Evidences of Learning Through Collaboration in Design and Technology Tasks in Indian Classrooms

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Working together in a group or teamwork is a soft skill that is highly valued in the job market. 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. The paper focuses on the results of a study (that was part of a larger project) conducted with middle school students in three different socio-cultural settings in India. This paper will report the evidences of collaborative learning that occurred while the students engaged in the design and technology units.

Introduction

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.

Collaborative learning refers to 'situation/interactions/ mechanisms in which two or more people learn or attempt to learn something together – kind of social contract' (Dillenbourgh, 1999). In collaborative learning, learners work together by communicating whereby they are, stimulated to discuss, negotiate and, ultimately, create new knowledge (Baker et al., 1999). 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). 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.

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) and hence there is a need for research in classroom contexts with students engaged collaboratively in meaningful tasks.

By its very nature, Design and Technology (D&T) is a social and collaborative endeavour and this aspect needs to be reflected in D&T education. 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 modern organizations. The roots of developing these soft skills lie in the school experiences of students. Rowell (2002) recommends that skills needed for collaboration have to be recognised and nurtured from childhood. Researchers have pointed out 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). 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.

Methodology

As a part of our study to introduce D&T to the Indian school students, we designed three D&T education units that were communication and collaboration centred. The units were a) making a bag to carry books, b) making a working model of a windmill that could lift weights and c) making a puppet and collectively putting up a puppet show. The overall approach of our D&T units was a modified form of the Design-Make-Appraise approach suggested by Kimbell (1994) and is presented as a model elsewhere (Choksi et al., 2006). As suggested by Kimbell et al., (1996), thinking about design progresses through iterative interaction between the hand and head. The phases in our units were not linear and students could go back and forth in the phases. During the units students needed to work in groups, on tasks that were connected with their immediate social context and were specifically designed for use among mixed ability students, both boys and girls, in different socio-cultural settings. Each task followed a pattern: students were set a real life problem, they then explored the context, came up with alternative designs, chose the best design, projected the materials and their quantities needed for making and communicated these to other students in their setting who questioned them about their design. Then the groups engaged in making the artefacts and finally they evaluated the artefacts made by their groups as well as those made by other groups in the setting.

In the trial of each D&T unit, around 20-25 students of Grade 6 (11-14 years old) worked together for about 15 hours across 5 sessions. To bring in diverse socio-cultural contexts, 3 settings were chosen: English medium students from an urban school, Marathi medium students from an urban school, and tribal students from a government-run residential Marathi medium school (*ashramshaala*) located at a distance of about 60 kilometers from Mumbai. The units were tried in all the three settings separately. To encourage collaborative learning, students worked in groups of around 3-4 members each. In each setting there were 2 groups of girls, 2 groups of boys and 2 mixed sex groups. The number of boys and girls participating in the trials were equal. Video records and detailed field notes were maintained during the trials of the units.

During the trial of the units, apart from formal communication that was specifically built into each unit, students also interacted informally amongst their group members as well as members of other groups. During this informal communication they shared their ideas, learned new skills, reflected on their work and many a time acted as 'peer teachers', resolved conflicts, shared resources, etc. (Mehrotra et al., 2007).

Analysis Framework Used for Studying Collaboration

This section elaborates on the elements of collaboration observed while students worked in groups for the three units. Collaboration has been studied 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 units 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.

The purpose of analysis of collaboration was to understand a classroom community by following the emergence of shared knowledge or learning among group members while realising common goals and using techniques, practices, tools and facts. That is, 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.

Results

In the discussion below, we will document evidences of learning that we came across as students engaged in the D&T units. It is a qualitative account of learning that emerged as a result of students working in teams and interacting among themselves. Evidences of learning have been reported under following heads: a) Realisation of common goals, and b) 'Diffusion' of learning through tools and techniques and facts while 'on-the-job'.

a) *Realisation of common goals:* All the three 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 with other members in a group and many students were more concerned with achieving their own goals rather than working for collective goals. The transcript given in Table 1 is an excerpt of a conversation between members of a girls' group in urban Marathi setting during the bag-making unit. This conversation took place between a girl (G1) who was responsible for making the handles of the bag and another girl (G2) who was responsible for stitching the body of the bag.

The transcript shows that the members of this group, although working on making a bag, were less interested in

G1 (to G2): See if it [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.

Table 1. Evidence of group members having separate goals

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.

Realisation of common goals among group members occurred over time when they discussed about making their artefacts. Not only did group members realize the common goal but there were also evidences of the entire setting taking cognisance of the goals of the units and modifying their actions according to 'best fit' for the unit. For example, 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 (excerpt of the conversation given in Table 2).

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 Table 1, where members within a group were not interested in how others in the same group worked.

b) Diffusion of learning through techniques, tools and facts: In this sub-section, 'diffusion' of learning through tools and techniques and through facts has been discussed

G1 (member of a girls' group showing to members of another boys' group, with ruler, the height of the puppet that they were planning to make)
B1 (member of 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?

Table 2. Evidence for realization of common goal in the puppetry unit

under separate 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, more and more members engage in new practice and the community itself is transformed and there is learning in the entire community. According to Lave & Wenger (1991) changes in the existing practices of the community are constitutive of 'progress'.

Diffusion of Learning Through Techniques and Tools: 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 given in Table 3, which occurred during the bag-making unit in the urban Marathi setting in a girls' group.

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: 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.

Table 3. Evidence of diffusion of learning through techniques

In the example 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 the 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

Fig. 1. a. Students learning to fix rivets during the bag-making activity. **b**. Student observing another student using a drilling machine

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 incident 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'. 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.

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 handles of paper bags in the urban English 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 1a).

After observing the researcher, the members of the group took turns to fix each rivet. This practice soon spread to a mixed sex group seated next to this girls' group, who also requested the researcher to teach them how to put rivets in the handle slots. After these groups, three other groups of the setting who had made paper bags used the same technique. This 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.

It was observed that not all members of a setting practiced the use of certain tools. For instance, groups that made their windmill with materials, such as plastic bottles, aluminum foil, etc,. did not use tools such as the drilling machine or saw, but often gathered around to watch those students who worked with the tools. 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 1b.

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 that were similar but varied in length. The idea of 'stool-like' tower surfaced in many groups simultaneously and it was a fashion. Despite all their towers being similar, their blade designs and shaft assemblies were different (Figure 2). This practice is also an example of 'appropriation' of ideas.
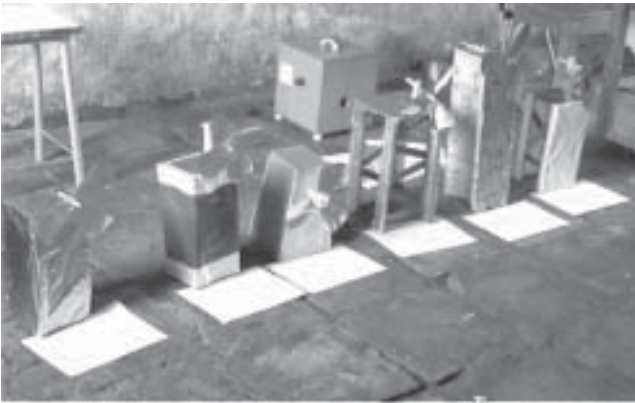
F**ig. 2.** Stool-like towers in rural setting

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 school subjects, such as Mathematics, Biology, Social Studies, Drawing, etc. For this purpose in each unit we had a session on 'concepts' related to that unit. For example in the bag-making unit, we formally explained to students the idea of measurements and units. We observed instances where students were confused about units and their labelling. However students on their own learned the fact that having strong joints in the bag was the key to increasing the overall strength and durability of the bag. Thus students learned the concept of strengthening joints while they worked on making their bag to carry books.

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 movements (of the blades) 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.

Conclusions

The analysis of collaboration in the three units was carried out to see evidences of learning that occurred while students worked in groups. In the study, D&T units were designed to give students opportunities to investigate, analyse, 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. The evidences of learning were seen through realisation of common goals, diffusion of learning through tools, practices and facts. There were instances of learning within the smaller groups in which students worked as well as at the community or the classroom/setting level.

While collaborative learning is helpful in classroom situations, it also has its drawbacks. One of the drawbacks of working in groups is the inevitable conflict that occurs among group members and across groups. These conflicts have been outlined in another paper (Mehrotra et al., 2007) and involve controlling limited resources such as scissors, beads, etc.; unfavourable work distribution among group members; and debates on procedural aspects of the activity. The tendency of some members to dominate the group activities and some members not getting a chance to try their hand at new skills were also observed during the trials which is another disadvantage of working in groups.

The observations of trials of the units indicated that collaboration can be encouraged during D&T units and students can benefit from it. 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. It will thus be able to fulfill the larger aim of providing education for a cohesive society with greater equality of opportunity and better access to quality education by different social groups including girls, learners with special needs and learners from disadvantaged groups, as spelt out in National Curricular Framework. (NCERT, 2000; NCERT, 2005)

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