Moving from Analysing to Designing Artefacts: Studying Middle School Students' Ideas about Design and Designers

Farhat Ara, Sugra Chunawala and Chitra Natarajan

Homi Bhabha Centre for Science Education, TIFR, Mumbai, India

The paper presents an investigation of middle school students' naïve ideas about design and designers and details of the trial of design-related activities aimed at sensitizing students to issues of design. Twenty five students studying in class 7 participated in the study conducted over a period of 5 days. A questionnaire was administered to all students at two occasions, pre and post intervention and a few students (eight) were interviewed in the pre-intervention stage. The activities ranged from analyzing familiar and unfamiliar artefacts to designing artefacts. Preliminary analysis of the survey revealed students' intuitive ideas about design and designer. Most students stated that animals are also designers and referred to nest and home building activities. However, when referring to humans they focused mainly on aesthetic aspects of design. In the designing activity students generated various creative solutions to a given real-life problem. The present study would provide opportunities to develop and try out more and different activities with students and even with teachers.

Introduction

We live in a designed world, being surrounded by infinite and perpetually increasing designed artefacts. Design and Technology (D&T) enables one to make changes in the made world not in an ad hoc manner but in a planned way; conceiving what does not yet exist, managing uncertainty and risks, exploring all possible solutions and evaluating them on the basis of criteria such as economics, politics, aesthetics, ethics, etc. This is nothing but designing.

Emerging technological innovations have exceeded the capability of individuals to understand and manage these innovations. In order to develop the knowledge, understanding, technical and interpersonal skills indispensable for the ever advancing scientific and technological society, D&T education has been introduced in various countries throughout the world (Jarvis & Rennie, 1998). The Standards for Technological Literacy: Content for the Study of Technology by International Technology Education Association (2003) considers design as "the core problem-solving process of technological development. It is as fundamental to technology as inquiry is to science and reading is to language arts."

Design ability is a form of natural intelligence possessed to some degree by everyone (Cross, 1982). However, the lopsided nature of the present literacy-numeracy education system gives undue emphasis to rote learning. Design, according to Cross, is a third culture different from the established cultures of sciences and humanities and should be a part of general education just as the sciences and the humanities. This paper aims to report preliminary results of a pilot study which sought to explore middle school students' naïve ideas about design and to develop and try out design-related activities that would sensitize students to issues of design.

Studies on Students' Ideas about Design and Designers

In science education, the intuitive concepts of students are well documented and are regarded as significant for teaching and learning, but the same is lacking in D&T education (Layton, 1994) where there are few studies on students' ideas about design and designers. A study of Canadian elementary students' naïve beliefs about design and design-

ers revealed that students have robust perceptions of design and designers which remain rigid even after completing designing and making activities (Welch et al., 2006). Another study with Canadian and English students, (Hill & Anning, 2001) revealed that students exposed to D&T curriculum tended to consider design as an activity such as making things or drawing. Newstetter & McCracken (2001) found that Georgian graduate students of computer science and engineering fields tended to consider design as a product and not an activity, and associated designing with creativity, invention, brainstorming and arts and rarely with their own fields. The present study is significant because D&T has not been yet introduced as a subject in the Indian school curriculum.

The objectives of the present pilot study are threefold: to study middle school students' naïve understanding of design and designers, to explore the possibility of introducing design-related activities among students and to examine the impact of these activities on students' ideas about design and designers.

Research Questions

- What are middle school students' naïve ideas about design and designers? What products, activities, skills and professions do they associate with design, designing and designers? Are there any gender stereotypes in students' ideas about design and designers?
- What different designs solutions do students generate for a design problem while working in groups?
- Does students' understanding of design change after their engagement in specific design activities and if it does what are the changes?

Methodology

Research Design

The research design is a "one-group pre-post intervention" one having the following three phases:

- Survey of students' ideas of design and designers. The survey was conducted through questionnaire of all the students and detailed interviews of a few.
- Development and trials of specific design-related activities.
- Studying the impact of design-related activities on students' understanding of design and designers after their engagement in design activities.

Sample

The student sample for the study was from a school located in the vicinity of the researcher's institution in Mumbai. It consisted of 25 students (7 girls and 18 boys) from Class 7 (12-13 years of age). Students' willingness to participate in the study, their proximity to the researchers' institution and the researchers' rapport with the school management influenced the selection of the school and sample. These students (like most Indian students) did not have D&T education in their curriculum. The students' linguistic background was varied, with most students reporting different Indian languages spoken at home while the medium of instruction in the school was English. The language used by the researcher was also English.

Students were asked to form groups of 3 or 4 members. Prior experiences with the dynamics involving mixed sex groups, (Khunyakari et al., 2007; Mehrotra et al., 2007) led us to request only single sex groups (2 groups of girls and 5 groups of boys).

Data Collection

The interaction with the students was carried out over a period of 5 days, for approximately two and half hours per day, during the school vacation. The pre and post intervention surveys were in terms of structured or semi-structured individual responses of students. Eight students (4 girls & 4 boys) were interviewed (audio-recording) after they responded to the pre-intervention questionnaire. The design activities generated semi-structured and unstructured collective responses, questionnaires, written records, drawings, oral presentations. The activities and the student interactions were audio and video recorded. At a time there would be a special focus on any two groups. The details of the researcher-student interaction are presented in Table 1.

Results and Analysis

Students' Ideas about Design and Designers (Before and After the Intervention)

Students' responses to the survey are presented qualitatively and give an indication of their spontaneous ideas of design. The term design is not taught to these students in any academic context and hence their ideas would be based on factors other than school, such as, everyday use of the word or the media. When asked "What comes to your mind when you hear the word 'design'. Write as many phrases as you can think of", most students in the pre-intervention stage (54%) associated design with arts, such

Session	Researcher-student interaction
Day 1	--Pre-intervention survey of students' ideas about design & designers [~40 min]
	--Handling of 2 familiar artefacts (electric iron, fountain pen) [~40 min]
	--Handling of 1 traditional artefact (hurricane lantern) [~30min]
Day 2	--Recognizing 3 displayed unfamiliar artefacts. Students guessed the functions based on the structures from among the choices provided. [~30 min]
	--History of familiar artefact (writing tools) presented by researcher [~40 min]
Day 3	--Handling of 2 familiar, similar looking artifacts (ball-peen & clawed hammers) to find similarities and differences between the two. [~40 min]
	--Handling and recognizing 3 unfamiliar, dissimilar looking artefacts that performed the same function (kinds of knife sharpeners); each group was interviewed while handling the artefacts. [~45 min]
Day 4	--Designing solutions for a real world problem. Each group generated ideas, developed solutions, considered design decisions, made sketches, evaluated their solutions and wrote design proposals. [~100 min]
Day 5	--Each group presented their designs to other groups, who questioned, evaluated and provided feedback on the presented design solutions [~80 min]
	--Post-intervention survey of ideas about design and designers [~40 min]

Table 1. Researcher-student interactions involving the survey and trial of design activities

as, decorations, drawings, pictures/paintings and patterns. In the post-intervention stage this number came down to 40%.

When asked to complete a phrase, "Designing means…" most students, (64%) after the intervention stated that design was some kind of activity (imagining, forming ideas, shaping things, making things attractive, planning, making things, transforming, inventing or creating artefacts) compared to 25% of students in the pre-intervention stage. The term 'designing,' was associated with the activity of 'making things attractive' by most of the students in both the stages of the study.

To the question, "Designers are people who…," students mentioned professions such as, architecture, fashion designing, textile designing and product designing or attributed certain skills to designers such as imagination, creativity, concentration, ability to learn and think (for example, one student wrote, designers… "are always creative and full of imagination"). A few students recognized that designers in different fields have specific knowledge and skills (for example, one student wrote, "…fashion designers cannot design cars").

When asked "Can animals design? Write a few lines describing your ideas", there was a little difference in students' responses in the 2 stages. Most students (67% in pre-intervention and 64% in post-intervention) stated that animals design. They reasoned that animals make their homes for shelter, such as birds, ants, bees, and 2 students considered chimpanzee's use of tools as designing. Other students said that animals design as they plan before hunting or defending themselves. The interviews in the pre-intervention stage revealed that students perceived animals engaged in 'mental designing', in the sense that animals planned and made their homes but the design is 'in their heads.' Only 3 students related the designing by animals to the patterns on their bodies such as stripes on tigers, zebras, etc. Students, who believed that animals did not design, attributed this to the lack of skills, such as creativity, imagination or thinking ability; a few even mentioned the lack of hands and 'big brains'.

Interestingly regarding designing by animals or prehistoric people, most students viewed designing as 'making' or 'planning' but to the earlier questions about designing and designers in general, students presented design as 'making things attractive.' Not surprisingly then, when asked whether designers solved real world problems nearly half of the students disagreed in the pre-intervention stage. However, after actually solving a real life problem in their design activities, this number reduced to about one-fourth of the original sample.

Most students, both before and after intervention, perceived working in a team, sketching ideas, planning, imagining new products, knowing about different materials as skills re-

Item No.	Questionnaire item	Pre-intervention (N= 24)	%	Post-intervention (N= 25)	%
A	Work in a team	19	79	24	96
B	Observe people	17	71	25	100
C	Sketch ideas	22	92	25	100
D	Understand how things work	17	71	25	100
E	Work on their own	7	29	7	28
F	Plan	21	88	25	100
G	Solve problems	15	62	17	68
H	Imagine new products	21	88	25	100
I	Know about different materials	22	92	25	100
L	Communicate with others	16	67	25	100

Table 2. Students' responses to a question on the skills designers need

quired by a designer (Table 2). However, post-intervention there was a marked increase in the number of students, who considered observing people and communicating with others as the essential skills of designers.

In the interviews, students had stated that observing people was not essential for designers since they were creative people and need not get ideas from anywhere else except their own creative thinking. For example one student said, 'I don't think it is necessary to observe people. If observing people gives an idea to the designer so it would not be called a design.' Another student's response was, "If they observe people and invent something or design something like that…we can call it a kind of copying something." Few students in both the stages considered working on their own as a skill a designer needs.

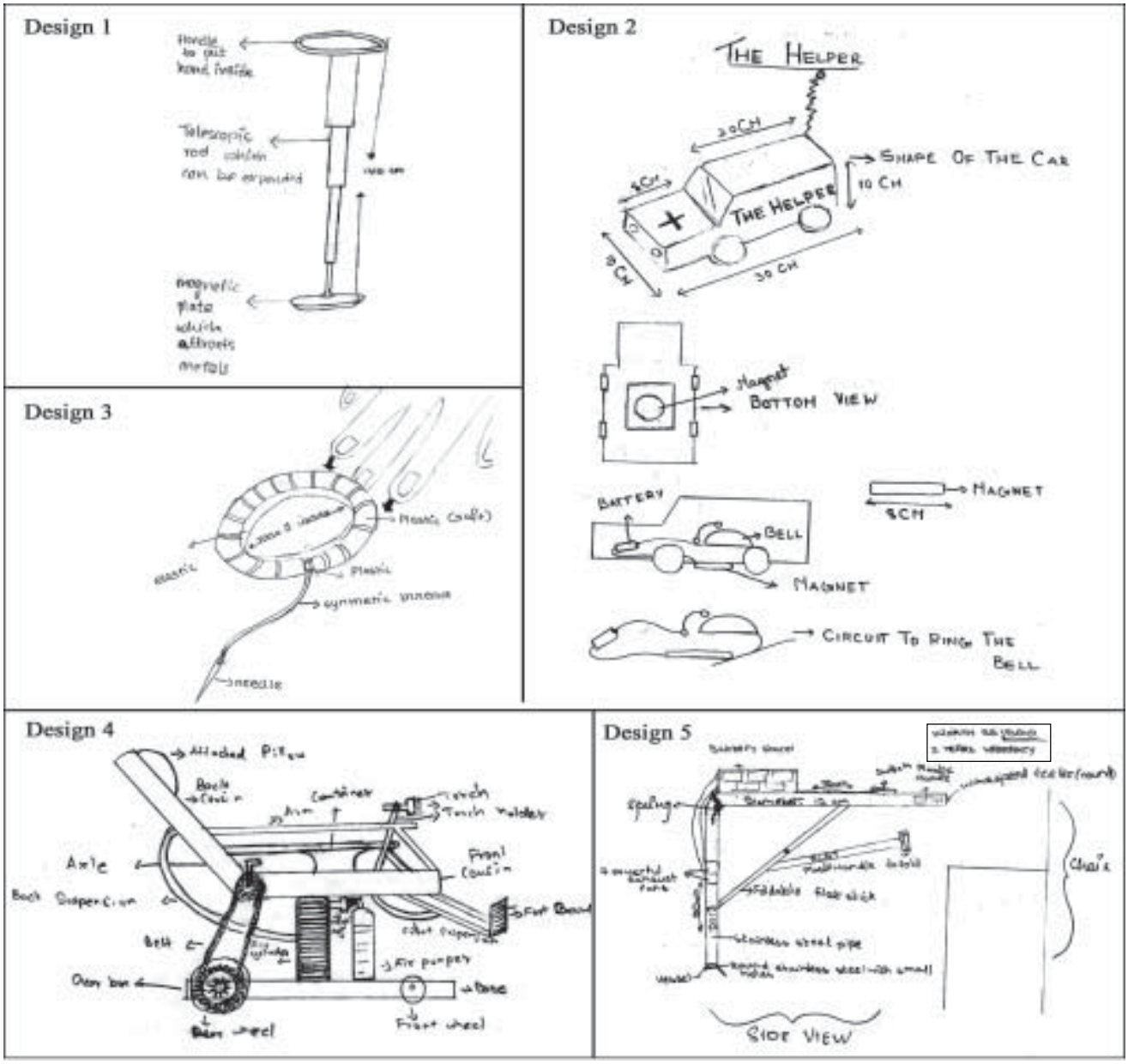
There were some evidences of gender stereotypes in students' responses in the 2 stages of the survey. In the pre-intervention questionnaire, 38% of the students designated the designers as 'he'. Surprisingly, this number rose to 48% in the post-intervention stage. About 21% of the students mostly girls, designated the designers as 'he/she' in the pre-intervention stage while this number again reduced to zero in the post intervention stage. Other students avoided the issue by using plural terms or referring to 'designers.'

Students' Responses to the Activities

The activities that involved handling artefacts were aimed at introducing students to structure-function relationships of artefacts, while the historical presentation was aimed at encouraging students to question the development of design aspects of artefacts and to make them appreciate that artefacts have undergone intentional and purposeful changes.

Apart from handling actual artefacts, students were also provided with pictures (electric iron – a familiar artefact, hurricane lantern – traditional one). Preliminary analysis revealed that though all the students could state how the electric iron is used, only 1 group (of boys) could differentiate and label all the visible parts correctly. The other groups missed some parts or did not label them correctly. Most students were not familiar with the materials of the parts, such as "bakelite" or "Teflon". The fountain pen (a familiar artefact) seemed to be an under-explored artefact by students. Nib, grip, ink holder and cap were the common parts marked. No student marked the feed of the pen and did not seem to consider it different from the nib. Students introduced their own terms/phrases for describing parts of pen such as "part from where ink goes to nib", "finger grip", for the nib holder; "part where ink is put" for the ink holder. Most students had seen a hurricane lantern before but were not sure of how to use it. However, they learnt this from peers and from the researcher. Almost all groups introduced their own terms for the various parts of lantern, for example, "part from where CO_2 and O_2 pass" or "exhaust" for the crown; "burning material", or 'flame producer' " for the wick. Thus after knowing the function of a part of an artefact, students used the knowledge for naming the part of the artefact.

By handling the two different types of hammers and using them (ball-peen and clawed hammers), students recognized the difference between the two. But none could identify the riveting function of the ball-peen hammer. Students gave appropriate reasons for not choosing metal for the handles. Almost all groups reasoned that the metal handle would make the hammer heavy so it might slip or might be hard to carry; metal might also vibrate or rust and hurt the hands. With respect to unfamiliar artefacts, each group was pro-



Design 1: Use of magnet (girls' group)
The design included an aluminium telescopic rod. To one end of the rod is a magnet which would attract the fallen metallic needles and to the other end is a handle for holding the rod.

Design 2: Use of magnet (boys' group)
A remote control car is used with a magnet attached to its bottom. When the needle gets attracted to the magnet, it completes a circuit in the car and an alarm rings. The car can then be controlled to climb up the ramp against the sofa to the user.

Design 3: Preventing needle from falling (girls' group)
This design is in the form of a bracelet which the person sewing or knitting wears. It is made of elastic material. One end of a synthetic thread is attached to the bracelet while the other end is attached to the knitting or sewing needle. There is thus no chance of the needle falling on the floor. It could also be used as a bracelet.

Design 4: Manual lifting by adjusting height of chair (boys' group)
In this design, the principle of air suspension to raise and lower the height of the wheel chair is used. Any object can be lifted from the floor. It can also be used by people who cannot walk.

Design 5: Use of air pressure (boys' group)
This design uses the principle of air pressure, in the same manner as a vacuum cleaner. Exhaust fans present in the pipe forces the needle to get stuck at the mouth of the pipe. The needle could be retrieved by pulling the retractable handle.

Fig. 1. Different design solutions generated by students

vided with 3 different kinds of knife sharpeners. Each group was observed and interviewed separately while they interacted with these artefacts to identify them. Groups (4 out of 7), which were able to identify the unfamiliar artefacts adopted similar strategies. These are listed below:

- Handled the artefacts one at a time
- Operated the artefacts in all possible ways (shaking to hear if it made any sound, rubbing the stone on their fingers to feel its texture, rolling it on the table, etc.)
- Ruled out alternate hypotheses by testing (using the nib of a pen to check out the sharpening material, passing paper through the groove of sharpeners for changes, etc.)
- Questioned and critiqued each other and justified their own explanations.
- Made use of the similarities between the artefacts to identify their function (of the 3 sharpeners, 2 were similar in orientation while 2 had similar texture of material)

Students' Solutions to a Design Problem

The design problem set to students had come up during consultation with a Professor of Industrial Design Centre, Mumbai. This problem was modified for the purpose of this study where it served as a design activity.

On reaching old age some people have difficulty in bending to pick up fallen things from the floor. Rita's grandmother is very old and also has a problem with her vision. She cannot sit on the floor because of her backache. So she usually sits on a chair or on sofa and sews clothes or knits sweaters. Sometimes she drops the sewing or knitting needle on the floor but she cannot bend to pick it up because of backache. Design a device for Rita's grandmother so that she can easily lift the sewing or knitting needle from the floor without bending.

Each group came up with 2 design solutions. A few design solutions are presented in this paper (Fig.1). Preliminary analysis reveals that all the designs demonstrated elements of creativity, imaginative thinking, use of scientific concepts, such as magnetism, air pressure, air suspension and an understanding of the use of some technological concepts, such as the use of remote control car, telescopic rod, pulley and gears, etc. Students' solution varied from simple to complex designs. For example, while quite a few groups referred to magnets in their design, the complexity involved differed. The groups consistently kept the user in mind when designing the artefact. All the groups also decided on the cost of their designed artefact (Design 5, cost indicated in a box). Two groups enhanced the quality of their design by increasing the possible uses of their artefacts (Design 3; Design 4). It is also interesting to note that the designs of the two girls' groups were simple and easy to make.

Conclusion and Discussion

This pilot study indicates that just as in science education, students have naïve ideas about design as well. The study attempted to help students evolve their ideas of design and designers through an engagement in design activities. Students did consider that designing was an activity conducted by animals and prehistoric people and essentially focussed on examples of making to justify their stance. However in general when referring to design they considered it as merely making things attractive to users. Focusing on aesthetics alone in design creates a limited and superficial conception. That intentionality, a lot of effort and experimenting besides creativity bring about a well-designed product, was missing in students' responses in the survey. However it was interesting to note that while actually designing their own artefacts, students did not consider aesthetics as their prime concern. The activity of designing a solution to a real life problem had some effect on students' ideas about design and designers. More students after the intervention connected design to solving real world problems. Also the solutions that students developed for the problem set to them showed an amazing range from simple to complex solutions and were focussed on the user.

Students are future consumers, manufacturers, engineers or designers and thus they need to have a critical attitude towards designed products and be aware of the way in which the products/systems affect individuals, society and environment. They must become considered users rather than passive consumers of technology (McLaren, 1997). Through design education, students learn not only the process of design but also understand and evaluate products. The present study was limited to only 5 days and to a group of 25 middle school students. The findings of the pre-sent study will provide further opportunities to researchers to develop and try out more and different design activities with students and even with teachers.

References

Cross, N. (1982). Designerly ways of knowing. *Design Studies*, 3(4), 221-227.

Hill, A. M., & Anning, A. (2001). Comparisons and contrasts between elementary/primary 'school situated design' and 'workplace design' in Canada and England. *In-*

ternational Journal of Technology and Design Education, 11, 111-136.

International Technology Education Association. (2003). *Standards for technological literacy: content for the study of technology*. Reston, Virginia.

Jarvis, T., & Rennie, L. J. (1998). Factors that influence children's developing perceptions of technology. *International Journal of Technology and Design Education*, 8, 261-279.

Khunyakari, R., Mehrotra, S., Chunawala, S., & Natarajan, C. (2007). Design and technology productions among middle school students: an Indian experience. *International Journal of Technology and Design Education*, 17(1), 5-22.

Layton, D. (1994). A school subject in the making? The search for fundamentals. In Layton, D. (Ed.), *Innovations in science and technology education* (pp. 11-28). France: UNESCO Publishing.

McLaren, S. (1997). Value judgments: Evaluating design? A scottish perspective on a global is-sue. *International Journal of Technology and Design Education*, 7(3), 259-278.

Mehrotra, S., Khunyakari, R., Chunawala, S., & Natarajan, C. (2007). Collaborative learning in technology education: D&T unit on puppetry in different Indian sociocultural contexts. *International Journal of Technology and Design Education*. doi: 10.1007/s10798-007-9037-1.

Newstetter, W. C., & McCracken, M. W. (2001). Novice conceptions of design: Implications for the design of learning environments. In Eastman, C. M., McCracken, W. M., & Newstetter, W. C. (Eds.), *Design Knowing and Learning: Cognition in Design Education* (pp 63-77). Oxford, U.K.: Elsevier Science Ltd.

Welch, M., Barlex, D., & O'Donnell, E. (2006). Elementary students' beliefs about designers and designing. In Norman, E. W. L., Spendlove, D., & Jackson, G. O. (Eds.), *Designing the future, The D&T Association International Research Conference 206*, 165-176, Wellesbourne: Design & Technology Association.