Designing for Children

- With focus on ‘Play + Learn’

Implementing D&T Education in Indian Middle Schools

Lessons from Trials.

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Abstract: The words design and technology (D&T) denote ideas and objects as well as processes and activities, thus integrating knowledge and action. Two factors contribute to the exclusion of hands-on activities like D&T from classrooms: the existing episteme-techne divide and lack of schemes for integrating activities in Indian schools.

These aspects were addressed in a research initiative at HBCSE that developed D&T units through classroom trials among urban and rural middle school students, who collaboratively engaged in making a bag, a windmill model and making puppets and staging a show. Analysis of the trials had two distinct strands. In one, socio-cultural aspects of communication and collaboration among students were analysed. In another, students' design explorations and representational strategies were studied for evidences of their progression in design thinking within and across the D&T units. The study highlights the significant role of D&T education model in promoting collaborative learning in Indian classrooms.

Key words: *design, D&T education, design productions, collaboration, communication, technology.*

1. Introduction

The distinct human capability of designing, crucial to both cultural development of civilizations and cognitive development of individuals, receives scant attention in school learning. The existing school system lacks an environment that can

nurture habits of creative imagination or visualization of solutions to real world problems.

This paper argues for the need to include an education in design and making at school level by sharing experiences from development and trials of design and technology (D&T) units for urban and rural schools in India and presents some of the key findings from classroom research. It is proposed that an exposure to designing and making will equip students to demand for and live in a better designed world.

1.1. Rationale for introducing design and technology in schools

The research reported in this paper is grounded in philosophical considerations of technology and education, socio-cultural aspects and empirical studies on perceptions of technology among students and teachers. From a philosophical viewpoint, technology is a complex construct coloured by contexts of specific use (Pacey, 1983). Technologies and their use have been shaped by socio-cultural influences which in turn have contributed to the evolution of technologies (Basalla, 1988). Such influence manifest in the range of artefacts, in several communities of practice, and the very evolution of technologies.

The terms design and technology are used as 'noun' (objects and ideas), and as 'verb' (processes and activities). Empirical studies show that students have a narrow view of technology - predominantly as electronic objects ((de Vries, 2005), (Khunyakari et al, 2008), (Mehrotra et al, 2008)), which need to be challenged by providing contexts and learning experiences. Design, which lies at the core of any technological endeavour, involves visual thinking, constructive use of mental imagery and purposeful manipulation of available materials and resources in problem solving. Co-ordination of the mental (head) and the manual (hand) towards generating a desired outcome (heart), and integration of knowledge, skills and values in authentic design problem solving situations are two of the most compelling implications of integrating D&T in school curricula.

Two factors have contributed to the exclusion of hands-on activities from classrooms. First, the theory-practice divide and episteme-techne hierarchy prevalent in all societies since Aristotle, and a lack of understanding among educators on the philosophy of integrating D&T in education. Second, there is

lack of a satisfactory scheme for conducting, analyzing and assessing activities in the geographically, socio-culturally and economically diverse Indian school settings. This includes among other things facilitation of equitable locally appropriate and globally valid activities, and development of assessment rubrics for equitable comparisons. This study addresses these two concerns.

2. Methodology

A research initiative at the Homi Bhabha Centre for Science Education (HBCSE) engaged students from urban and rural schools in 3 D&T units. These were: designing and making a bag to carry a set of books to a friends place, designing and making a windmill model to lift given weights, and designing and making puppets and collaboratively staging a puppet show. Each unit included activities based on pre-requisites of knowledge, procedures and skills among students and had to appeal to rural and urban girls and boys. The sequence of activities within each unit was tailored to use students' prior understanding in new learning engagements.

2.1. Sample

The sample consisted of 20 to 25 middle school students in Class 6 (age range 11 to 14 years) from each of three settings: an urban Marathi medium (official language of Maharashtra State) school, an urban English medium school and a rural (tribal) Marathi medium school. The last was a government-run residential school (*Ashramshaala*) for tribal children. Middle school students were chosen to take advantage of their developing ideas and abilities: to engage in formal reasoning, to make ideas explicit and to generate productions that reflect real world objects. The sample selection was guided by three broad concerns: (a) inclusion of urban and rural settings; (b) local language (Marathi) and English; and (c) inclusion of boys and girls.

After obtaining necessary permissions, the field trials were conducted between August 2003 and September 2004 with urban students at HBCSE and with rural students in their classrooms. Each D&T unit was carried out in every setting over 15 hours spread across 5 days. The language for researchers' instructions was the same as the medium of instruction in each of the schools. Students had to voluntarily organize themselves into 2 groups of girls, 2 groups of boys and 2 mixed-sex groups. Each group had 3-4 individuals.

2.2. Data

The data collected from the unit trials were in the form of audio and video records of student interactions, their paper-pencil productions which included activity and evaluation sheets, students' drawings and write-ups. Researchers' field notes supplemented the data.

3. Insights from developing D&T units

Insights on developing and implementing D&T units in classrooms were gained from conceptualizing activities within each unit and their development through classroom trials. These are discussed in the following section, while students' productions are discussed later.

3.1 Developing units through classroom trials

The development and trials of the units paralleled design. Goals evolved during the development, constraints of the units emerged, and the trials provided the feedback to refine the units. Figure 1 encapsulates the process of development through classroom trials. The units were tried in one setting and insights so gained led to modifications before subsequent trials: a continuous process of feedback and modifications.

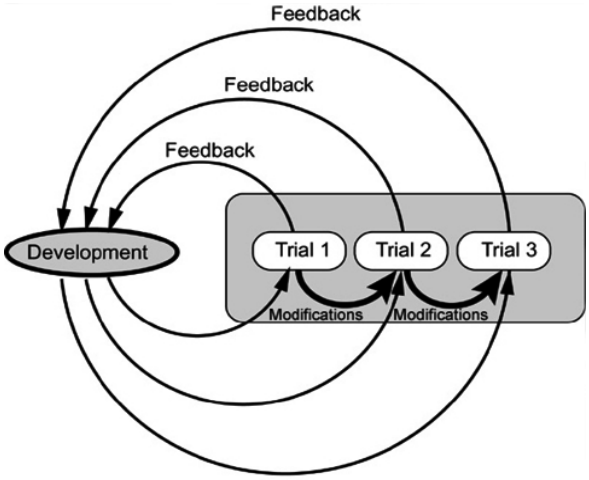


Figure.1 The process of development through trials

3.2. Structure of a D&T unit

The transaction of each unit in classroom was guided by a pedagogical model developed by us (Choksi et al, 2006): *Collaboration and communication centred D&T education model for the Indian context* (see Figure 2). Its structure was

inspired by the Assessment of Performance Unit (APU) that proposed a Design-Make-Appraise approach to teaching technology from the primary through secondary levels in the UK (Kimbell et al, 1996). Our model emphasizes collaboration and contextualized design problem solving while integrating social issues in decision-making, and knowledge and skills across school subjects. Each D&T unit consisted of a sequence of about 8 activities briefly described below in terms of resource inputs provided by researchers and insights gained from the outcomes.

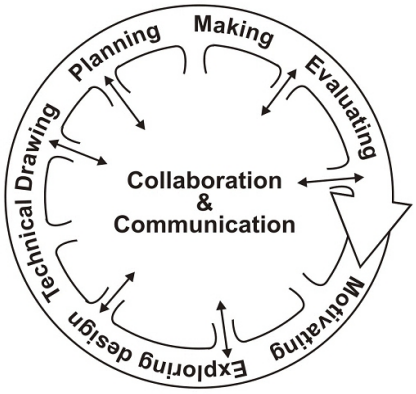


Figure.2 Collaboration and Communication centred D&T education

(a) Motivation and investigation: Researchers used several strategies for involving students in class discussions: presentation of anecdotes or story, discussions of students' experiences of visits to locales, or favoured leisure activities. These served as contexts for negotiating problem situations (design brief) and introducing the artefact as a solution.

Students were then exposed to a variety of artefacts and knowledge related to the solution through different modes: print and other media, models, worksheets, etc. They were encouraged to explore structure-function relations, material properties and other design aspects. Their attention was drawn to facts (school subjects, body proportions), social aspects (stereotypes, modes of expression e.g. languages, *mudras* and movements), historical (bags, windmills in different countries and purposes) and cultural aspects (aesthetic, dress-codes, dialects and behaviours of puppets). Students shared their ideas and experiences.

Figure.3 Motivation activity, example of visuals and poem by a girl on windmill

(b) Design exploration: Interactive discussions in the first activity provided ideas for solving the stated problem. Students worked within groups to generate a design for the artefact through collective explorations of their individual design ideas. They talked and gestured, used graphical modes like sketching and modified each other's drawings. All material productions of each group was preserved in a group portfolio.

Each group made drawings of their conceptualized artefact. The explorations and interactions not only revealed students' ability to conceptualise a design in shared mental spaces, but also provided insights on the aspects they considered while doing so – size, shape, materials, assembly, mechanisms, etc.

Figure.4 Design exploration, collaborative designing, and its result

(c) Technical drawing: The group had to produce a drawing showing details of size with their dimensions and units, relative locations of components and overall size of artefact. The activity engaged students in estimation of measurements and proportions, and depiction skills. Students had to list the materials required, their quantities and estimated cost. Resources listed were provided for making.

Students had problems representing their visualized 3-D design ideas on 2-D paper. During trials it was realised that teaching perspective drawing was less

useful than exposing students to conventions in technical drawings: e.g. notations for depicting object dimensions using arrows. Evidences that students internalise such skills taught in authentic contexts came from their use in all their subsequent paper pencil productions.

* Encourage using conventions – leaders, arrows & end lines

* Encourage estimations of materials, quantities & costs

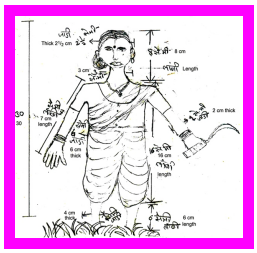
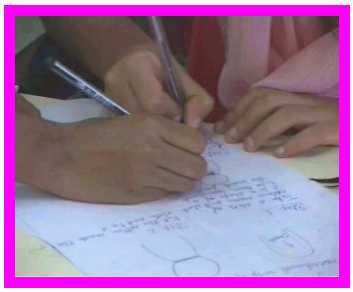


Figure.5 Technical drawing, group discussion, a puppet character in rural setting

(d) Plan for making: The actual making of the artefact had to be visualised as a step-by-step plan for making - *procedural map.* It includes the visual mode of drawing accompanied with a written description of the process. Design productions are mental efforts that save physical effort while making and optimize use of resources (Mitcham, 1994). Procedural maps were introduced through familiar contexts of making tea or a pinwheel. Students identified and allocated tasks among group members ensuring collaborative effort.

* Visualize steps in making before actual making

* Distribute work



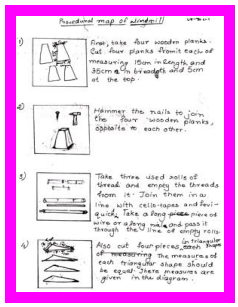


Figure.6 Procedural maps, simultaneous work, procedural map of a windmill model

(e) Communication of design and plan: Each group had to make a formal presentation to the Class. Besides honing students' public speaking skills, this enabled an open review of design ideas by peers, encouraged constructive suggestions, questions and doubts. Groups changed their design with useful suggestions. In all settings, through the three units, students evolved in content and structure of their communication and gained confidence. Group members took turns to make explicit the evolution of their ideas, factors that affected their design, details of their design including technical drawings, list of materials, anticipated process of making and work distribution among members.

* Presentation of design details in class

* Skills of reviewing & constructive feedback

Figure.7 Design communication, group presentation, and response to questions

(f) Making: Implementing plans through actions: Students were provided with the requested list of material resources. Making involved transformation of available material resources into desired artefacts guided by design and anticipated plan for action. Additional tools and materials were made accessible to all groups as students collaboratively engaged in realizing their design ideas. Students were free to refer to their group portfolio and modify designs if needed. The context of making provided the ambiance for students' active engagement and dynamic interactions with materials, tools and other resources under supervised guidance, countering and resolving problems.

* Use of appropriate tools, materials & resources

* Guidance in proper & safe use of artefacts

Figure.8 Making, manipulating materials and tools

(g) Planning and implementing the system: Systems involve two levels of planning and design: to make the components of system, and then their assembly. The third unit on puppetry was a technological system. After making the puppets, groups dissolved and students voluntarily re-organised to form new teams for scripting dialogues, composing music, making props, stage-setting and stage performance (puppet handling, dialogue delivery, etc.).

* Discuss tasks

* Make required preparations

Figure.9 Designing a system, collaborating in puppet show

(h) Evaluation and reflection: Groups evaluated their own and others' products using a semi-structured format given by researchers. This encouraged students to reflect on their designing and making activity and organise their reflections. Groups could additionally devise their own criteria for assessing their products. Both qualitative and quantitative evaluations were encouraged. Groups then shared their reflections through a formal presentation, discussing the merits and demerits of design alternatives used to address the same problem.

Figure.10 Evaluation, product communication

4. Insights from students' engagements and productions

Analysis of students' engagements were in terms of: (a) Collaboration and communication among students as they engaged in activities, and (b) aspects of design and cognition as revealed through students' productions.

4.1. Collaboration and communication

Aspects of collaboration within and among group members were observed with respect to the roles played by the members, conflicts and their resolution, sharing of resources, communication, peer review among the students, realization of common goals and diffusion of learning through techniques, tools and facts. The patterns of student behaviour and their comments during interactions suggest that they dynamically adopted different roles as leader, worker, communicator, critic, artist or mediator within and across groups. Instances of disagreements over work distribution, control of limited resources such as needles, scissors and beads for decoration were evident. Often conflicts occurred during the closure of sessions when groups preferred to have all resources handy and were reluctant to share. Yet they shared and worked towards a collective goal and 'diffusion of learning' through observation and helping was noticed in all setting. Roth (1996) has described diffusion as adopting of resources and practices as more and more members engage in a

new practice. The practice then gets integrated in the community and thus transforms the community itself.

During the activities, students communicated formally with other groups, and informal communication occurred within and across groups as illustrated in Figure 3, where a black dot represents a student. Peer review and feedback was built into the units. Students spontaneously developed criteria to be critical in their evaluation of their own as well as other group's products. Students showed competence in appreciating the appealing aspects of other group's products while diplomatically questioning the economics, worth of a material and quality of other group's products. The quality of presentation also improved considerably through the three units.

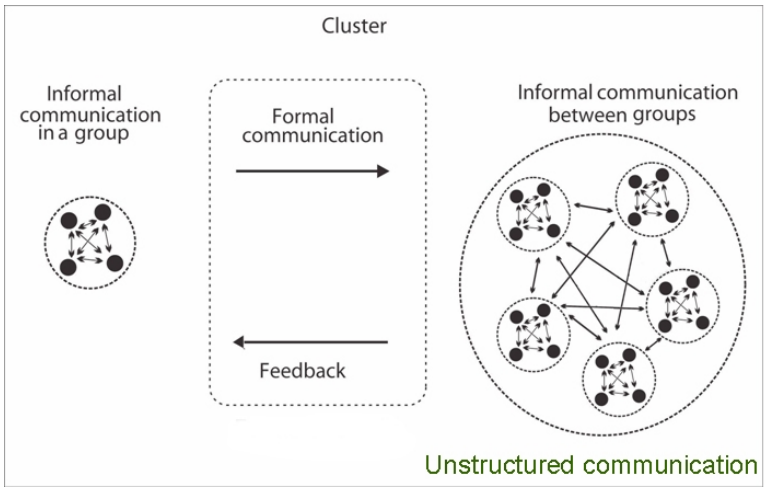


Figure.11 Formal and Informal communication in D&T education units

4.2. Cognitive aspects in design productions

Students' exploration using sketches, technical drawings and procedural map are collectively referred to as their design productions. Figure 4 is an example of productions of a mixed sex group. These were analyzed for various aspects: how a D&T unit influenced students' productions, representational strategies used, visuo-spatial thinking, knowledge and skills in depictions, writing and organisation, students' progression in design within and across the units and socio-cultural features.

Students' prior perceptions of materials and their properties as well as their concerns about environment, costing and social stereotypes, shaped their design ideas. The level of complexity and familiarity of the product designed was related to the extent of design explorations, which were more for a complex design like

windmill model than for puppet or bag. Students used a range of representational strategies to reveal part details: different or mixed perspectives, X-ray drawings (seeing through opaque objects), selective abstraction for focussing on part. They spontaneously created and used graphical symbols, icons and analogies, estimated length and quantities, visualized joints, complex assemblies and reinforcements.

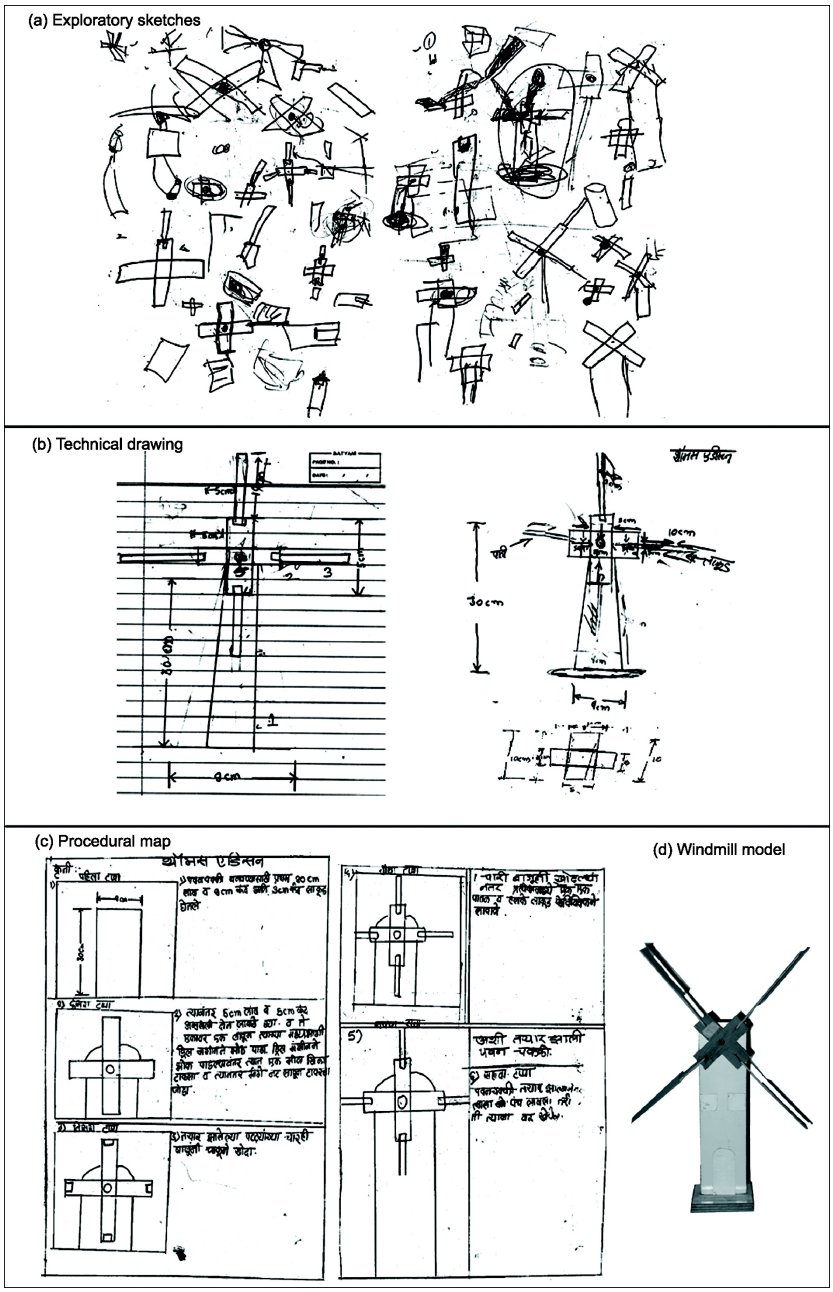


Figure.12 Design productions of windmill model by a group

In general, groups improved their procedural maps across the 3 units: presentation of content, connectedness of the visualized steps of making an artefact, and matching textual description with drawings. Choice of materials and tools, the nature of exploratory sketches, variety in design and attention to

issues of stability were some areas that showed evidences of the differences between the urban and rural groups. In their working, groups did not refer to their productions and yet knew how to proceed ahead to arrive at their expected outcome indicating shared cognition among members of a group.

5. Conclusions

Three D&T units were developed iteratively through classroom trials among students from three school settings. The analysis of the development and trials provided valuable insights on the role and influence of the sequence of activities on students' design learning. It revealed interesting aspects of the dynamics of student interactions in design engagement, benefits and limitations of students' collaborative practices, role of communication in design and aspects of cognition in design activity.

Motivation, design exploration and planning of making were opportunities for both discovering students' knowledge and skills as well as authentic contexts for providing them with inputs across school subjects. Besides, activities from design explorations to making engaged students in imagination, visualisation, representation and manipulation – crucial elements for innovative thinking and action.

Students' verbal and non-verbal productions during their engagements gave evidences for several design related aspects: (i) design thinking occurs from exploration through making to evaluation; (ii) once conceptualised by a group, the design is internalised by all members; (iii) there is progression of knowledge and skills through each D&T unit and across the three units. These units provided unique opportunities for reflective thinking, which they used to hone their skills of design expression in socially suitable ways.

The empirical study highlights the significance of integrating D&T education units in classroom practice and its positive role in promoting equitable learning in Indian classrooms.

Acknowledgement

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