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Collaborative learning in technology education: D&T unit on puppetry in different Indian socio-cultural contexts

Swati Mehrotra · Ritesh Khunyakari · Chitra Natarajan · Sugra Chunawala

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Abstract The paper reports on the trials of a Design and Technology (D&T) unit carried out in three different Indian contexts with a focus on collaborative learning. Both collaboration and technology education are not common to the Indian school system. As part of a larger project to introduce technology education, suitable for middle school girls and boys in urban and rural areas, three culturally appropriate and gender sensitive D&T units were developed. All the units were tried out with middle school students in different socio-cultural settings: two schools in urban areas (with different languages of teaching and learning) and one in a rural area. This paper presents details of a unit on puppetry which involved making a puppet and staging a puppet-show. Aspects of collaboration within and among groups were observed with respect to: roles played by the members, conflicts and their resolution, sharing of resources, communication and peer review among the students. The trials in the three clusters indicate the potential of this D&T unit to provide collaborative learning situations for the multicultural contexts of Indian classrooms.

Keywords Collaborative learning · Communication · Gender · Middle school students · Socio-cultural settings · Technology education

Introduction

Technology is an integral part of all societies and is both shaped by society and shapes society. In its many forms, it is entwined within the fabric of human existence (MacKenzie and Wajcman 1985). The word 'technology' is used variously to represent things, actions, processes, methods and systems and is often symbolic of progress in various spheres.

S. Mehrotra (✉) · R. Khunyakari · C. Natarajan · S. Chunawala
Homi Bhabha Centre for Science Education, Tata Institute of Fundamental Research,
V.N. Purav Marg, Mankhurd, Mumbai, Maharashtra 400 088, India
e-mail: swatim@hbcse.tifr.res.in

S. Chunawala
e-mail: sugrac@hbcse.tifr.res.in

Realizing the all-pervasiveness of technology, many countries worldwide have introduced technology education in their school curricula. Technology education as a part of the school curriculum has different goals and trajectories within each country, which depend upon the country's concerns governed by economic, political, social or epistemological considerations (Layton 1993).

One of the proclaimed, but unmet goals of technology education is to give students teamwork skills (Denton 1994). According to Rogoff (1998), in any classroom, teachers and students comprise a community of learners in which knowledge is shared and co-constructed. The importance of collaboration in technology tasks cannot be underestimated. Hennessey and Murphy (1999, p. 27) state that ''collaboration is an important aspect of problem solving which enhances learning (including planning) by making thinking more explicit and accessible and enabling pupils to construct joint understanding of tasks and solutions.'' Collaborative learning is not only about collaborating to learn, but also learning to collaborate (Collazos et al. 2002), and for this reason attempts are made to assess participants' progress in terms of the quality of the learning process and not just the outcome.

Collaboration, like technology is a slippery concept. Not all groups are necessarily collaborative, and some groups collaborate much better than others. Beneficial effects of collaboration on learning of technology have been enumerated by Rowell (2002), who recommends that skills needed for collaboration have to be recognised and nurtured from childhood. Ridley (1998) argues that we come together in groups and conform to the norms of those groups, out of a human need for reciprocity. Gender influences the processes involved in collaborations and the transition from observing to doing a task. Perceptions of teamwork may differ between boys and girls. Besides, among mixed-sex groups, different perceptions of teamwork may emerge. Studies have shown that satisfactory social relations among members of a team enhance a group's efficiency (Wood and Rhodes 1992).

Indian context

In recognition of the importance of science and technology in society, the apex text-book producing body in India, the National Council of Educational Research and Training (NCERT), has, since the year 2000, introduced books titled 'Science and Technology' at the upper primary and secondary school levels. Earlier, the books were titled 'Science' and presented technology as applied science or as an 'add-on' to science. The recently revised books continue the trend. At present in the Indian curriculum there is no subject that has Design and Technology (D&T) as its components. Ramadas (2003), suggests that integrating technology with science in this manner could have negative consequences for meeting specific learning objectives. Technology presented in this way fails to make connections between different subject areas, such as, history, geography, language and craft and fails to address the purpose of learning about technology, which is different from science.

Another problem that plagues education in India is its exclusive nature. To ensure equity and gender balance in education, the Indian Government has laid down detailed policies. A National Curricular Framework (NCERT 2000) focused on providing education for a cohesive society so that equality of opportunity and access to quality education by different social groups including girls, learners with special needs and learners from disadvantaged groups, is ensured.

Along with its exclusive nature, the Indian system of education is rigid and resistant to change and focuses on learning analytical skills, logic, etc. Learning activity is isolated and

does not encourage children to make linkages to real world. There is overemphasis on individual learning which is in contrast to what Tagore had said of achieving happiness by 'realising ourselves through others' (NCERT 2005, p. 2). The individual approach to teaching/learning favours a limited engagement in teaching and learning on the part of both students and teachers. Lecturing is the most common mode of teaching. Besides, learning/teaching is for gaining marks/rewards in examinations that do not assess soft skills. There is a mismatch of skills and competencies needed in working life and those obtained by an individual at school and college. The need for technical skills combined with soft skills such as skills of communication, effective presentation, negotiation, teamwork, social-esteem and self-management is being increasingly stressed by organizations (Nayak 2003). Educationists as well as employers have emphasized the need to train students in these skills as part of general education (Thangamuthu 2007, Karnik 2007).

Therefore a curriculum that integrates soft skills with technical knowledge would be greatly desirable. Design and Technology activities provide one of the many ways in which soft skills can be integrated with technical knowledge. At the same time D&T education can serve to integrate knowledge across school subjects and in mixed ability and multi-cultural classrooms it can be an inclusive endeavour for the children of the rich as well as the dispossessed, for those in the indigenous or the modern mould and for girls and boys.

Background and rationale

This paper is part of a project that was initiated at the Homi Bhabha Centre for Science Education, Mumbai, India in the year 2002–2003 and involved the development and trials of D&T units for Indian middle school students. The three units were: making a bag, making a working model of a windmill and making a puppet and staging a puppet show. The units were designed within the frame of collaborative learning, wherein groups of students shared a goal and were held together with a common sense of purpose. In each unit a problem was set for the students that had a real world context. The units were selected on the basis of increasing order of complexity of tasks and of opportunities for 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 given weights. This activity was more complex, having many sub-parts and involved more mental and physical work. The third unit on puppetry was based on a systems approach to technology. Each group had to make a puppet and all the puppets made by them were needed to put up the show, thus involving a second level of collaboration, with the entire cluster collaborating.

This paper focuses on one of these units—the unit on puppetry. Puppetry, besides being one of the most ancient forms of entertainment in the world, is also part of the cultural heritage of India (Kamat 2000). It is an art form that unites crafts, design and drama (Contractor 1984) besides being a pedagogic device that can help in the development of imagination and creative thinking of students (Singh 2004). The puppetry unit had interdisciplinary components that integrated topics from different subjects of the curriculum: human body joints and their movement, body symmetry and proportions (biology), speech, dialogue writing and character description (languages), dress and gestures of people from different regions (social studies), estimates and measurements (mathematics), cutting, sewing, decorating (vocational/craft), music (arts), costing (economics) and materials (science).

Methodology

The overall approach used in all the units was an adapted version of the design-make-appraise (DMA) approach. DMA is a non-linear approach involving steps such as identification of a need, investigation, development of ideas, refining the ideas, modelling, making and evaluating (Kimbell et al. 1991). The key characteristic of this approach is that it strikes a 'balance between active designing and reflective appraisal….' through group discussions (Kimbell et al. 1996, p. 13). The DMA approach adapted by us included aspects of communication and collaboration among students and teachers at its core and is proposed as a model for D&T education at school level (Choksi et al. 2006). Table 1 presents the steps undertaken in the process of conducting the trials of the unit on puppetry.

The unit was tried with a total of around 60–65 students of Grade 6 (11–14 years of age), with about 20–25 students in each of the three clusters. The three clusters were the three socio-cultural settings in which all the units were tried. We ensured that the number of boys and girls participating in each of the trials were about equal. The three clusters were: an urban English medium school, an urban Marathi (official language of the State of Maharashtra) medium school, and a rural Marathi medium school for tribal students (*Ashramshaala*). The rural school is located about 60 km from Mumbai city. In each cluster, students were asked to form groups of 3–4 members. Each cluster had 2 groups of girls, 2 of boys and 2 mixed-sex groups. In the trials of the D&T units, students worked for a total of 15 h in five sessions. Video and audio records were maintained during the trials of the units. The video and the audiotapes were transcribed after trials and the transcripts were supplemented with the field notes that were maintained during the trials. Plate 1 depicts the activities undertaken by students and some of their productions.

Analysis of collaboration

Working together in a group is something to be encouraged in technology tasks, not merely for completing a project with pre-determined goals but also for learning to work and

Table 1 Stages in the D&T unit trial on puppetry

Stages	Elaboration of activities
Day 1 *Investigating*	Introduction of different kinds of puppets by researchers. Each group in a cluster wrote a story with 6 characters. From these stories, one story was selected by the cluster through negotiation. Each group then selected a character from this story to make a puppet and made a character sketch (drawing + writing).
Day 2 *Designing & Communicating*	Students were provided information about human body joints, their movement, symmetry and proportions. They made technical drawings, step-by-step plans (procedural maps) and decided the quality and quantity of materials needed for making the puppet. They also made paper cut-outs of the puppets and communicated their designs formally to other groups.
Day 3 *Making*	Cloth cut-outs were made by the students. They practiced sewing on scraps of cloth and made choices about the assembly, such as, how the head, hands and feet would be attached to the torso. They decorated the puppets after making them.
Day 4 *Designing the show*	The entire cluster came together to design the show. They split into different teams: for music, dialogues, stage, props and lights.
Day 5 *Staging the show & Evaluating*	Students made a stage, had a rehearsal and put up their show for an audience. They later evaluated their own puppet as well as the puppets of other groups and communicated their evaluations to the cluster.

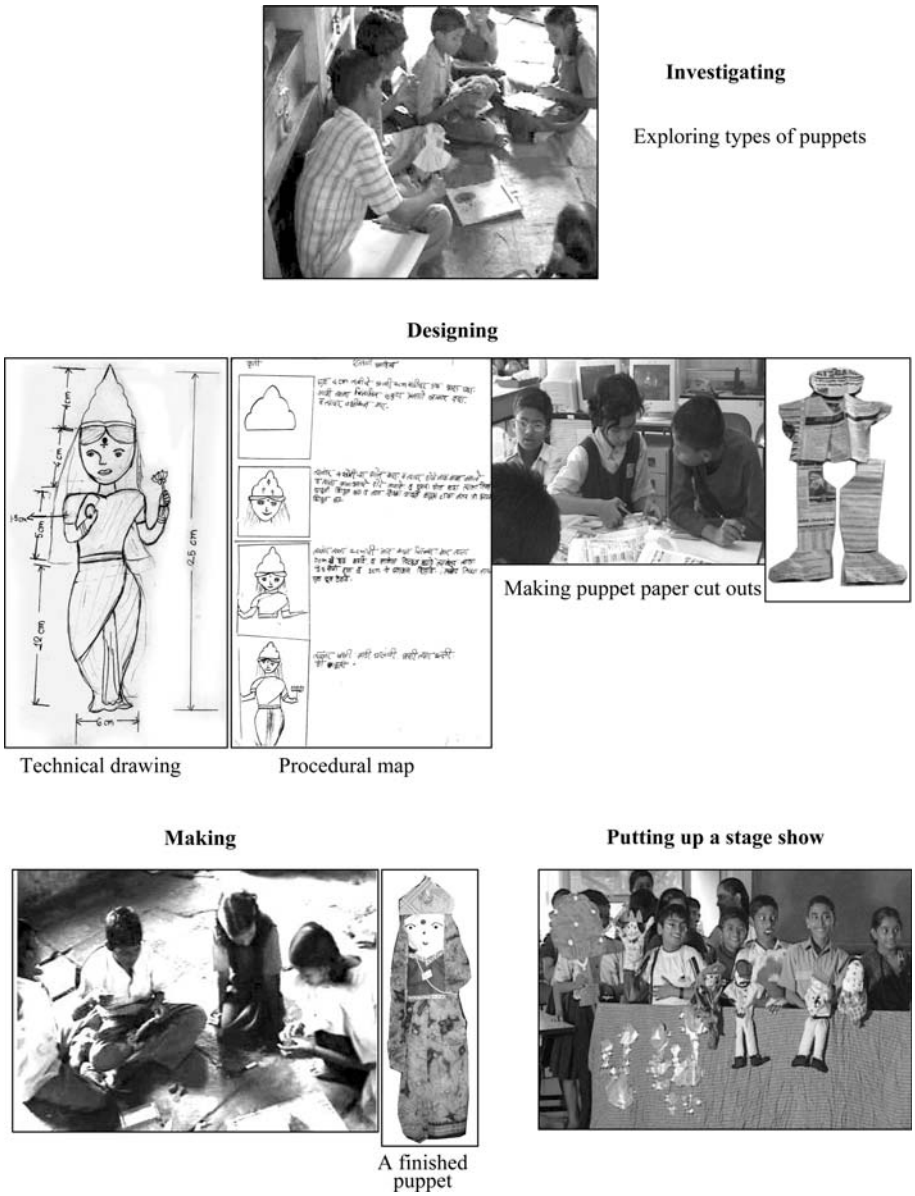


Plate 1 Glimpses of students' activities and productions in the trials of a D&T unit on puppetry

operate as a team. By its very nature, D&T is a social and collaborative endeavour and this aspect needs to be reflected in D&T education. Collaboration goes beyond mere working in groups, to synthesizing the knowledge brought to the situation by each group member (Roschelle 1992). Borden and Perkins (1999) have proposed a collaboration checklist that includes leadership, planning, decision making, conflicts, conflict resolution, capacity building, communication, connectedness, customs, political climate, rules, resources and catalysts. While most of the studies on collaboration have been done in the context of

internet/computer use, Jeong and Chi (1999) have proposed several factors in an educational context, such as, cognitive conflicts, partner expertise, and amount of verbalization that are responsible for improving learning in collaboration. In our work we focussed on collaboration through group dynamics, conflicts and resource sharing, communication, and peer review.

This paper reports preliminary observations that were made for generating analytical categories for use in data analysis. We classified our observations on the basis of categories that emerged through review of relevant literature as well as from discussions on the audio and video data among the four researchers. The categories established in this study are elaborated below.

Group dynamics or the nature of interactions that take place within groups is a major aspect of collaboration. These interactions include the roles taken on by different members of the group, the relations between group members, and the environment that is maintained in the group. Rowell (2002) has analyzed group interactions in terms of establishing roles such as, manager-assistant and identities in terms of participatory contributions such as, tutoring, imaging and planning, manipulating, testing and mediated participation. In our study, the observations of group dynamics are made under the category of *roles played by the members*.

Conflicts can, in particular, affect the overall learning environment of the classroom. Conflicts exist whenever incompatible activities occur (Deutsch 1973) and have been classified in different ways. Johnson and Johnson (1995) have categorized school related conflicts among students as controversy, conceptual conflict, conflict of interests and developmental conflict. Jones et al. (2000) reported the occurrence of conflicts within interacting groups over sharing of resources in classrooms. They found a gender-related pattern in how students in dyads relate to each other and the materials.

Communication is an important component of collaboration. It mediates interactions in collaborative technology tasks not only through verbal discourse but also nonverbally, through sharing of technical (physical) tools, drawings, writings and gestures (Dillenbourg et al. 1996).

Peer review, whereby students review written and oral work of other students and make suggestions for improvement, is yet another aspect of collaboration. Peer review benefits students' learning in terms of developing their written skills, critical thinking, collaboration and professional responsibility (Kern et al. 2003). It can also serve as peer tutoring or feedback, which helps students realise their errors and rectify these in order to improve their designs. Our observations on the above parameters are discussed in the following section.

Elements of collaboration observed

Observations of different groups and group members were made during the trials of the puppetry unit for each of the clusters. Besides, field notes and videotapes, students' writings on different occasions were sources of data. In the interactions of the group members within and across groups, observations were made with respect to: (a) roles played by different members of a group, (b) conflicts, conflict resolution and sharing of resources (c) communication and (d) peer review. In the sections that follow, we present examples from clusters as a whole and within and across groups in the clusters.

(a) Roles played by different members of a group: The video records showed that students adopted different roles within and across groups—as leader, worker, communicator, critic, writer/artist and mediator. This informal role-adoption was evident through

patterns of behaviour or comments made by the individuals. While no leader was formally appointed, we observed that one of the members of the group tended to assume the position of a leader. The 'leader' was either an academically bright student or a physically well-built one. The leader suggested ideas or initiated a line of thought and action. In the example given below, a girl (G2) took on the role of the leader of the group and other members consulted her before doing any task. She even rebuked her group members. The following is an excerpt of a transcript of conversation that took place between her and her group members (Urban English medium, mixed sex-group) during the planning phase of the unit:

G1 (one girl to another girl—G2—in her group): What do we have to do now?
G2: We need to make the procedural map first.
G1: Now?
B1 (boy): What! Procedural map also?
G2 (to B1): Yes. If you want to make, then make, if you don't want to make, don't make!

Other roles, such as those of a worker, writer, artist and communicator, were often taken up by members in a team who possessed some specific skills like, drawing, composing poems, decorating or possessing good public speaking skills. A mediator would help resolve conflicts and maintained the cohesion of the group. This mediation could also be in interactions with other groups, especially when all the groups in a cluster worked together in putting up a stage show. When all the groups in a cluster had to come together to put up the stage show, the existing groups dissolved and regrouped to form new teams for managing stage setting, music, lights, dialogues and compering. Generally there was a bonding in the cluster and the new teams emerged spontaneously. At times group loyalties played a part in making members unwelcome in the new teams as seen in the following response of two boys in the English medium cluster in their attempts to turn away someone who was not a team-member.

B1 (a boy in the music team): Go away, go away (along with gestures)
B2 (another boy in the music team): Why do you come here?

(b) Conflicts, conflict resolution and sharing of resources: There were many instances of disagreements among group members. 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 helps to determine his or her level of acceptance or rejection by the peers as well as successful completion of a task. The conflicts that occurred within or across groups were usually settled without the intervention of the researchers. However, one conflict in the English medium cluster, where it was difficult for different groups to agree on a common story, took nearly 30 min to get resolved, and that only occurred after the researchers' intervention. The researchers helped the students to negotiate the selection of a common story by deciding on criteria for eliminating stories, such as, unequal number of male and female characters, avoiding stories with animal characters, those with less variation in the characters, etc.

The dynamics of resource usage within groups in different clusters was interesting. Some resources were available in plenty, while others were in limited supply. We found evidences of sharing as well as attempts to establish control over resources. In some groups, members who completed their work helped other members and groups: in the

Urban Marathi setting, members from an all-girls group provided help to a mixed-sex group in draping the puppet. On the other hand in other groups fights broke out over the sharing of small or easily available resources: members of an all-boys group in the Urban Marathi medium setting prevented other group members from borrowing their needles though there was an unlimited supply of these provided by the researchers.

In the rural Marathi cluster, boys in mixed-sex groups, tried to control limited resources, like tools (e.g. scissors) and other materials (e.g. beads for decoration), 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). However, in the urban English and Marathi medium clusters no definite dominance pattern was evident in the mixed-sex groups. The perceived-to-be-academically-bright student, who was the leader of the group, often controlled the resources within a group.

Attempts at controlling limited resources played a crucial role in leading to conflicts. However, in our study, we observed that conflicts emerged even over abundant resources (needles and thread). Escalation of conflicts was also a function of time. As a session neared its close, the groups preferred to have all the resources handy and were reluctant to share.

(c) Communication: Oral and written communication were essential components of our D&T units. Golub (1988) suggests that collaborative learning offers opportunities for students to talk and it is during their talk that much of the learning occurs. In our study students who came from a variety of language backgrounds, were free to express themselves in any language that they felt comfortable. Their exchanges lead to sharing of ideas and transferring skills between group members and across groups as well. In general students were articulate during formal presentations of the stories, character sketches, design of puppet and while presenting their evaluations. Table 2 presents a character sketch, a drawing and a completed puppet of an all-girls' group in the Marathi medium cluster.

We observed that in the English medium cluster, while English was used for formal presentation, a colloquial form of Hindi (official language of India) was used for informal talk. The urban Marathi medium students spoke Marathi and Hindi but wrote and presented in Marathi while in the rural Marathi cluster, Marathi was used almost exclusively for writing, presenting and talking, with a few words in Hindi and almost negligible English. Group members, especially those who dominated the groups, used a lot of commands. Boys tended to use swear words and slang while addressing each other. These were not necessarily aggressive speech patterns. Table 3 gives some examples of differences in communications in the same-sex and mixed-sex groups within the urban English medium cluster.

Context plays an important part in characterising the kinds of talk in formal and informal communication. Students engaged in dialogues, and gave explanations for their designs on different occasions. Hausmann et al. (2004) classified such communications as other-directed explaining, co-construction and self-directed explaining. We observed that students tried to explain their ideas to other members of the group for clarification of their own thoughts or for getting opinions (consensus) on their ideas. For example the following conversation took place in an all-boys' group in the Urban Marathi medium setting during the making of paper cut outs for their puppets.

B1: Hey see, if it's this big, is it okay? (while drawing on paper a circle for the head of the puppet)
B2: How long is it?

Table 2 An example of a character sketch, a drawing and a completed puppet of an all-girls' group from rural Marathi cluster

Character's name is Pratab. He looks good. His hair is black and kempt. He wears half sleeved shirt and a white *dhoti* (wrap around). He is a farmer and he works on fields. The color of his shirt is green. He eats *chapatti* (kind of bread) and *chutney* (sauce). He works hard on the fields. He uses leather *chappals* (footwear). He uses a sickle to cut rice. He is good natured. He speaks Marathi. (translated)	 Drawing	 Completed puppet

Table 3 Examples of communication in different groups within the urban English medium cluster

All-girls group	Mixed-sex group	All-boys group
Tell me one thing, do we insert the hands first?	*What do you think, he is—a basket ball player?*	*Hey *@#**! Let me cut!*
(Use of an inclusive 'we')	(a boy joking about the length of the sleeves of the paper cut-out made by his group)	(use of swear word and demanding- Translated to English)

B1: 12 centimetres.
B2: It's fine.
B1: See, this is how it will look (after completing the circle)

Communication frequently involves more than a verbal message, and expression of emotions and attitudes is more non-verbal than verbal. Effective communication requires that we understand the role of non-verbal behaviour—anything other than utterances—as a dimension of communicative competence (Gunawan 2001). Non-verbal communication can be a part of verbal exchanges when some ideas or skills are being communicated, or they may be independent of verbal components. We saw the former in acts of explaining and gestures for communicating ideas and emotions, such as showing a 'V', indicating victory (successful completion of the task). Students also communicated without words, by grabbing, trying to gain control over limited resources, ignoring, maintaining eye contact or pushing and shoving.

There were 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). Non-verbal communication, such as, ignoring or refusing to look at or listen to

another member also showed gendering, with girls in mixed-sex groups often finding it difficult to be heard.

(d) Peer review: Peer review is an important part of the D&T education as it helps students make value judgments about the worth and quality of their own and other people's products (Ritchie 2001). In D&T, it is essential for students to evaluate the processes as well as their outcomes. Opportunities for evaluation and feedback were built into the unit in the stages of designing and making. Each group presented details of their technical drawing, character sketch and completed puppet to the cluster. Students gave and received feedback to these presentations in a healthy and constructive manner. The feedback helped to bring about changes in the story, character and design of the puppet.

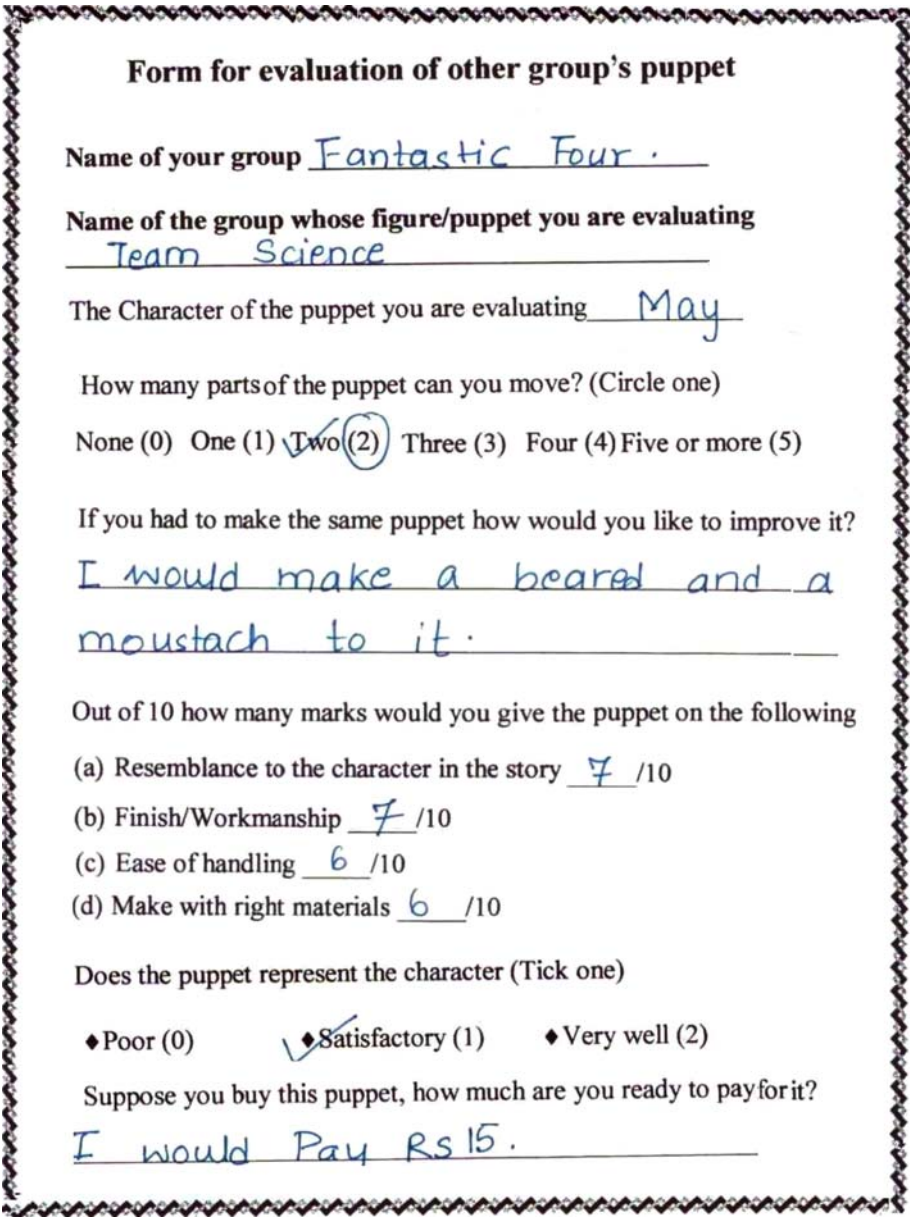
Students evaluated their own finished puppet as well as those made by other groups after staging the puppet show. Criteria used for evaluating the puppets included: ease of handling the puppet, ease of its movements, resemblance to the character in the story, appropriateness of materials used and the economics involved. Semi-structured evaluation sheets based on the criteria of *functions*, *aesthetics, materials, economics* and *design* were provided to the students. Plate 2 depicts the evaluation done by a mixed-sex group from the urban English medium cluster of another group from the same cluster.

While evaluating the puppets of others, students made a point of appreciating some aspects and presented criticisms diplomatically. In return, groups presented their rebuttal to the criticisms and justified their positions. While evaluating their own puppets, all groups reported that their puppets were easy to handle. Most (10 out of 18 groups) groups rated themselves better than other groups. The groups that evaluated themselves lower than others were also evaluated low by other groups. In each of the three clusters, no single puppet was unanimously chosen as the best or the worst. Regarding economics, students from all three clusters had a limited idea about costing of a commodity. They merely knew the terms 'profit' and 'loss' (taught at school) and somehow contrived to show a profit on the costing of their puppet.

Conclusions

The paper addresses the nature of collaborations among students participating in a D&T unit. It indicates the potential of a D&T unit to provide collaborative learning situations in the multicultural contexts of Indian classrooms. As collaboration is not a regular practice in the Indian classrooms, we initially found it difficult in the trials to get students to work in groups to achieve a common goal. The D&T unit on puppetry was so designed as to encourage students to investigate, analyze, synthesize, and evaluate ideas in groups.

The observations of trials conducted in multi-cultural settings indicate that D&T education can encourage collaborations among students and can also be benefited by collaborations. The researchers provided an environment that was informal and encouraged active exploratory learning among students. Working in groups helped students to share their material and non-material resources such as their skills and knowledge. The sharing and the verbal/non-verbal exchanges delineated the processes involved in reaching the goal and provided a perspective on others' views. The unit created opportunities for increased communication and feedback. Students formally presented their ideas to the cluster, verbally and through drawings. All group members could ask questions about the presentations and seek clarifications. The feedback received by the presenting groups led them to defend the group's design or to change it and the constructive criticisms helped the groups to focus their efforts on solutions.



Form for evaluation of other group's puppet

Name of your group Fantastic Four.

Name of the group whose figure/puppet you are evaluating
Team Science

The Character of the puppet you are evaluating May

How many parts of the puppet can you move? (Circle one)

None (0) One (1) Two (2) Three (3) Four (4) Five or more (5)

If you had to make the same puppet how would you like to improve it?

I would make a beared and a moustach to it.

Out of 10 how many marks would you give the puppet on the following

(a) Resemblance to the character in the story 7 /10

(b) Finish/Workmanship 7 /10

(c) Ease of handling 6 /10

(d) Make with right materials 6 /10

Does the puppet represent the character (Tick one)

♦ Poor (0) ♦ Satisfactory (1) ♦ Very well (2)

Suppose you buy this puppet, how much are you ready to pay for it?

I would Pay Rs 15.

Plate 2 Evaluation by a mixed-sex group from the urban English medium cluster

Collaboration is a social process and in order to study aspects of it, we observed processes such as communication, roles played and relations developed between members within and across groups. The occurrence of conflicts among students during the processes involved in the unit, in contrast to instances of spontaneous sharing and peer approval, has a bearing on successful teamwork as well as on the completion of a task. On a positive note, every cluster put up a very entertaining show. This study is a beginning in the

planning, trial and analysis of a D&T unit to be conducted as a form of collaborative learning experience in multi-cultural contexts in India. The unit on puppetry was a D&T unit planned not only to appeal to Grade 6 students of different regions and girls as well as boys, but also to engage them in collaborative learning. The inclusive and collaborative nature of the unit is appropriate for the multicultural Indian context.

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Author Biographies

Swati Mehrotra is a research scholar pursuing her Ph. D. at the Homi Bhabha Centre for Science Education, Tata institute of Fundamental Research, Mumbai. She has done her Masters in Nutrition from the M.S. University at Baroda, India. Her research interests include understanding Indian middle school students' conceptions about technology. She focuses on gender issues and group dynamics, particularly involving communication and collaboration, in the context of Indian middle school students from different socio-cultural settings engaging in design and technology units in classrooms.

Ritesh P. Khunyakari is a research scholar at the Homi Bhabha Centre for Science Education, Tata Institute of Fundamental Research, Mumbai. He has a Masters in Botany with a specialization in Plant Biotechnology. He is pursuing a Ph. D. in the area of design and technology education. His research interests include Indian middle school students' ideas about technology, and the development of prototype design and technology units for Indian classrooms in urban and rural settings, with particular reference to studying issues that relate to drawings, design and cognition in collaborative design and technology classroom engagements.

Chitra Natarajan is Associate Professor at the Homi Bhabha Centre for Science Education (HBCSE), Tata Institute of Fundamental Research. Mumbai, India. She has a Masters in Physics from the Indian Institute of Technology (Mumbai), a Ph. D. from CWRU, USA, and a Postgraduate diploma in Environment and Ecology. For over 15 years she was engaged in R&D on the science of surfaces. More recently she has been involved in science popularisation, talent nurture and teacher orientation programs and R&D in science and technology education at the HBCSE. She is the series editor of eight books on science, technology and

society as part of an activity-based curriculum for post-school students. She has over 30 publications including those in journals and books and covering physics, developmental issues and science education. She is a member of the ''multilingualism network'' that engages with issues of sustaining multiple modes of expression. She is currently involved in R&D of design and technology curricula for school education.

Sugra Chunawala is a Reader at the Homi Bhabha Centre for Science Education, (HBCSE), Tata Institute of Fundamental Research, Mumbai, India. She is a Bachelor in Psychology (University of Bombay), and has a Masters in Social Work, (Tata Institute of Social Sciences), Mumbai, and a Ph. D, in Science Education (University of Poona). Her research interests include attitudinal studies of students and teachers: their perceptions of science, school, scientists and technology. She has published research papers and technical reports on students' alternative conceptions of science topics, in the areas of health, living and non-living, ideas about forests and experiments. Her interest in gender and science has led to the development of an exhibition and a booklet on ''Gender and Science''.