed by single-sex girls' groups (1053) and mixed-sex groups (950).

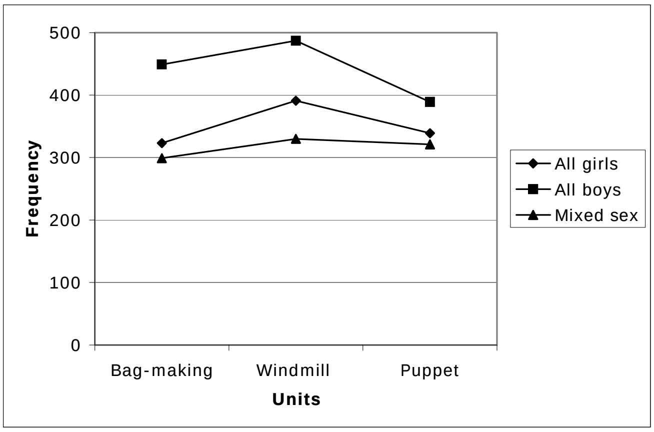
Figure 5: Overall frequency of talks exchanged in the gender groups



The fact that students in the mixed-sex groups contributed least number of dialogues in all the units could be an indication that in mixed-sex groups both boys and girls restrained themselves while talking in the group.

Figure 6 presents the comparison of the talks in the 3 units by gender groups. The figure indicates that the mixed-sex groups had the lowest frequency of talks in all the 3 units and remained almost constant across the three units.

Figure 6: Comparison of talks in the 3 units by gender groups



The single-sex boys' groups had a higher frequency of talk and retained this across the three units, followed by the single-sex girls' groups who had the second highest frequency across all the three units. Bag making was the first unit and all the gender groups (boys, girls and mixed) increased the frequency of talks for the windmill unit. The frequency of talks decreased in the puppetry unit for both the single-sex groups.

The profile of talks in the 3 units by the gender groups is presented in Table 11. Single-sex boys' groups showed the maximum frequency of each kind of talk, followed by single-sex girls' group and mixed-sex groups. Disputational talks were the highest in single sex boys' groups (125) and least frequent in mixed-sex groups (97).

Table 11: Frequency of different kinds of talks in gender groups

Gender groups	Disputational	Cumulative	Exploratory	% Total
Single-sex girls	32 (105)	32 (671)	32 (279)	32 (1055)
Single-sex boys	38 (125)	40 (847)	40 (353)	40 (1325)
Mixed-sex	30 (97)	28 (601)	28 (250)	28 (948)
Total	10 (327)	64 (2119)	30 (882)	(3328)

**Figures in brackets indicate the frequency of talks*

Table 12 presents the frequency of talks in the 3 settings based on gender groups. The mixed-sex groups in both the urban schools followed the overall pattern of occurrence of the least dialogues. On the other hand, the single-sex boys' groups had the highest frequency of talk, which has almost equal contribution from the single-sex boys' groups from the two urban settings. In the rural Marathi setting, however, the mixed-sex groups were not very different from the single-sex groups. The difference between the urban Marathi and urban English setting came from the higher frequency of talk from the single-sex girls' groups of the urban

Marathi setting. The highest frequency of talks/ dialogues among all settings occurred among the urban Marathi students.

Table 12: Frequency of talks for all the units in the 3 settings based on gender groups

Gender groups	Single-sex girls	Single-sex boys	Mixed-sex	%Total
Urban English	33 (349)	38 (501)	33 (317)	35 (1167)
Urban Marathi	38 (397)	38 (500)	36 (340)	37 (1237)
Rural Marathi	29 (309)	24 (324)	31 (291)	28 (924)
Total	32 (1055)	40 (1325)	28 (948)	(3328)

**Figures in brackets indicate the frequency of talks*

The results of the comparison of talk in the gender groups indicate that with respect to exchange of dialogues, boys' groups tended to talk more than the girls' groups. While this may seem counter-intuitive to some, research on gender and talk has also indicated similar results (Eckert & McConnell-Ginet, 2003). A reason for differences in amount of talk in boys' and girls' groups could be because both the sexes use different strategies of talking within their groups. Girls' groups tend to have an egalitarian ethos, while boys learn to use strategies that raise their status (Eckert & McConnell-Ginet, 2003). Within mixed-sex groups, the styles of talking that boys and girls engage in also differs (Fishman, 1978).

4.3 Results of informal communication and collaboration

The analysis of informal communication and collaboration in the 3 units was carried out with the purpose of understanding students' interactions and learning when working in groups on common tasks. Learning viewed as change in practice or behaviour was seen within smaller groups in which students worked as well as at the level of the classroom/setting. Various elements of collaboration were scrutinized during the course of the trials. The observations of the trials of the 3 units indicated that the design and technology units encouraged collaborations among students.

Informal communication

Informal communication refers to the casual verbal and non-verbal exchanges that take place between members of a group while working on a common task. Such interactions between group members and also across groups may be useful for planning and making. Some analyses of informal communication have been reported in Mehrotra et al., (2007b). In this study informal communication in student interactions was observed through:

a) *Role adoption*: Students adopted different roles within and across groups - *as leader, worker, communicator, critic, writer, artist and mediator*. This informal role-adoption was evident through patterns of behaviour or comments made by the individuals. While no leader was formally appointed, the position of a leader was assumed by a member of the group who was also accepted as leader by other members of the group. The 'leader' tended to be an academically bright student or a physically well-built individual. The leader often suggested ideas or initiated a line of thought and action. Group members took on other roles that depended on their possessing some specific skills such as, drawing, composing poems, decorating or possessing good public speaking skills.

Gender aspects related to role adoption: It was observed that girls often took or were given the tasks of decoration of artefacts, drawing or sewing, while boys tended to take up tasks that required the use of tools and equipments. In some mixed-sex groups in the urban settings, it was noted that while students came to the front of the class to present their work to others, the boys in the group took the lead in introducing the group.

b) *Conflicts, conflict resolution and sharing of resources*: Many instances of disagreements among group members were observed over the course of the trials. Often arguments took place because of unfavourable work distribution, over control of resources, or having to comply with a group decision. There were frequent debates between group members on the procedural aspects of the activity. The ability of an individual to resolve conflicts with peers is important and helps to determine his or her level of acceptance or rejection by peers. Conflicts also occurred across groups and all conflicts were usually settled without the intervention of the researchers. Conflicts emerged even over very small and abundant resources such as needles and thread. However we found evidences of sharing also. In some groups, members who completed their work helped other members and groups.

Gender aspects related to resource use: The dynamics of resource use within groups was interesting. Some resources were available in plenty, while others were in limited supply. Attempts at controlling limited resources played a crucial role in leading to conflicts. In the context of trying to control limited resources such as scissors and other materials like beads for decoration etc., it was observed that boys in mixed-sex groups usually exercised control over resources and girls had fewer chances to handle these. Studies in secondary schools have shown that girls rarely engage in playing with tools and equipment, while boys not only have more experiences, but also a perceived expertise with equipment (Jones et al., 2000).

c) *Non-verbal (gestural) and casual language use:* Informal communication among group members was harder to track than formal communication for various reasons. One of the reasons is that informal communication need not always be verbalized. We saw non-verbal communication in acts of explaining ideas and gestures for communicating emotions, such as showing a ‘V’, indicating victory (successful completion of the task). Students communicated without words, by grabbing, trying to gain control over limited resources, ignoring, maintaining eye contact or pushing and shoving. In all the units students used their hands and facial expressions to convey messages within their groups. Physical movements were often used for giving estimates of length, height of objects. According to Roth (2002) gestures are important indicators of learning, as they express levels of understanding before students express their new understanding in words.

Gender aspects related to non-verbal (gestural) and casual language use: The verbal communication showed gender references in students’ language use, often through explicit comments, such as, “this is ladies’ stuff” (by one member of an all-boys’ group) and “it’s nice that you have girls in your group” (a member of an all-boys’ group to a boy of a mixed-sex group where girls were decorating the puppet). Non-verbal communication, such as, ignoring or refusing to look at or listen to another member also showed gendering. For example, girls in mixed-sex groups often found it difficult to be heard (Mehrotra et al., 2007b).

Evidences of collaboration

Collaboration was studied at both the group and the larger classroom/setting level. The purpose of analysing collaboration was to understand interactions between students and the emergence of shared knowledge or learning while realizing common goals and using techniques, tools and facts. We sought to document instances of actions (as well as talk) that led to new resources and practices becoming available and ‘diffusing’ throughout the setting. These are elaborated below.

a) *Realisation of common goal*: The 3 units in our study were designed in such a way that students had many opportunities for participating in collective activities. We observed that initially many students had problems working in groups together with others and many students were more concerned with achieving their own goals rather than working for collective goals. But once students began working in groups, they accommodated to the fact that group goals such as making a windmill model that can lift some weight was as important (or more) as individual goals, such as making the parts of the windmill, attaching the assembly to the tower, decoration etc.

b) *Diffusion of learning through techniques, tools and facts:* The term 'diffusion' is used to refer to a situation where more and more members of a community/classroom use a certain resource or engage in specific practice (Roth, 1996). By using these resources and adopting the practices, the community itself is transformed. According to Lave and Wenger (1991) changes in the existing practices of the community are constitutive of 'progress'. In our study we found that when students faced a problem and became aware of what others were doing, they could adjust their actions, redefine their problems, utilize new materials, or build on explanations, or utilize the knowledge from their earlier experiences to solve the problem.

A practice that spread quickly among members of rural Marathi setting was of making wooden 'stool-like' structures for windmill towers. All the windmills made in the rural setting had similar towers, but of varying lengths. The idea of 'stool-like' tower surfaced in many groups simultaneously and it appeared as though students in this setting were pre-decided on the design of their towers. In other words, the idea of making 'stool-like' tower was a fashion. Despite all their towers being similar, their blade designs and shaft assemblies were different. There were other examples where tool-related practice diffused in the entire cluster, for example, the use of drilling machine or saw. To become a member of the practice, students had to find a way, through their own experience, to *appropriate* the use.

Studies by sociologists of scientific knowledge indicate that tool-related practices belong to that form of knowledge that is most difficult to communicate and that often has to be learned in the context of its use and from an experienced practitioner (Collins, 1982). One of the practices that all the groups in a setting learned; was the use of rivets for strengthening the holes in which the handles of the paper bags were put. During making, one of the groups realized that they needed to use something to strengthen their bags and they thought of rivets to be put at the mouth of their bags and they learnt the technique to fix them from the researchers. This technique was later used by many groups in that setting. The classroom changed as a physical and social setting, in its practices (weaker holes in which the bag handles were put was replaced by a technique in which a simple tool needed to be used to make the holes strong), and in the resources available (use of rivets and hammer).

In the case of diffusion of learning through facts, we observed that in all the settings for all the 3 units, not all the facts that were given to the students in the beginning of the unit were applied by them while making the products while some facts were explicitly applied by the students. We also observed that students learned a few practices and facts 'on-the-job' which they could apply in other situations also.

Diffusion of learning indicates that learning that occurs at the group level and at the community level needs to be understood at various levels such as changes in practice, in tool usage, techniques and facts. Tools, techniques, facts are components of a community (Roth, 1998) and can offer students exploration and manipulation possibilities, and also have the ability to structure and sustain communication. By sharing tools and other material resources during the activities, students learn from collaborative work. They give and receive help, share knowledge, build on each others' ideas, recognize and resolve contradictions between their own and other students' perspectives, observe others' strategies, negotiate and thus learn to work in group and benefit from it. This study provides some evidences of these changes studied in the context of design and technology units in the Indian settings.

5. Conclusions

The survey of urban and rural sixth grade students' ideas of technology indicated that Indian middle school students have a concept of technology that is mostly associated with objects and activities depicting modern appliances used for speeding work and easing life, usually seen in the urban areas.

Students' reasons for associating objects or activities to technology were consistent and included the benefits of technology such as involving speed and less physical strength, being human-made and dynamic. Students even related technology to natural categories. According to students 'not technology' referred to objects or activities that did not involve machines, were unrelated to science, or were things found in nature. This survey indicates that humans working on objects are considered to be more related to technology than humans or objects alone. Both boys and girls had similar ideas about technology. This is noteworthy because despite the similarity of perceptions of technology, students, both males and females see different roles for technology in their lives as reflected through their comments about the suitability of career options for males and females. It is these perceptions of technology that are at the root of gender disparities in technology and engineering related careers at higher education. These findings have implications for teachers and educators who need to find ways to help students broaden their concept of technology to include activities, processes and systems apart from objects. One of the ways to broaden students' ideas about technology is to engage them in personally meaningful hands-on activities.

We developed 3 design and technology units that provided scope for students to collaborate and communicate their ideas in a non-competitive environment. The activities had scope for accommodating multiple ways of expression so that students both boys and girls and students from rural and urban areas could participate equally. We ensured that the language used in classrooms was close to the everyday language of children so that students could have a better understanding of concepts and their applicability.

The broad framework of analysis for formal communication was based on the socio-cultural discourse analysis. Socio-cultural discourse analysis draws from Vygotsky's idea of the conception of language as a cultural and psychological tool. While analysing students' talk it is essential to note that we are not suggesting that overall frequency of talk, or talk within design/product communication or the profile of talk is in any way superior or inferior in itself. These are aids to analysing a classroom situation.

The analysis indicated that the overall frequency of talks exchanged in product communication was more than in design communication, though the pattern was different in the 3 units. Thus it appears that student talk in formal communication depends on the nature of the units. Regarding the profile of talk, cumulative talk decreased in product communication in all the 3 units while there was an increase in exploratory and disputational talks. This increase in exploratory talks during the product communication was more than increase in disputational talks for all the 3 units and is important because exploratory talks are considered a hallmark for critical thinking.

With respect to the socio-cultural settings it was seen that the maximum exchange of dialogues took place in the urban Marathi setting, and the least exchange of dialogues took place in the rural Marathi setting. Disputational talks were more common in urban groups than in rural settings and more common in single-sex boys' groups than single-sex girls' groups. The profile of talks indicated that the urban groups were closer to each other than to the rural group. The results of the comparison of students' talks by gender groups showed that most dialogues were exchanged in the single-sex boys' groups and least in the mixed-sex groups.

Informal communication that occurred while students were engaged in the units was observed through roles taken by students, conflicts, conflict resolution and sharing of resources and informal communication via gestures. Students took up various informal roles during the execution of the units depending on their skills. Instances of arguments among group members were observed during distribution of work, controlling resources, or having to comply with a group decision. Gestures were used to communicate ideas as well as emotions.

Collaboration that occurred during the units was studied by following the emergence of shared knowledge or diffusion of knowledge or shared practices among group members and then the entire setting. There were evidences of students' learning from other members in the group. The evidences of learning through collaboration were studied through the way students in a group realised common group goals, learned the use of tools, techniques, practices and facts.

The results of this study indicate that communication and collaboration centred design and technology tasks can help students in developing new ideas and skills that will be useful for them in development of social skills and citizenship apart from technological knowledge and skills. At another level technology education could also provide a forum where researchers and teachers could collaborate for the improvement of education.

Technology education can provide a good platform for introduction of skills of teamwork along with technical, procedural and conceptual knowledge. It can broaden student's concept of technology and can help in creating a 'balanced' picture of technology which can contribute to bringing about a change in the profile of human resources in the area of science and technology in the country. Introduction of a gender-sensitive technology education at the school level may address the problem of skewed gender ratios in technology related fields at the tertiary level. The inclusion of a particular subject in the curriculum is not only a matter of establishing its need in satisfying the general goals of education, its appropriateness in content and pedagogy, but it is also influenced by educational policies and logistics of implementation. Hence, it seeks understanding and cooperation from policy makers.

6. Limitations of the study and directions for further research

This study has some limitations of scope and generalizability with respect to data, sample and analysis. The physical scope of this study was limited to middle school students in schools in and around Mumbai. The survey data came only from sixth grade students. Only three design and technology units were developed and tried in three settings. We encouraged group work or team work to facilitate mutual exchange of ideas in the classrooms but our resources for data recording were not sufficient to capture the intricacies of the dynamics of group work. Since we did not have a camera monitoring every group or even a particular group through all the trials, the existing video/audio recordings provide data of a setting on the whole, but do not give all the details of informal communication in the groups. In the rural settings due to problems of logistics such as power failures, the quality as well as quantity of video data was limited.

There is a need to carry out research to find out the profile of talks during each of the phases of D&T activity. This will help in knowing the stage at which 'maximum constructive talks happen'/exploratory talks and then teachers could be trained to encourage certain kinds of talks in each of the phases so as to aid in peer learning. Another possible area of research could focus on single-sex boys' and single-sex girls' groups while they are involved in D&T tasks to find out the differences in working styles in the two groups.

In our study we did not look in detail at students' informal communication, but during the study we realised that informal communication (which adhere less strictly to rules and conventions) is also a rich source of information. Students' casual discussions and notes while they are involved in the D&T tasks could give an idea about how concepts are developed in a group and can also give more details about the kind of collaborations within the groups. Therefore a study of informal communication is a potential area of future research.

A possible way to analyse the data is at the linguistic level, where one could study the structural organization of classroom communication between students. The grammatical and pragmatic features of the discourse data could be analysed to give an idea about how students' words/messages are understood by their peers while they are engaged in teamwork during D&T activities. Another possible variation could be in the choice of D&T units, i.e., different and more or less culturally rooted units could be planned for trials and then students' communication across settings could be studied.

The crafts and arts teachers along with science teachers can be trained in content and the pedagogy of conducting collaborative teaching which is specially suited for introduction of technology education in the Indian classrooms. The units tried by us in this study can be tried in the real classroom contexts, that is, the units can be taken out of the 'laboratory'.

If this study were to be done differently then I would try to use better methods of data recording and would record informal communication also. I would preferably focus my video camera on two or three groups in a setting and would follow these groups for the three units. This would help me in getting an idea of how groups evolve in their designing and making abilities over time and then a comprehensive framework for comparison could be developed. Another way that this research can be done differently is to carry out trials of one or two units in greater detail instead of three units so that we can have more parameters of observation during the trials.

I would like to develop better methods of assessment of student's understanding and progress, wherein some part of it would be objective and some part subjective. Interviewing students could help in getting closer to understand what they learned during the units. Interviewing would also help in knowing the extent of contribution of individual students to a group activity. This would give a better feel of the group dynamics. As far as research methodology of this work is concerned, a methodological triangulation, which could include detailed video data, students' interviews and daily logs, would enhance the value of the results from this study.