DESIGN AND TECHNOLOGY EDUCATION'S POTENTIAL TO ADDRESS DIVERSITY

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India harbors diverse socio-economic, regional, political, religious, linguistic, ethnic, caste and gender differences. Catering to this kind of diversity in Indian classrooms can pose a challenge to teachers, particularly when there are added dimensions of diverse learning styles, skill sets, self expression, subject interests and abilities. This paper reports observations from a two day Design and Technology (D&T) workshop with eight student participants, who were presented with a design challenge, set in real-world context. Students worked in two single sex groups, and engaged in exploring, drawing, planning and making of the product (solution) collaboratively. Further, through discussions, students evolved their own criteria to evaluate the product. The insights gained through these observations, though preliminary, shed some light on how D&T units can provide possibilities of inclusion in a diverse Indian classroom.

Introduction

India is synonymous with diversity, such is the variety of cultures that prevail here. With a population of over 120 crores, India is home to a myriad of religions, ethnicities, castes and languages, often leading to several sections of societies facing discrimination and marginalization. The plethora of diversities is reflected in Indian classrooms, and can be a challenge to teachers as students differ not only in their home contexts, but also in their learning styles, skill sets, self expression, subject interests and abilities. India's national educational policies and curriculum frameworks have acknowledged student diversity and call for providing an inclusive environment for all, thus attempting to address the variations in children's backgrounds, needs and interests. Despite initiatives at the policy level, there is a need for sustained efforts to address diversity at the classroom level as well. It is in this context that we explore the possibility of Design and Technology (D&T) education as an inclusive approach to teaching and learning.

Addressing diversity in classroom

Over the last few decades, addressing diversity has emerged as an important discourse in educational literature. Enslin & Hedge (2010) say, "*If diversity is 'the great issue of our time' inclusion is commonly regarded in public discourse and policy as a key solution to the injustices suffered by groups excluded from the mainstream of society"* (p. 385). Literature on addressing diversity in classrooms has spanned several areas. For one, it is now acknowledged that diverse students bring to school

different learning strategies, languages and ways of knowing (Heath & Mangiola, 1991; Cleary & Peacock, 1998). Studies also deliberate about the crucial role of a teacher in identifying diversities and developing strategies that may effectively address these (Rahman et al., 2010; Wiseman, Cooner & Knight, 1999). In the Indian context, there are several recent studies; on how science, science education and diversity are inter-linked; aiming to understand how national policies are aligned with inclusion and diversity; emphasizing perspectives and practices around inclusive education (Kumar at al., 2010; Kumar 2014; Chunawala & Natarajan, 2012; See Science Education for Diversity Project, 2010-13).

Several advocates of culturally responsive teaching (Ladson-Billings, 1992) also suggest that a teacher can address the interests of their diverse students and help in skill building if they are aware of their students' backgrounds, their values, languages and literary practices (Abt-Perkins & Rosen, 2000). Dias (2004) in a comprehensive review of literature in the realm of addressing diversity and communication, discusses some strategies such as: *use of narrations or stories, introducing multiple expression modes, group work, participatory and active learning by removing the boundaries between life and educational processes, having a goal oriented activity, design and production of technical devices, linking formal and non-formal activities to bridge gaps between everyday personal life and the world of structures and institutions* (p. 129). In the current study, an attempt was made to map the features of the D&T unit used in the workshop, to Dias's recommendations of fostering an inclusive environment that values diversity of modes of expression and communication.

D&T education

D&T education is an interdisciplinary subject that involves planning, exploring, imagining, drawing and making, though not limited to this. It helps to hone quantitative reasoning, manual and procedural skills and technological knowledge. D&T also provides opportunities for one to make aesthetic, social and value judgments as well as evaluations. D&T does not have a marked place in the current Indian education curriculum albeit its 'integrated' nature (Buchanan, 1992), unlike countries like Australia, England and New Zealand. However, in the Indian context, one can see sporadic elements of D&T in subjects like art, craft, and Socially Useful Productive Work (SUPW), but this has largely been desultory in nature (Mehrotra, 2008). Even technology education, colloquially referred to as engineering discipline in India, is a stream that is offered after Grade 12. Several educationists advocate D&T education in school curriculum (Baynes, 2008; Owen-Jackson, 2002) to groom citizens to develop their knowledge, technical and interpersonal skills which are required to sustain in today's society.

In the area of D&T education, some literature has emphasized how D&T and inclusion go hand in hand. D&T can offer opportunities for developing students' cultural awareness and understanding of their place in the world (Howe et al., 2001). D&T tasks have often '*reflected the culture of the technological world the students and teachers inhabited'* and given scope to make explicit linkages across science, technology and society (Natarajan, 2007, p. 166). The 'language' of D&T encompasses a wide range of verbal (speaking, arguing, discussion, presentations) and non-verbal communication modes (gesturing, drawing, using symbols, making models), thus providing an inclusive space to support a variety of learning and expression (Natarajan, 2004). Thus the guiding question for the current study was to explore what kind of inclusive dimensions can a D&T unit provide in an Indian context? The objective of this exploratory study was to gather instances of “inclusive practices” during

the implementation of the D&T unit.

Methodology

A two day D&T workshop was organized with eight students (4 males, 4 females) from Mumbai, in November 2015. A diverse sample was selected through convenience sampling. All students were between 11-13 years, and hence parental consent was sought before the workshop.

Students' profile: There were a total of 8 students, all from grade 9 except one. There were 4 females (PS, RS, PT, SM) and 4 males (SM, MD, AD, FA). The students were linguistically diverse (spoke Hindi, Marathi, English, Tamil), regionally diverse (families were from North India, Maharashtra, Tamil Nadu), came from different religious backgrounds (Hindu and Muslim), had differing likes and dislikes. Three students reported that they liked science, 1 disliked science, 2 disliked mathematics. All students had somewhat similar socio-economic backgrounds. All except FA studied in the same school run by a private trust that followed Maharashtra State Board syllabus. Both schools were English medium, and were located in suburban areas of Mumbai. PS did not attend day 2.

Relevant sessions of the workshop were video and audio recorded. Two non-participatory observers individually maintained notes. Audio clips were transcribed and videos were scanned for evidences of inclusive spaces and practices. For example, instances where; students brought in their own perspectives and experiences, students' participation during group work, students' participation in different tasks and their methods of individual and collective expression etc. The observations of the workshop are described and categorized using a collaboration and communication centred D&T education model (Choksi et al, 2006; Khunyakari, 2015), which has six components, namely, Motivation, Exploring design, Technical drawings, Planning, Making and Evaluating.

Observations from the workshop

Revisiting science topics

Initially, concepts of hot and cold objects, temperature, units of measurement, conversion between degree Celsius and degree Fahrenheit, good and bad conductors of heat were revised with students. These topics were related to the problem task, hence a quick recap of these science topics was carried out. Students were asked to think of examples from their every day life about hot and cold things. According to students, cold things included, ice-cream, ice, *falooda* (iced-drink), *zameen* (floor), cold drink, water, *tulsi* (plant), *centre fresh* (chewing gum), mint, air-conditioner, while examples of hot things, included fire, sun, beverages, water, cooking vessels, iron, desert region, volcano.

Motivation and investigation

Students were provided a context in the form of a story, for developing a product (solution) for a real-world problem: *Suppose you are going to your friend's house which is an hour away. It's a hot day and you have a bottle of chilled cold drink with you, which you have to keep chilled during the course of your journey. Design and make something that can keep a bottle of water cold for the longest possible time*. Most students said they had encountered similar situations in life. The science textbooks of

Maharashtra State Board has chapters on 'Transmission of heat' and 'Effects of heat (class 7)'; 'Reflection of light' and 'Metals and non-metals' (Class 8); 'Heat' (Class 9). Thus the problem presented to students was related to their school curriculum yet was something they had all encountered in their everyday lives.

Exploration of design

Students were asked to make groups. Of their own accord, they split to form two single sex groups. Each group was asked to collaboratively arrive at a sketch of the product that would 'solve' the problem effectively. The goal was clearly defined, as mentioned in the design brief story. Team A (girls) used a consensual approach to negotiate a solution and started to design their product, while team B (boys) initially did not work collaboratively, had some differences of opinion, but over time, negotiated into producing a single design for their product.

Technical drawings

Students had to put down their ideas on paper. Figure 1 presents the technical drawings of the groups. At the end of day 1, both groups were expected to produce their technical drawings, a list of materials they would need to make the product, and also indicate the quantity of material required for each part of the envisaged product they were going to make.

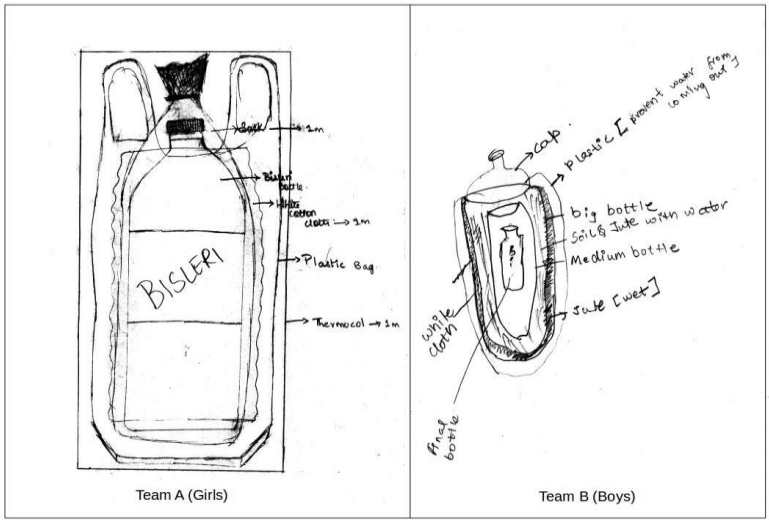

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Figure 1: Technical drawings of Team A-Girls (left) and Team B-Boys (right)

Planning

Planning involved the teams listing materials and tools required for making the product. Team A requested 12 items, which included jute, white cloth and thermocol. Their justifications for the choices were based on their past knowledge. For example, one girl (PR) mentioned that she had seen her grandmother wrapping cold water in a jute bag to keep it cold. Similarly, they recollected that they have seen ice-cream/cubes being stored in thermocol boxes. As for the white-cotton cloth, they said that in school science they have learnt that light-coloured surfaces reflect heat. Members of Team A used their earlier experiences from life and school to tackle the task. Initially, students asked for just enough material as per the dimensions of their design and did not account for buffer material required for sewing. On being questioned they realized that they have under-accounted the materials and needed to revise their dimensions. Team B also listed 12 items, however they did not explicitly state why they

wanted the chosen materials, though they did specify decoration when asked about the colours and paints. Leaders implicitly emerged in both teams. In team B, the leader had a dominating character (SM) while in team A, the leader (RS) was more of a facilitator.

Making

On day 2, Team A divided the work amongst themselves systematically and used each person's strength to allot tasks. For example, one girl (PT) who was shy and often did not answer questions, took up tasks that involved cutting and stitching. The others (RS, PR; PS on day 1) were good at drawing and writing and hence they did the writing, tabulating and making of technical drawings etc. One of the girls (RS) emerged as the team leader, and took the initiative for the measurements and was more confident in answering questions. She also was not hesitant to guide her team mates when they had contradicting views. Team B worked more collaboratively on the second day as the 'product making' was time bound. It is also possible that they were inspired or challenged by their peers who were already ahead in terms of making their product. All members contributed, and involved themselves in different tasks and troubleshooting. The measurement and cutting for the bottle was mainly done by SM and MD while AD involved himself in the measuring, cutting and stitching of the jute bag. FA who was initially shy and did not speak much, took up the initiative of filtering and refining mud with MD.

Both groups were free to modify their original designs. Though the final product broadly conformed to their technical drawings, there were some changes incorporated. For example, team B added an extra material (silver foil) for their product while team A chose not to use a material (plastic cover) that they had originally asked for. Both teams sprinkled chilled water on their jute and cotton cloth layer. The girls (team A) did not spend much time in making their product attractive. On the contrary, the boys (team B) emphasized the product aesthetics. For example, they requested silver foil to make their product “attractive and shiny” (AD). When team B members (MD and AD) did the sewing for their 'cloth bag', they opted for coloured threads to make the product look more beautiful.

Evaluation

Once products were made, they were tested for their effectiveness. The results were tabulated and graphical representations were made to show temperature readings at 0 minutes and after 90 minutes, for each of the bottles. Teams had to 'test' their products against 5 bottles provided by us. Bottle 1 had no cover (control), bottle 2 had a woolen sock cover, bottle 3 and 4 were wrapped with bubble wrap and foam sheet respectively, and bottle 5 was a thermos flask. Bottle 6 was the team's 'test' bottle. In order to provide a non-competitive environment, teams were asked to test their product against bottles 1-5 and not against the other team's product. In general, it was observed that students had difficulty in understanding how to design and conduct an experiment to assess effectiveness of a product.

Despite care in conducting the measurements, errors crept in at various stages and there were problems in making graphs. The facilitators helped students with correcting their calculations and graphs. Evaluating the product required students to draw on their quantitative and graphicacy skills. The latter part of the evaluation required students to make judgments about their design as well as their peer's design, and reflect on the strengths and weaknesses of it. Students through discussions evolved criteria to assess and evaluate the products. These were: 1) usefulness (effectiveness of the product); 2)

appearance (product should be attractive); 3) quantity of materials used (less materials, simpler, therefore better); 4) economic value (product should be low costing); 5) environment friendly (eco-friendly materials used); 6) replicability (potential for mass manufacture); and 7) compactness/portability (should fit in a bag, can be used while traveling).

Poor performance in any of the 7 categories was assigned 2 out of a possible 5 points, fair performance was assigned 4 points and good performance yielded 5 points. Thus the maximum total possible was 35 points, and minimum was 14 points. Both groups gave a formal presentation communicating the effectiveness of their product, and on the advantages and disadvantages of their design. The products of both teams ranked second in terms of effectiveness, with thermos (bottle 5) being the most effective. Presentations were followed by self and peer evaluation with a rubric that was developed using the above mentioned students' criteria. All the students evaluated their own as well as their peer group's product using the rubric. This exercise encouraged them to reflect upon their own design critically and compare it to the other design on a range of criteria. Interestingly, all members of team A (girls) gave higher points to the product of team B as compared to their own product; and all members of team B (boys) gave higher points to team A's product as compared to team A's points *to their own* product. When asked what they would have changed in their design to improve their product, team B said that they could have used clay from the river bed, it would have maintained the low temperature more. They also mentioned that their product was heavy as compared to the other team. Team A mentioned that they could have used thicker thermocol or outer material as they were concerned that the product might break during the journey, owing to its flimsy nature.

Discussion

This study draws from the Vygotskian theory of learning as a social process (1978). Participants in this workshop came from different cultural backgrounds, had different likes and dislikes, and brought their unique experiences to the task in hand. Despite differences, students were able to work collaboratively and communicate with each other, express their ideas and critique products. The D&T task used a story to contextualize an authentic design problem which was goal oriented (Murphy & Hennessey, 2001). The task called for multiple expression modes (Natarajan, 2004), involved group work (Johnson et al., 1981), and connected school science to everyday life (Aikenhead, 2006). Tasks were alloted by the group members (Dillenbourg et al., 1996) drawing on their individual strengths. At each stage, students were exposed to fresh perspectives emerging from different group members, thus requiring them to come to a consensus on aspects of design and making. Our observations indicate that when this heterogeneous group of students were faced with the design problem which had no single right answer, students sought multiple view points from all group members after which they had to justify the selection of one (of those solutions), and make decisions for which the entire group would collaboratively work on.

Communication was a key element in this activity; students were encouraged to speak in any language they were comfortable in, and they chose to speak in Hindi and English which most of them could understand. Students almost spontaneously discussed how they would tackle the 'cold challenge' posed to them and engaged in different modes of individual and collective expression. The task required students to make written records, that included tabulations, graphs and drawings; use verbal communication modes and gestures to express their ideas to the other group members as reported in earlier studies (Khunyakari, 2008; 2015; Mehrotra, 2008), thus catering to diverse learning styles and

expressions. The products made by students were influenced by their home settings, their school learnings and their prior exposure to science, technology, skills and knowledge relevant to the D&T challenge (Ara, 2013). Further, the activity drew on their cognitive and motor skills. Students participated in a range of tasks like, drawing, making of the product which included stitching, cutting, measuring, sticking, filtering etc. This offered opportunities for students to hone a diverse span of motor skills versus just verbal skills, as in traditional classrooms.

The task also elicited students' own value systems and judgments. Students developed evaluation criteria and while doing so demonstrated their values on issues of economics, environment, sustainability and aesthetics. Evaluation '*allows the pupil to make a judgment or decision about the aspects of design as it develops, or to reflect on the strengths and weaknesses of the design once it has been completed*' (Kimbell et al, 2002, p. 208). The evaluation of self and peer performance is an essential aspect of D&T activities and generates in students an ability to be fair, unbiased, self critical and reflective (BCME, 2008) despite having objective and subjective criteria for evaluation. This aspect emerged when interestingly, all members of team A (girls) gave higher points to the product of team B as compared to their own product. Qualities such as being self-critical, reflective and unbiased are also important when dealing with diversity in the classroom or in the world. Lastly, the D&T task integrated various school subjects like arts, craft, science, mathematics, language and social studies. It is possible that the interdisciplinary nature of the design task engaged the students throughout the activity, despite several of them mentioning their lack of interest in sciences and mathematics, at the beginning of the workshop.

There seems to be a potential in using such D&T activities in Indian classrooms to address diversity as well as concepts from the school curriculum. If D&T modules tap into students' differential abilities, experiences, interests and strengths whilst catering to multiple learning styles, there is potential for such an activity to address diversity even in a seemingly homogeneous classroom. However, there can be logistical and practical barriers to implementing D&T units in Indian classrooms. Although no broad claims can be made based on this study, the observations do provide some insights into this under-researched area of D&T education, particularly in the Indian context. Further work is needed to develop more concrete D&T modules that are inclusive in nature.

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