**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:*

<u>Students' ideas of technology</u>

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.

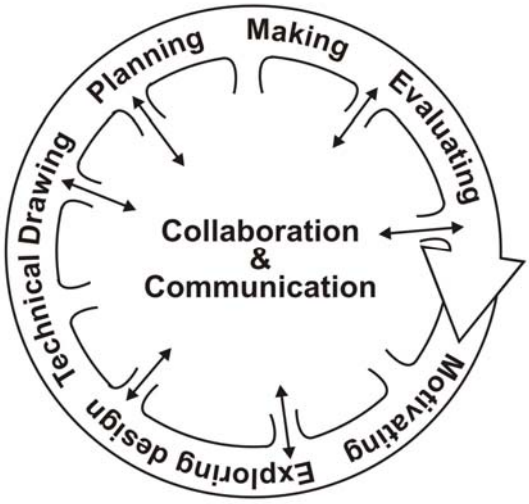
The units were selected on the basis of increasing order of complexity of tasks and intra and inter group collaboration. The *bag making* unit viewed technology as a product (artefact) and could be done by an individual, though a group was involved in the process. The *windmill* unit required students 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**<br>**Investigation & Motivation** | Introduction of various kinds of bags/windmills/ puppets by researchers<br>Writing words for the artefact/ system in various languages by students |
| **Day 2**<br>**Designing** | Technical/academic inputs related to the units provided by researchers<br>Designing the artefacts to be made by students<br>Technical drawing of the artefacts by students |
| **Day 3**<br>**Planning & Communicating** | Procedural map of the artefact by students<br>Materials needed for making and their quantities listed by students<br>Work distribution within groups listed by students<br>Communication of design to the entire cluster by students |
| **Day 4**<br>**Making** | Actual making of the artefact by students |
| **Day 5**<br>**Evaluation & communication** | Students critically evaluate own products as well as those made by others<br>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*).

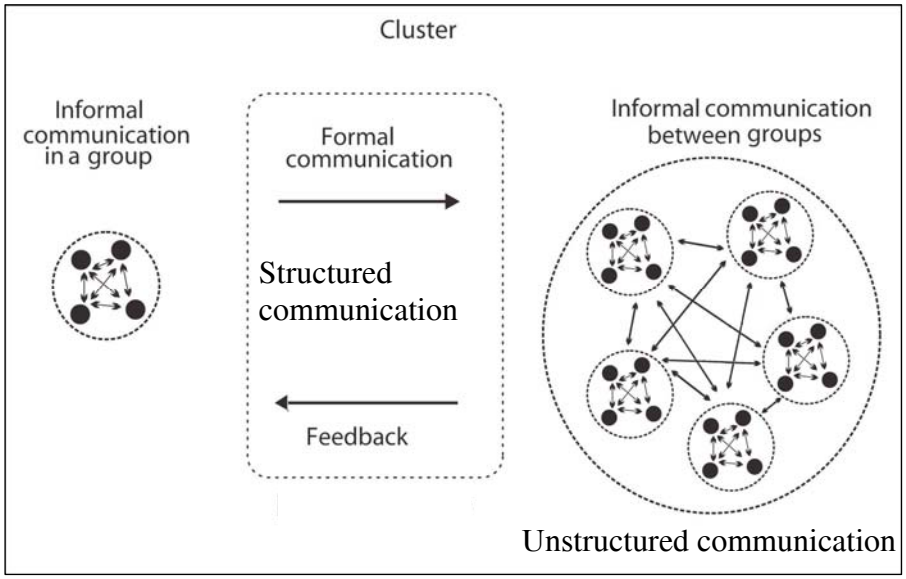
During formal communication all the members of a group came to the front of the classroom and presented their work orally to other groups in the cluster. A scheme developed by Dawes et al. (1992), that categorizes talk as, disputational, cumulative and exploratory was used for analysing the formal communication. 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:<br>• Roles and responsibilities taken by various members in a group<br>• Conflict, conflict resolution and sharing of resources<br>• Informal communication through gestures |
| **Collaboration** | Video /audio records | Observed through:<br>• Realisation of common goals<br>• 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<br>First we had made hair with wool, then it was not looking long so we made it with cloth | **Information (C)**<br>**Reflection (E)** |
| P2: | We had difficulties with the saree<br>There were problems in sewing<br>I sewed it but it opened quickly | **Reflection (E)**<br>**Reflection (E)**<br>**Reflection (E)** |

**Key: C= Cumulative talk, D= Disputational talk, E=Exploratory talk, P= Presenters**

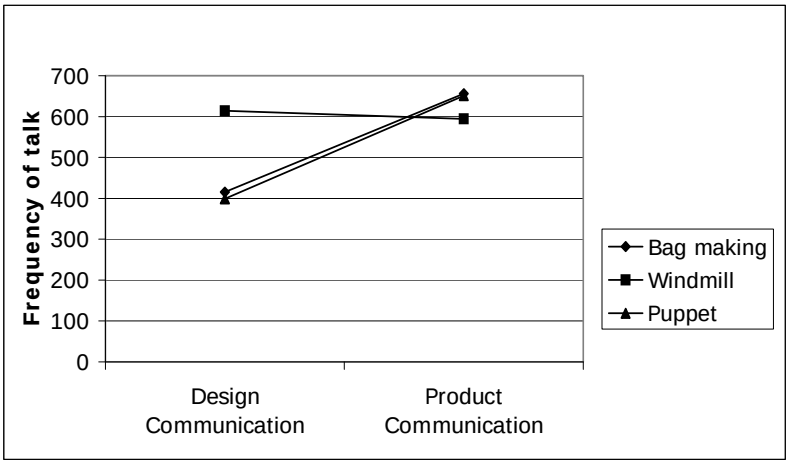
The results are first presented according to the units, then by socio-cultural settings and finally by gender. In the three units a total of 3328 sentences occurred in dialogues during

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**

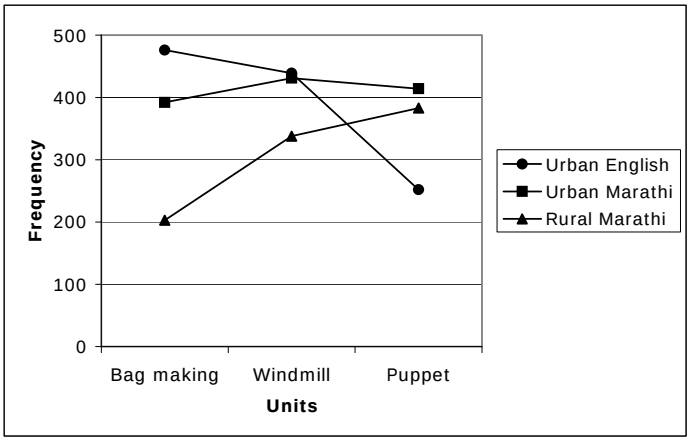
| Kinds of talk | Bag-making | | Windmill | | Puppet | | Total |
|---|---|---|---|---|---|---|---|
| | Design | Product | Design | Product | Design | Product | |
| **Disputational** | 5 (22) | 19 (126) | 6 (39) | 11 (67) | 3 (13) | 9 (60) | 10 (327) |
| **Cumulative** | 81 (335) | 41 (271) | 79 (484) | 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.

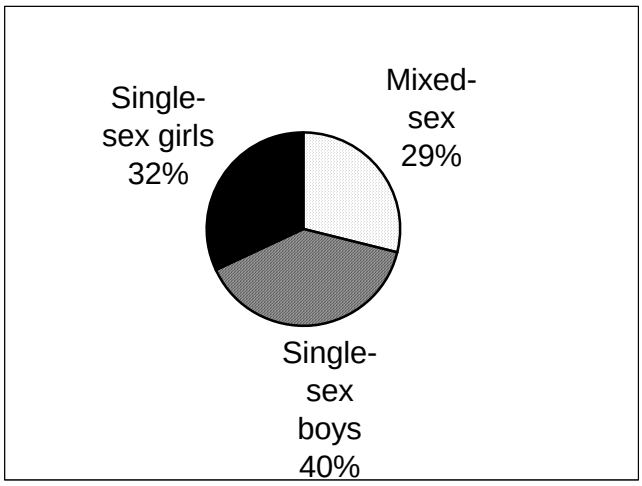
**Table 10: Profile of talks in 3 settings for design and product communication**

| 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).

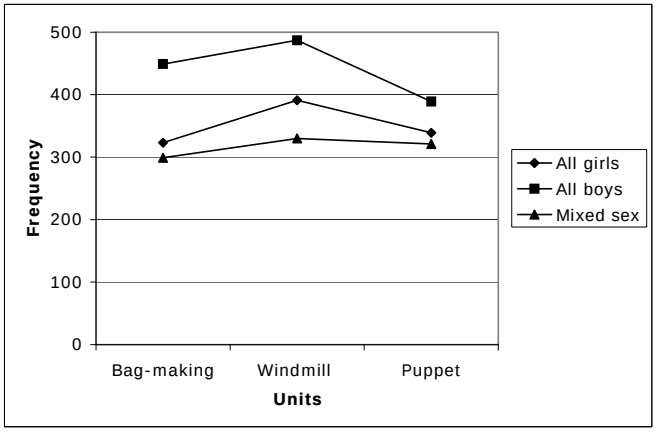
**Figure 5: Overall frequency of talks exchanged in the gender groups**




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.