Investigating Students', Teachers' and Designers' Ideas about Design and Developing Design Activities for Indian Middle School Students

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Synopsis of Ph.D. Thesis

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Synopsis

Chapter 1

1.1 Introduction

This thesis investigates students', teachers' and designers' ideas about and attitude towards design and designers through a survey. It also attempts to develop appropriate design activities for Indian middle school students. The survey sample consisted of: students in elementary schools (Classes 5, 6; age 9-10 years) and middle school (Classes 7, 8, 9; age 11-14 years), in-service and pre-service teachers as well as designers (PhD design students). A questionnaire was developed with different features for each of the samples surveyed. All the samples were drawn from the city of Mumbai. Based on insights from piloting the survey on middle school students and insights from the literature on design and technology education, several design activities were developed and tried with middle school students on 3 separate occasions. The thesis reports on the survey, the development and trials of the design activities and analyses of specific design activities to see how students relate structure and function of artefacts and finds evidences of creativity, and design decisions skills in students' solutions to real world problems.

1.2 Research background and rationale

Traditional pedagogical patterns of education, such as authoritative, teacher-centric and lecture-based approach, still remain the same for most of the last century at least in the developing nations like India. The Indian education system today also seems to be detached from real life issues and concerns (Menon, 2005). Most school activities are not meaningful and students do not understand the purpose and the usefulness of doing them. These students then tend to memorise the content taught in schools. However if authentic learning has to take place, it requires the active and constructive involvement of the learner. The educational philosophies of Gandhiji and Dewey have argued for the importance of providing education that involves students in authentic real-world experiences in which they engage in dialogue, take action, and reflect on possible outcomes. The craft-centred Basic School of Gandhi was similar to Dewey's Laboratory School where learning was encouraged by the active involvement of the sensory organs, that is, *learning by doing.*

In the present day there is an increase in the complexity of life. Even a small farmer in India is influenced by various factors such as global warming, global trade arrangements, the technology of genetically modified crops and seeds, global consumption patterns, shipping and storage systems and so on (Kasturi, 2005). Any human activity today now involves multiple disciplines. Buchanan (1992) states, '*Without integrative disciplines of understanding, communication and action, there is little hope of sensibly extending knowledge beyond the library or laboratory in order to serve the purpose of enriching human life'* (p. 6). Buchanan suggests that design is one such 'integrative discipline'.

Again in an urban context, with a click of a button, one has large amounts of information at one's disposal. It serves no purpose for individuals to just receive and store knowledge. They must know what, why, how and where to apply the relevant knowledge effectively. Thus a society dominated by scientific and technological advances, requires individuals who will not only create data but also know how to convert it to knowledge and apply that knowledge in their work. There has been an increased recognition that design activities provide an opportunity to shift from this era of 'information acquisition' to 'knowledge application' and would lead to meaningful learning and development of higher order thinking skills. Design

education thus has been recognised worldwide as being of crucial importance and hence has been introduced in schools as part of the curriculum in various countries throughout the world.

In India, Gandhiji's philosophy of Basic Education motivated the Education Commission in 1966 to introduce Work Education and Socially Useful Productive Work in schools, but today these subjects have become an adjunct to the already lopsided literacy-numeracy curricula since they rely on recipes and non-reflective practices, rather than on creativity and reflection.

Literature suggests that there are at least two views which explicitly advocate the inclusion of design in general education. The first is that of design professionals (Cross, 2006; Lawson, 2005) who consider design ability as a form of natural intelligence possessed to some degree by everyone. According to this view, design should become a part of general education as it has its own ways of knowing, thinking and acting, different from sciences and humanities.

The second view is echoed by educationists (Baynes 2006; Kimbell et al, 2002; Gwyneth Owen Jackson, 2008) who advocate the inclusion of design and technology education in school curriculum in order to develop among future citizens the knowledge, understanding, technical and interpersonal skills necessary for an advancing scientific and technological society.

In countries like India where neither design nor technology is a part of the school curriculum, the matter is further complicated since design has been transformed to something banal and inconsequential by the widespread media coverage. According to Heskett (2002) design today is assigned a lightweight and decorative role for fun and entertainment, and is considered useful only for monetary profits.

Although design is an integral part of our need to adapt to any situation by creating artefacts and tools, it is variously perceived by philosophers and lay people. The possibility of varied interpretation of design has also led to confusion among fledgling designers and has propagated a manufactured image of design and designers among the general public.

With a multitude of meanings of design it is important to learn what individuals understand by design and their attitudes to design and designers. It would be interesting as well as important (from the curricular point of view) to document Indian students' spontaneous and unschooled ideas about design and designers.

1.3 Objectives of the study

The purpose of the study is four-fold:

i. To study elementary and middle school students', teachers' and designers' ideas about and attitude toward design and designers;

ii. To develop design-based activities through trials among urban middle school students;

iii. To assess the influence of design-based activities on middle school students' ideas about design and designers and

iv. To analyse aspects of structure-function relation of artefacts, creativity and design decision skills in students' responses to the design-based activities.

1.4 Research questions

The research addressed the following main questions:

1. What are students', teachers' and designers' ideas of and attitude towards design and designers?
2. What specific activities can be developed for Indian middle school students to engage them in designerly thinking?
3. What is the relation between students' design activities and their understanding of design?
4. What aspects of structure-function relation of artefacts, creativity and design decision skills are evident in students' responses to the design-based activities?

1.5 Theoretical framework

A survey of students', teachers' and designers' ideas of and attitude toward, design were conducted through questionnaires and drawings. The theory guiding students' survey of ideas was the constructivist theory, which supported the belief that even if Indian students have no formal education in design, they have their own ideas about design and technology and teachers/curriculum planners need to be informed of these ideas in order to develop appropriate teaching strategies or suggest improvement in the curriculum.

The basis for studying teachers' ideas of and attitude towards design rests on the principle that teaching and learning is a matter of interaction. Students have a direct influence on what the teachers have prepared for the class and what the teachers teach (de Vries, 2005). It is important to know about teachers' understanding, since it would be the teachers who would be expected to teach design and technology in the Indian classrooms.

The activities that were developed and tried among middle school students drew upon several contemporary theories of learning including the Constructionism theory of Papert (1993), Vygotsky's socio-cultural theory, Robert's (2005) model of children's role in designing and Barlex (2007) pedagogical principles of design-with and without-make.

Papert (1993) asserts that people learn better while constructing anything even if it is a sand castle on the beach, or a theory in physics. This is so because of the strong interaction between thinking and action during the act of construction. Thus we provided appropriate learning opportunities of hands-on activities to students to develop their design skills and actively construct their own knowledge about design during the trials.

The sociocultural theories recognize that learning is not just an individual matter, but that it develops within a social environment, through interaction with peers, adults, and others in the society. It was attempted to make the design tasks meaningful and challenging and engaging for the students, who worked in groups/dyads for all the activities.

The tasks were organized around 4 roles suggested by Roberts (2005), that students adopt during design tasks (Fig. 1.1). These 4 roles are those of the Observer, User, Designer and Maker. According to Roberts, the 4 role-views are intended to provide working perspectives towards the better comprehension of design and technological activity and of cognitive modelling. As observer and user, students are involved in judgment and evaluation of

existing realities while as designer and maker, students plan, make mock-ups, test and evaluate and make artefacts in the design classrooms.

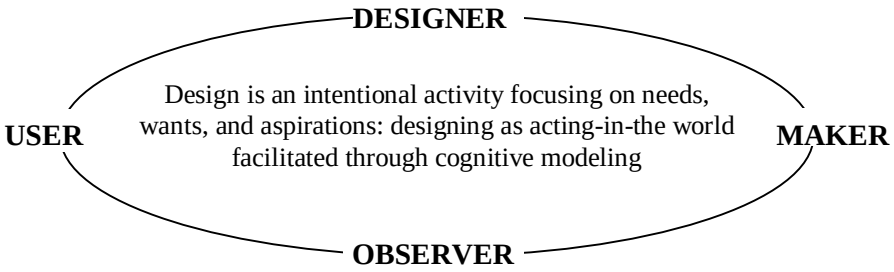


Fig.1.1 Four roles of students in a design classroom offering complementary perspectives on learning-through-designing (Roberts, 2005)

This model served as a vehicle for creating design tasks for Indian middle school students in the present study. The themes and contents of the tasks were selected, formulated and coordinated to appropriately and effectively meet the learning goals. The learning goals were imbedded in the tasks.

We looked for creativity in students' designed solutions with respect to the following features listed by the National Advisory Committee on Creative and Cultural Education (NACCCE), 1999 (Barlex, 2007): using imagination, pursuing purposes, being original, and being of value.

The design and make activities were analysed using Barlex's pedagogical principle of design-with and without making (Barlex, 2007) and his framework for analyzing students' designed solutions through 5 design decisions that students might adopt while designing solutions (represented by a pentagon in Fig. 1.2).

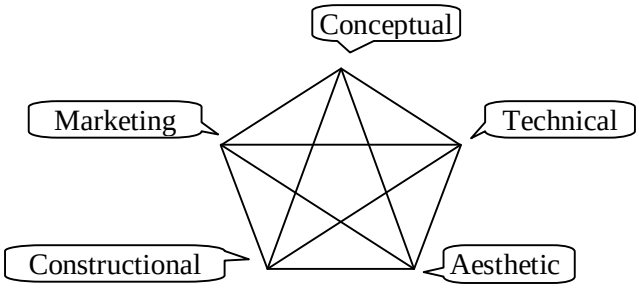


Fig. 1.2 The Design decision pentagon (Barlex, 2007)

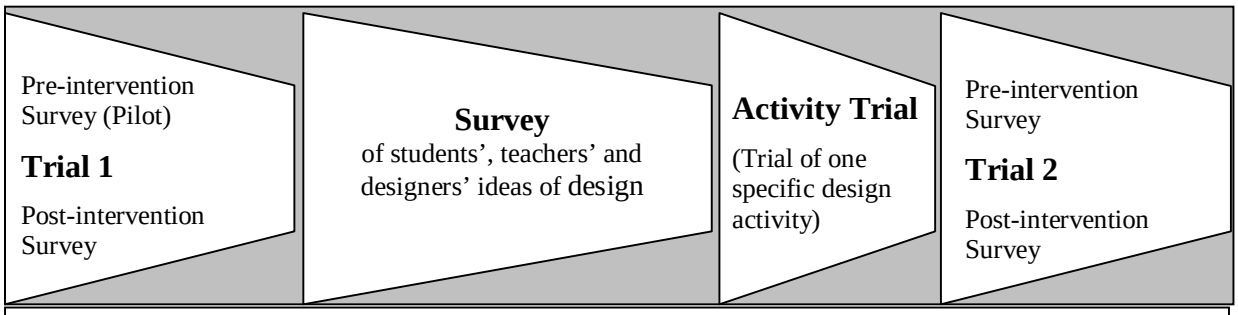


Fig. 1.3 The progression of the research study

Figure 1.3 depicts the progression of research study in a chronological order. The survey was the main focus of the research study. A variety of design activities were developed and tried among middle school students in Trials 1, 2 and in 'activity trial'. Trials 1 and 2 were similar to each other in their research designs while activity trial involved testing one specific

activity with a small group of students. The details of the study are discussed later in Chapters 3 and 4.

1.6 Organization of the thesis

Chapter 1 provides an introduction to the thesis with the background and the context in which this research was undertaken. It also presents the aims and motivation of the study. The theoretical framework and the research questions guiding the study are discussed. Chapter 2 discusses the relevant literature in the field of design and technology education. Chapter 3 discusses the survey of students', teachers and designers' ideas on design and designers. It highlights the objective of the survey, the methodology used and the development of the questionnaires. It also discusses the procedures used to analyze the responses and the results of the analysis. Chapter 4 outlines the development and trials of the different design activities among middle school students. Chapter 5 reports the analysis of students' responses to specific design activities focusing on the aspects of structure-function relations of artefacts, creativity, and students' design decision skills. Chapter 6 discusses the influence of the design activities on students' ideas of design. Chapter 7 is the concluding chapter where the result of the studies is discussed in line with the research questions raised. Finally the implications and recommendations for future research work are addressed.

Chapter 2

Literature review

Chapter 2 of the thesis presents a review of literature pertaining to the following issues: understanding of design from a historical, philosophical and educational perspective, the cognitive aspects of design, pedagogy for promoting design learning worldwide and a review on understanding students' teachers and designers' ideas of design.

2.1 Design from a historical, philosophical and educational perspective

According to Buchanan (1995), there is a growing recognition that the design of the everyday world deserves attention not only as a professional practice but as a subject of social, cultural and philosophical investigation. Notable designers, historians and design theorists have contributed to establishing a better understanding of design and its practices.

In the English language, 'design' can serve either as a noun or a verb. As a noun, design can mean a form, arrangement, pattern, blueprint, template, model, outline, plan, plot, scheme, or sketch, or artistic shape (Mitcham, 2001). As a verb, design may mean to mark out, to plan, devise or intend, to draw, to impose a pattern, or to produce a template for subsequent iteration, In yet another sense, perhaps as an adjective, design could mean something trendy or fashionable, for instance when we use the word 'designer' in connection with clothes or accessories.

The origin of design could be argued in four ways (Buchanan, 1995). One argument is that design actually began in the twentieth century with the formation of design as a discipline. The second argument is that design originated in the early period of Industrial Revolution with the need for mass production and the development of technology. The third argument holds that design is an inherent human ability and it began in the prehistoric period with ancient humans consciously acting upon nature in order to transform and mould it according to their needs. The fourth argument considers that design began even before the prehistoric period, that is, with the creation of the universe.

The simplest idea of design is given by Archer, "*Design is that area of human experience, skill and knowledge which is concerned with man's* [sic] *ability to mould his environment, to suite his material and spiritual needs*" (Eggleston, 2001). According to Archer, design is a "*goal directed problem solving activity*". Archer (1984) sets three criteria for an activity to be recognized as a designing activity: i) the prior formulation of a prescription or a model, before the product is actually made, ii) the intention of embodiment as an artefact/hardware and iii) the presence of a creative step. Thus for Archer, an architect preparing a plan for a house is clearly designing but a sculptor shaping a figure or a musician composing a song are not (Archer, 1984).

In contrast, Thomas and Carroll (1984) suggested that any problem can be looked at as a design problem. For them design is a way of looking at a problem than a type of a problem. Thus a problem which is typically considered as a design problem such as designing a house can be viewed otherwise, if say the architect has a standard set of features and variations which he/she applies in their plans.

Literature thus provides a varied definitions and meanings of design, sometimes conflicting with each other. The researcher considers design as a discipline, a process and a product. As a discipline it explores the relationship between the user, the product and the contexts in which the product is used. As a process it refers to the intentional, iterative problem solving process that converts ideas into systems or products. As a product it may refer to the outcome of the design process such as specifications, sketches, models or shape of the products.

Bruce Archer has been one of the major contributors besides Cross (2006) and Layton (1994) who contributed towards the better understanding of issues associated with design education. Archer in 1976 proposed design as the missing segment of education to be placed alongside Science and the Humanities (Archer, 2005). He suggested fundamental grounds on the basis of which design should be included in education.

According to Archer (2005), modern society is facing a number of problems including material culture problem, ecological problem, the environmental problem, the quality-of-urban-life problem, etc. These problems demand that individuals need not only be equipped with literacy and numeracy but also need to possess 'a level of awareness of the issues in the material culture' which can only be achieved through design education. Echoing Archer's view, Baynes (2006), also suggests that the primary aim of design in general education is to develop design awareness (knowing about understanding design) and design ability (being able to design).

Cross claims that design should be included in the curriculum since it serves three important functions:

- Firstly design develops the innate abilities of students to solve real world problems which are ill-structured in nature, with little information and with multiple possible solutions;

- Secondly, design supports constructive thinking as opposed to inductive and deductive reasoning common to the sciences and the humanities;

- Thirdly, design offers opportunities for students to develop a wide range of abilities in non-verbal thought and communication.

2.2 Cognitive aspects of design

Design is considered to be one of the most significant intelligent behaviours of human beings. As such it is found to be strongly associated to the field of cognition. According to Cross (1982) design ability is a form of natural intelligence possessed to some degree by everyone. Cross (1982) identifies four basic design abilities as the ability to-

i. resolve ill-defined problems
ii. adopt solution-focusing strategies
iii. employ abductive/productive/appositional thinking and
iv. use non-verbal, graphic/spatial modeling media

In design cognition research, the main focus has largely been on *design thinking* that is, describing design-specific cognitive activities that designers employ during the process of designing. Cross (2006) suggested that design was different from the sciences and humanities because it has its own ways of thinking, knowing and acting primarily termed by him as the 'designerly ways of knowing'. He argued that while humanities and sciences rely on the verbal, numerical and literacy modes of thinking, design thinking relies on a range of modelling techniques that can be used to externalise ideas in the mind.

The notion of design as 'a way of thinking' has been explicated by various design philosophers such as Archer (Archer, 2005), Schon (1983), (Simon in Schon, 1983), Lawson (1980) and Cross (1982, 2001). Studies in design thinking have explored how designers frame or structure the problems (Cross 2004), design ability in novices and experts (Cross & Lawson, 2005; Cross 2004; Dorst & Reymen, 2004), the strategies employed by designers (problem-driven/solution-driven) (Lawson, 2005), or creativity in design (Cross, 2006).

2.3 Pedagogy for promoting design learning worldwide

Setting up appropriate design tasks is very crucial for effective design learning to take place. In 1991, the Assessment of Performance Unit (APU) model advocated the Design-Make-Appraise (DMA) approach for teaching designing and making skills to students in UK (Kimbell, Stables and Green 1996). In contrast, Barlex (Barlex and Trebell, 2008) developed a pedagogy termed as 'design-without-make', which challenged the traditional approaches to teaching design (through design and make activities) by providing opportunities to students to design but not make whatever they had designed. This approach was found to be effective in promoting creativity among students and also encouraged them to use modern and advanced technologies in their design.

In 1995, Barlex developed a robust pedagogy to promote design learning which included two tasks that students engage with: the 'capability task' and the 'resource task' (Welch, 2007). The capability tasks provide opportunities to students to use the knowledge, understanding and skill they have been taught, in an integrated and holistic way. Through capability tasks, students intervene and make improvements to the made world by designing and making products. The resource tasks are short, focused activities intended to teach the knowledge, skill and understanding that is likely to be useful in tackling design problems

In India researchers in academic institutions such as Homi Bhabha Centre for Science Education, have made attempts to explore the possibility of introducing D&T in Indian classrooms (Khunyakari, 2008; Mehrotra 2008; Choksi et al., 2006). They have modified the APU model to meet their research aims as well as to study collaboration and cognition in classroom interactions. More recent researches have also focused on students' designing (Ara

et al, 2009; Shome et al., 2011) and teachers' designing ability (Shastri et al. 2011). There also have been efforts by Indian organizations such as SRISTI (Society for Research & Initiatives for Sustainable Technologies & Institutions) founded by Anil Gupta whose aim was to bring notable inventions done by poor people to the attention of venture capitalists and financiers and also provide opportunities to students to harness their creative and innovative spirit by organizing competitions and awards for them.

2.4 Review on understanding students', teachers and designers' ideas of design

Literature indicates that studies on students' and teachers' understanding of design and designers are very few. These studies are mostly limited to students who either already had D&T in their curriculum (Hill and Anning, 2001) or had an exposure to the process of design (Newstetter and McCracken, 2001). The present study is significant because D&T is not a subject in the Indian school curriculum. According to Wolters (1989) it is important to take students' interests, opinions and needs into account while developing technology curricula. The intuitive concepts must be accounted for in order to bring about change in them. Learning about students' ideas about design and designers is important for a future design and technology education to be designed. It is equally important to study teachers' understanding of design because teachers' background knowledge and understanding in any curriculum area will determine the kind of attitude they take towards teaching and learning. According to Cross and Lawson (2005), studying professional designers of outstanding ability would give us insights and understanding about design as an activity. It could be useful in guiding pedagogy for the development of 'better-than-average-designers' and for facilitating the transition from naïve designer to the expert designer.

Chapter 3

A survey of Indian students', teachers' and designers' ideas of and attitude towards design and designers

3.1 Introduction

A survey was designed for elementary and middle school students, teachers and designers. The survey involved selecting three kinds of sample: students (elementary and middle school students), teachers and designers. Strategies were developed to draw the sample, develop the questionnaire for each sample and administer them and analyse the responses. Four different questionnaires were developed- one for each sample. The methods for collecting the data were slightly different in each of the case. The survey with students was conducted in two phases: pilot and the final.

3.2 Sample

3.2.1. Students: pilot and final: The student sample for the pilot study consisted of 25 students (7 girls and 18 boys) from Class 7 (11-13 years of age) of an urban school. The sample for the final survey consisted of 521 students drawn from another urban school. This sample consisted of students from Classes 5, 6, 7, 8 and 9 and ranged from 9 to 15 years of age. Another sample of 22 students (Classes 7, 8, & 9) volunteered to participate in interview-based sessions for responding to the final questionnaire (Table 3.1). This sample was drawn from the same school as the pilot sample, but was different from the students in the pilot.

	Class	Average age (yrs)	No. of boys	No. of girls	Total
Final: Questionnaire	**Class 5**	9.4	35	40	75
	Class 6	10.4	57	61	118
	Class 7	11.2	61	47	108
	Class 8	12.4	43	52	95
	Class 9	13.3	56	59	115
Final: Interview	**Class 7**	10.8	4	5	9
	Class 8	11.8	3	1	4
	Class 9	12.8	5	4	9
Total			**264**	**269**	**533**

Table 3.1 Student sample in final survey

3.2.2 Teachers sample: A sample of 34 teachers (27 females, 7 males) was drawn from a College of Education in Mumbai. Of these, 24 teachers were pursuing graduation in education while 10 were in-service teachers.

3.2.3 Designers sample: The sample of designers included 4 doctoral design students (2 males and 2 females) and 1 female designer with a Master's degree in animation design. The 4 designers pursuing PhD were product designer (female), architect (male), user experience designer (male) and visual communication designer (male).

3.3. Tools used for the survey

The studies on students' ideas about design and designers are limited. The studies by Welch et al. (2006) and by Newstetter and McCracken (2001) informed the researcher's' construction of the questionnaire. Various items in the questionnaire were also informed by the studies done among Indian middle school students on their perceptions of technology by our colleagues Mehrotra (2008) and Khunyakari (2008).

The questionnaires for all the three samples had 3-4 sections:

A. This section included a short introduction to the purpose of survey and was aimed at collecting the demographic data of the students such as name, school, parents' occupations and students' own choice of career.
B. This section requested students to ***'draw a designer at work'***- aimed to probe students' images of designers, the nature and settings of their activities, their gender, etc.
C. This was the largest section and consisted of questions pertaining to students' ideas and attitude towards design. It included open-ended questions, such as, complete-the-sentences, and closed ended questions such as rating scales, dichotomous questions..
D. The last section consisted of several pictures depicting activities performed by individuals. Students were asked to indicate those activities which they considered were designing activities.

In order to address gender concerns, Section D had 2 complementary versions, - one version depicting all the activities done by males while the other depicting all the activities done by females. All pictures had captions indicating the kind of activities depicted (Figs 3.1, 3.2). Students had to respond to any one of the versions randomly given to them.

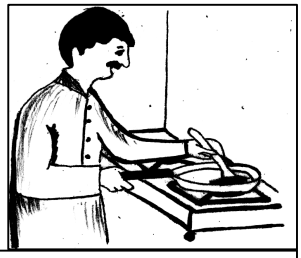


Fig. 3.1 'Making a new dish' Male version of Section D

Fig.3.2 'Making a new dish' Female version of Section D

Section B or the drawing task was adapted from Fralick et al's (2009) questionnaire on engineers and scientists. In the survey questionnaire this task featured an enclosed area where all the students were asked to '*Draw a designer at work*'. The task also required students to provide written responses on the drawn designers' gender, location, activity etc. Section B was dropped for teachers and designers. Section A was modified for teachers and designers to seek different information from them. Section C, which was the largest section including several open-ended and closed ended questions, had 4 separate versions: one each for (i) students of Classes 5 and 6, (ii) students of Classes 7, 8 and 9, (iii) teachers and (iv) designers.

3.4 Pilot survey and establishing validity and reliability of the questionnaires

The pilot survey was conducted with 25 students of Class 7. Eight students (4 boys, 4 girls) were then interviewed following their responses to the questionnaire. Piloting the questionnaire and analyzing students' responses to the questionnaire made it possible for the researcher to evaluate the questionnaire in terms of its comprehensibility for students. The results of the pilot study appeared in a peer reviewed international conference publication (Ara et al, 2009). The validity of the questionnaire was re-evaluated before the final survey for several features such as appropriateness of language in terms of age, gender and context, logical validity of the content, clarity of pictures, appropriateness of pictures and other contents in terms of gender. Two experts in the field of D&T education and one professional designer and design educator scrutinized and validated the questionnaire. Their critical comments and suggestions were incorporated into the final version.

A *test-retest* method was employed to establish the reliability of the final questionnaire. The final questionnaire was again administered to a part of the same sample (35 students of Class 7 of the final survey) after 3 months from the date of the first administration of the final survey questionnaire. Students were only tested for multiple choice questions and questions where they were required to mark the appropriate items from the list of items provided. The correlation coefficient for all the items was found to be more than 0.74.

3.5 Final survey and data collection

The final survey was done with 521 students as mentioned above. Data collection for students involved distribution of only Section A, B and C initially. Lastly Section D (Pictorial activities) was handed to the students which took about 5-7 minutes for completion. The interview sessions were conducted with students from Classes 7, 8 and 9 from another school (pilot school). The interviews were aimed at detailed exploration of their ideas about design and designers. The same survey questionnaire, without Section B, was used in the interviews.

The interview session with each student lasted for about 70 minutes. Their interviews were audio recorded and transcribed verbatim.

The procedure for administering the questionnaire to the teachers was the same as that for the students. The teachers' questionnaire did not include Section B (drawing task). The 5 designers were interviewed on 5 respective separate occasions. The questionnaire for the designers was very similar to that of the teachers except for some variations in the instruction. The interview with each designer lasted for about 1 hour and 20 minutes. Their interviews were audio recorded and transcribed verbatim.

3.6 Data analysis

Data analysis was done in two steps. The responses to the closed ended questions were coded using a pre-code (i.e. codes prepared before administering the questionnaire) while the open ended responses were coded using the coding categories that emerged from the data itself (de. Vaus, 1986). The second step of data analysis involved descriptive analysis using SPSS to obtain the frequencies and cross tabulations.

3.7 Results from the survey

The results for each of the questions have been discussed together for the students' and teachers' responses and separately for the designers. However, for any question, a comparative account of differences among these samples has been discussed. For each of the response in the survey, students' responses were probed in the interview.

3.7.1 Section C: Written responses

3.7.1.1 'What comes to your mind when you hear the word design?

When asked '*What comes to your mind when you hear the word design?* middle school students and teachers produced an average of 2 ideas per respondent. Elementary students produced fewer ideas. About 27% of the ideas generated by all were associated with design as *art* such as painting, decoration or pattern making. Very few of the ideas were related to *making* (5%) and *planning* (5%). More teachers (12%) than elementary (1%) and middle school (5%) students considered design as planning and mostly gave examples of planning from their own profession of teaching, such as planning of lesson plans/activities/curriculum and even *the future* and *character* of a child.

Designers displayed a sophisticated and holistic understanding of design and associated design with *creativity, simplicity and common sense, invention, creation improvement, communication, invention and conscious decision, drawings, and conflicts (between the client and the architect).*

3.7.1.2 ''Designers are people, who…'

While completing the sentence *''Designers are people, who…',* about 30% of the ideas from students and teachers was just '*design'*. Elementary students produced more such tautological responses (42%) than middle school students (25%) and teachers (8%). The activities mostly associated with designers were engaging in artistic work (like painting, decorating, making beautiful patterns), making, improving, drawing to construct, planning and coming up with

ideas and operating. The most common artefacts that students thought designers designed were clothes and fashion designers were the most cited of all the design professionals.

An interesting thing to observe was that though teachers considered design as planning and coming up with new ideas, most of it was related to the planning of intangibles such as any activity, lesson plans, curriculum or *future* of a student. Very few planning ideas of teachers were suggestive of the planning before making a tangible product. Students and teachers also spontaneously suggested what they thought were essential designing skills (15%) such as creativity and having ideas and imagination, specific knowledge, expertise in the field and drawing skill. For most of the teachers designers were creative and imaginative people who *'think differently'* or *'have different ideas'*. Designing for teachers was thus mostly a minds-on activity in which a designer was often seen to be contemplating or generating ideas. Designers' hands-on activities such as working with models, making products, testing products were largely missing from the teachers' responses.

In response to this question, designers mostly suggested the skills that designers have or need to have, such as observing skills, being sensitive to the surroundings, solving problems, having a multi disciplinary approach and communication skills. One of the designers' responded in the following way:

…is open to impressions, open to observations. A designer has to be like a sponge; has to absorb all influences… you have to know everything because you are designing for humans or may be for animals also; and humans are all kinds…And you have to be a cross pollinator. One thing applies somewhere else. Concepts from one place can be applied somewhere else. It's not copying but getting an inspiration.

3.7.1.3 Can animals design?

Greater proportion of teachers (68%) than students (35%) attributed designing ability to animals while elementary students (17%) least frequently agreed that animals can design. The most common argument in support of animal designing was their home-building activities (44%). The main reason stated in argument against designing by animals was their limited thinking ability or their limited common sense (44%).

Interestingly while considering designing by animals and ancient humans, students focused on their making activities. However while considering design in general, they mainly thought of design as some artistic rendering process. Even teachers, who mostly suggested designing of intangibles in general, resorted to making of tangible homes in case of animals. Students' and teachers' responses to this question could be explained by the fact that there are few/no evidences of 'artistic process' (especially painting and drawing) revealed in animal behavior. About 18% of the ideas of students (mostly from elementary school) supporting animal designing were in fact based the artistic endeavour evident in animals, such as paw prints or animal foot prints. Making of homes is clearly evident in animal behavior, while the ancient humans are known to use tools. This suggests that students' understanding of modern design is influenced by how it is portrayed in the media as something which is trivial and relegated to the status of decoration and making things beautiful.

Two of the designers suggested that animals do not design while 3 of them said that animals could design. The latter mostly justified on the basis of tool use and home building activities of animals, while those who disagreed suggested that animals were programmed or hard-

wired to respond to the environments and lacked *sufficient faculties…to affect their environment with some free will which only humans can do.*

The subsequent questions are not relevant to the students from Classes 5 and 6.

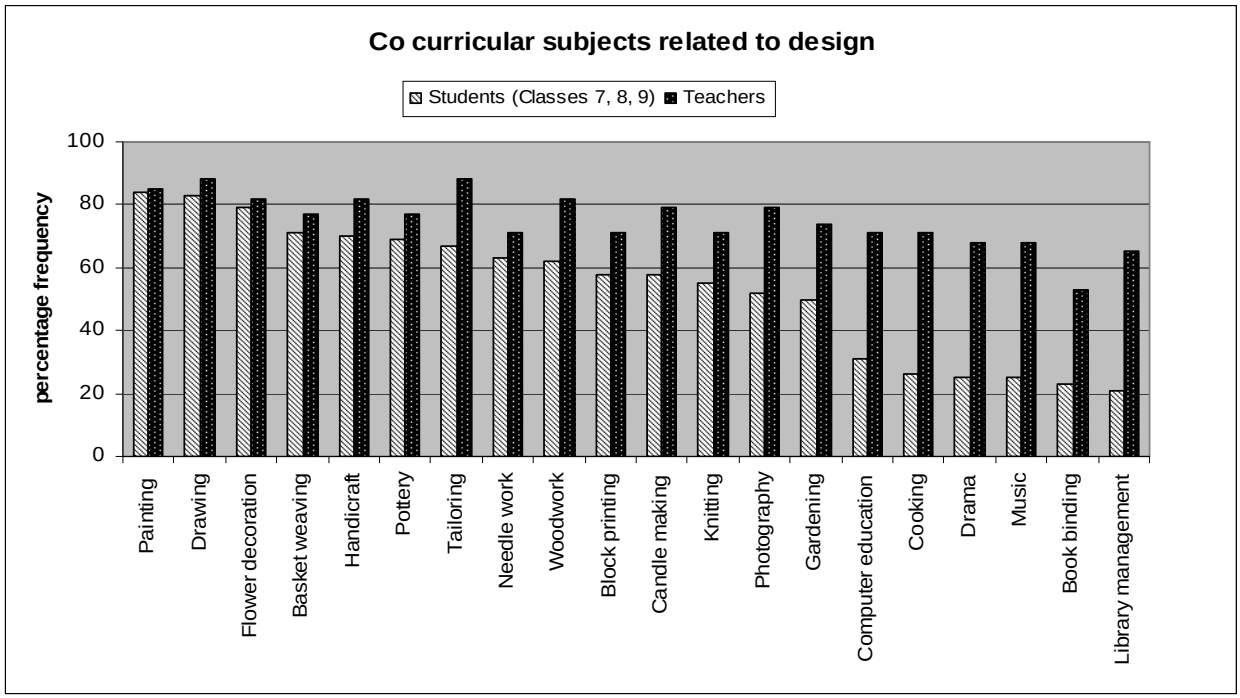
3.7.1.4 Design in different Indian languages

When asked to give Indian words for design, 74% middle school students and 88% teachers wrote different Indian words for the word 'design'. Most words were in Hindi and Marathi and some were in English as well. About 77% and 51% of the words generated by students and teachers respectively, were related to 'art'/artwork or its counterparts in Indian languages such as the word 'kala' and kalakari/kalakriti in Hindi, Marathi, Sanskrit, Bengali, Malayalam, Telugu etc. Only about 1% of the words by students and 14% by teachers, were related to plan such as *namuna, nakhsha, nakshika*. About 3% of students' ideas were related to the words like 'attractive' or 'beautiful' and its related counterparts in Indian languages like *'sundar' and 'sundarta', 'khoobsurat',* in Hindi. About 1% of student' words and 5% of teachers words were related to the English word 'creation'/invention, such as *'aavishkaar', 'khoj', 'shristi'*. The response to this question also suggests that most students and teachers associated design very strongly with art.

Each designer came up with one word. However, interestingly only 2 words were generated: *abhikalpana* (means planning), generated by 3 designers and *vastushashtra* (an Indian terminology for architecture), generated by 2 designers.

3.7.1.5 Designing in school subjects

A list of 20 vocational or technical school subjects were provided to students in the questionnaire. Students and teachers were required to indicate by a tick mark the subjects that they considered were related to design or which involved designing.



Graph 3.1 Middle school students' and teachers' association of school subjects with design

Teachers on the whole associated all subjects with designing. However, students rated some subjects as designerly more often than other subjects (Graph 3.1). The top five subjects that were most frequently associated with design by students were painting, drawing, flower decoration, basket weaving and handicraft, while the bottom 5 subjects that were least frequently associated with design were cooking, drama, music, book binding and library management.

An interesting difference between these top 5 and bottom 5 subjects is in the nature of the involvement (whether hands-on or minds-on) and the nature of the final products resulting from either the process of designing or artistic endeavor. Three of the bottom 5 subjects, except cooking and book binding, the end products are not tangible entities and do not involve hands-on activities. They are more associated with performance (drama and music) or organization (library management). The top 5 subjects have tangible products resulting from hands-on activities.

A question exclusively designed for teachers and designers was to find out whether they considered that design education should be a part of the school curriculum for students. About 27% of the teachers suggested that design education would bring out the creativity/other aptitudes of children. Interestingly 24% of the teachers suggested that design education should actually be included in teachers' education in order to make teaching more effective.

Of the 5 designers, 4 agreed that design should be introduced as a part of the school curriculum for students. Two of the designers suggested that design education would enable students to do hands-on activities and provide opportunities to nurture their creativity and imagination while 2 of the designers suggested that design education would help in sensitizing students to various aspects of design, including environment and sustainability. The designer who disagreed mostly felt that introducing design in the curriculum would be an unnecessary burden on the students, who anyway have the ability to design, and get involved in activities very similar to design like building and putting things together. Two of the designers suggested that design could be integrated into all the subjects instead of being a separate subject. They called for a more holistic approach to design rather than mere reductionist way of just introducing another subject.

3.7.1.6 Design occupation and gender suitability

A list of 18 design related occupations were provided and the respondents were required to suggest whether each of these occupations were suitable for girls/women, boys/men or both. Among the 18 occupations, 8 occupations were selected by more than 60% of the respondents as suitable for both genders

Occupations such as cooking, fashion designing, jewelry designing, teaching, tailoring and interior designing were considered suitable for only females. Similar findings have been reported by Chunawala (1987), Khunyakari (2008), Mehrotra (2008).

Carpentry was considered suitable exclusively for males by more than 90% of the respondents. Except for the profession of carpentry, both teachers and designers did not portray any gender-role stereotypes for other occupations. Girls demonstrated more stereotypes than did boys and, for the occupations of interior designing and painting, more

girls perceived it to be the feminine occupations while more boys considered them suitable for both.

Students' and teachers' responses were seen to be based on two factors, the current representations of men and women in the given occupations and their gender and social stereotypes associated with each occupation. For example, even though most Indian men are found to be chefs or cook in restaurants and hotels, students associated cooking with females since it is socially considered as a female's job at home.

3.7.1.7 Attitude and interest towards design

A list of 10 statements was used to probe students' and teachers' general interest and attitude towards design. Overall both middle school students and teachers exhibited positive attitude towards design. However, some stereotypes were also revealed.

Statements	**Agreed responses (%)**	
	Students	**Teachers**
I think designing requires creativity	90	91
I am interested in design	75	97
If design is introduced as an optional school subject, I will choose to study/teach it	74	85
I think girls/women can be better designers than boys/men	70	68
I think more girls/women than boys/men choose design professions	69	79
I like to read magazines about design and designers	62	56
We can design only after taking up courses in design	35	18
I feel designing needs a lot of mathematics	24	29
Anyone who is not good at drawings should not take up design courses	25	3
Design work is boring	21	0

Table 3.2 Middle school students' and teachers' attitude towards design and design learning

To the statement, whether designing needs a lot of mathematics, only about a fourth of students and teachers agreed, suggesting that most of them feel that design does not require mathematics. The low percentage of students who felt that mathematics is necessary for designing can be related to the attitude that designing is relatively easy.

It was found that about a third of the sample (33%) stated that for designing we do not require any special course. This reflects the generalist attitude towards design, what Archer (2005) and Cross (2006) suggests that design ability is possessed by all.
It was also found that both students and teachers demonstrated some gender stereotypes in their response to design learning. A large proportion (70%) considered that girls/women could be better designers than boys/men and more girls/women choose design professions. No difference was found between students' and teachers' responses to these, indicating that even teachers held this stereotype.

3.7.1.8 Nature of design

A set of 16 statements probed students' and teachers' ideas about the nature of design and designing activity. Students and teachers had to indicate whether they *agreed, disagreed,* or were *unsure* about each statement. The responses are given below in categories that were created to analyse them.

Design as activities	***Agree (%)***		***Unsure (%)***		***Disagree (%)***	
	Students	Teachers	Students	Teachers	Students	Teachers
To design means to make patterns	46	62	33	21	21	18
Design is about the appearance of things	54	62	29	24	17	15
To design means to draw	40	29	29	71	31	0
Designing means to give shapes to things	60	85	28	9	13	6
Knowledge and skills in design						
In design one has little opportunity to work with one's hands	35	12	29	27	36	62
Scientific knowledge is used in design	39	77	31	9	30	15
Consequences of design						
Designing improves things	70	97	20	0	10	3
A well designed product must look attractive	58	59	24	12	17	29
What designers do						
Designers solve real world problems	35	65	40	36	25	0
Designers get their ideas by observing people	66	62	21	3	13	35
Is design modern or ancient?						
Design is a modern activity	48	29	22	12	30	59
Ancient people have designed things	66	85	23	12	11	3
Design and other disciplines						
Art is the same as design	52	50	28	27	20	24
Designing and engineering are the same	17	24	47	32	37	44
Specific talent in design						
Design is a daily activity that we all do daily	56	85	22	9	22	6
People can learn to design	76	94	15	6	8	0

Table 3.3 Middle school students 'and teachers' ideas about design and designers

As indicated in Table 3.3, about 60% of students and 85% of teachers agreed that '*designing means to give shapes to things'*, and '*designing improves things'*. All designers agreed with these statements and 2 of them added that the *'things'* could be a product or a system. While more than half the proportions of students and teachers agreed that design is '*...about*

*appearance of things'*and that *'a well-designed product must look attractive'*, 2 designers suggested that a well designed product by default *is* attractive by virtue of its usability.

About half the proportions of students and teachers also agreed that design and art were the same. Less than one-third of the students and teachers proportions thought that designing and engineering were same. This reflects students' and teachers' strong association of design with art and less association with engineering. Two of the designers suggested that art, design and engineering were not *'same'* but *'similar'* since they used the same tools. They all argued that design has a pragmatic side which art lacks.

About 66% students and 85% teachers believed that ancient people did design. To the contrary statement regarding design as a modern activity, 48% students while 29% teachers agreed. In the interview a few students who agreed with both the statements suggested that design was both modern and ancient since there are more and varied design professions today, which were absent in ancient times. All designers disagreed with design being modern and argued that design was ancient.

About 76% students and 94% teachers agreed that *'people can learn to design'* which reflects a positive attitude of students regarding design learning. Together with the negative response to the attitudinal question on design (*We can design only after taking up courses in design*), responses may reflect the attitude that design is relatively easy for people to learn on their own and do. About 56% students and 85% teachers agreed that all people engage with design in their daily activities. Students in the interview suggested that people engage in design through *'drawing', 'painting', 'garnishing food'*. All designers reflected a generalist view of design and agreed that people can learn to design and people do design in their daily activities. Two of the designers also pointed out that *people can forget to design also* reflecting the view of Cross (2006), who suggested that design ability can be lost.

For the statement, *'designers solve real world problems'*, only about a third of students (35%) agreed, while 65% of teachers agreed. Teachers were probed for this response in a separate question where they provided justifications. Teachers who agreed mostly suggested that designers are apt at planning and so can solve any problem through their planning strategies (38%). About 17% indicated that designers solve problems by improving/making systems/ products. Those who disagreed mostly thought of social and political problems as real world problems and denied that designers can solve them (34%). Interestingly 2 of the designers argued that designers can create problems with the products/systems that they design and therefore designers need to be responsible. However, they did agree that designers *'intend'* to solve the problems.

More than 60% of both students and teachers sample agreed that designers get their ideas by observing people. More teachers (35%) than students (13%) disagreed with the statement. When probed further with students who disagreed with the statement, students revealed that, *'designers are creative, they make things on their own'*.

3.7.1.9 Skills of a designer

A list of 10 skills was provided and students and teachers were expected to tick mark those which they felt were necessary skills of a designer. The top skills that students and teachers most frequently associated with designers were *sketching* (83%), *planning* (81%), *generating ideas* (81%), *working in a team* (77%), and *imagining new things* (71%). The bottom 5 skills

associated with designers were *observing people* (64%), *gathering information* (64%), *communicating with others* (63%), *understanding how things work* (62%) *and solving problems* (35%). Thus both students and teachers showed a good understanding of the skills that a designer might possess. However, a very important skill, *solving problems* was not considered important by them. Only 35% of the entire sample had marked this skill as necessary for a designer. All designers agreed that they have these skills but in varying degrees. In fact one of the designers suggested that '*all designers are different because they have different degrees of these skills'*.

3.7.1.10 Qualities of a designer

A list of 20 contrasting pairs of qualities of a designer was presented in a question, wherein students and teachers were asked to circle any one of each pair. These qualities included (i) personality traits such as lazy/hardworking, kind/cruel, or timid/bold, (ii) skill-based traits such as organized/unorganized, practical worker/abstract thinker, (iii) biological traits, such as female/male or young/old and (iv) social traits such as poor/rich, or popular/unpopular.

It was observed that for all the personality traits, both students and teachers most frequently marked the positive qualities. Thus designers were viewed as intelligent (96%), hard-working (96%), honest (87%), interesting (87%), kind (96%), honest (85%), modern (82%), original (81%) and friendly (80%). Some teachers and all designers selected both the qualities.

Regarding the skill-based traits, it was observed that both students and teachers considered designers to be mostly organized (87%), interested in ideas (84%), artistic (78%), and scientific (71%). About 57% of the sample considered that designers were practical worker.

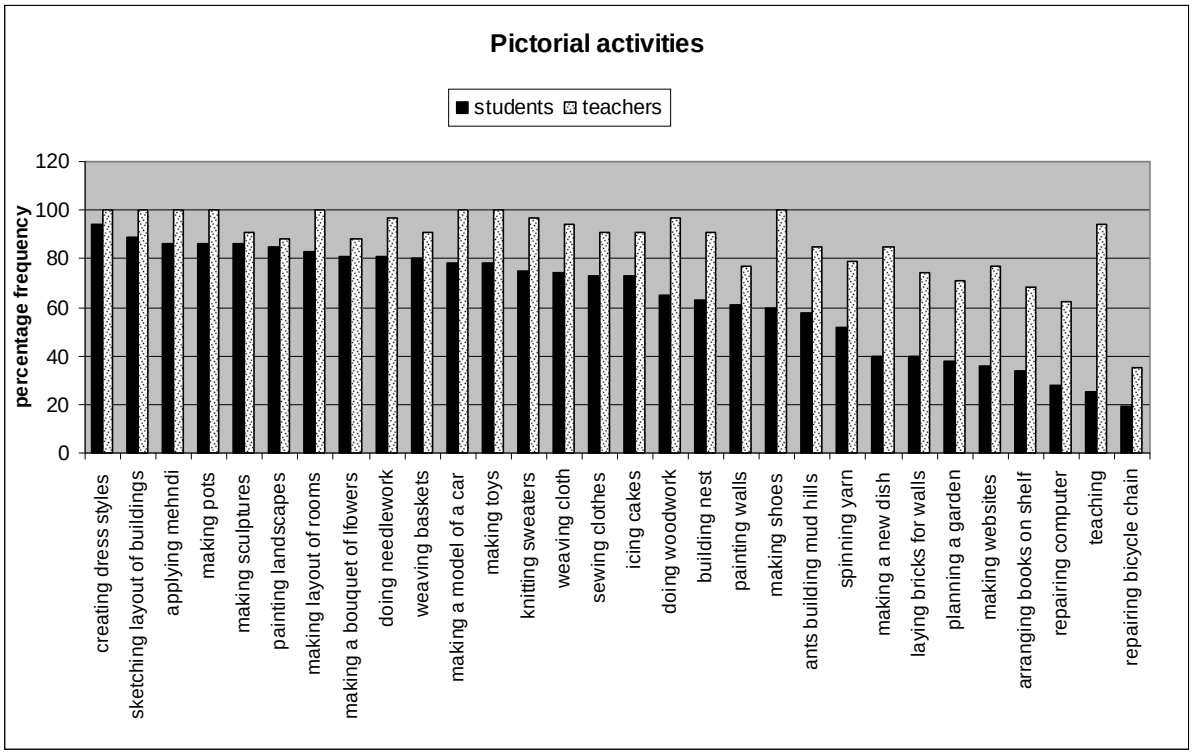
While marking the biological traits, about 48% of the entire sample stated that designers were females, 33% were males. This indicates that they considered design as largely a feminine profession. Most of them (79%) also suggested that designers were mostly young. While responding to the social traits, students and teachers mostly suggested that designers were both popular (68%) and rich (70%). All the designers showed a tendency to mark both the options for all the qualities.

3.7.2 Section D: Pictorial activities

Section D was common to the elementary and middle school students, teachers and designers. This question was given to all the respondents at the end of all the questions in order to avoid any influences of this activity on respondents' preliminary ideas on design and designers. The question consisted of 30 pictures and the respondents were required to indicate which activity pictures were related to design. As mentioned before the section had 2 versions: male version and a female version (Figs. 3.1, 3.2). Around 260 male versions were responded to by elementary and middle school students, while 271 female versions were collected from this sample. Among teachers, 20 responded to the male version while 14 teachers got the female activity pictures. The cross tabulation and chi square analyses revealed that there was no difference between the male and female pictures in their rating as designerly activities by the entire sample.

Graph 3.2 displays the perception of the activities by all students (elementary and middle school) and teachers. Middle school students more frequently marked the activities as

designing activities in compared to the elementary students while teachers more frequently associated all the activities with design than all students.



Graph 3.2 Students' (elementary and middle school) and teachers' perception of pictorial activities

The top 10 activities which were related to design by most students were largely associated with making patterns/drawings and making tangible products: creating dress styles, sketching layout of buildings, applying mehndi, making pots, making sculptures, painting landscapes, making layout of rooms, making a bouquet of flowers, doing needlework and weaving baskets. The activities which required organizing were least frequently associated with design by students, such as planning a garden, making websites, arranging books on shelf, repairing computer, teaching and repairing bicycle chain. Teachers marked most activities as related to designing except repairing bicycle chain.

Most designers suggested that all the activities could be related to design based on how one came about doing it. If problem solving was involved in the activities, design was happening.

3.7.3 Section B: Draw a designer at work

Only elementary and middle school students (511 in total) were asked to 'draw a designer at work'. Even the interview questionnaire did not include this Section. Most students (96%) depicted a person most often working alone (95%). The large number of students drawing a solitary designer indicates that students considered designing activity as an individual activity and not a team work. However, 9% of students did draw other human figures in their drawings as customers/clients, with whom the designers were working, and usually models in case of dress or fashion designers (Fig. 3.3).

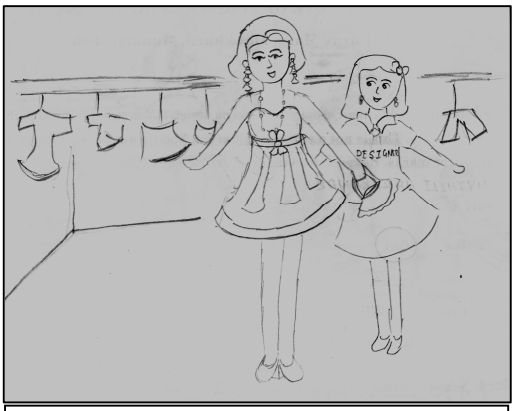


Fig 3.3: A female designer dressing up a female model, (a girl of Class 8)

About 60% of the students indicated their designers were males and 40% indicated their designers were females and more boys (87%) drew male designers while more girls (68%) drew female designers. It was found that younger students (Classes 5 & 6) depicted more male designers. This tendency however is reduced with increase in age and more than half the Class 8 students (52%) depicted female designers. It is interesting to note that regarding drawings of scientists there is an increase in stereotype with respect to gender, that is, fewer female scientists are depicted by older students (Chambers, 1983; Newton & Newton, 1998). However, in the present sample, it was found that while there were more females depicted in students' drawings, these were more from the older students. However most of these females were depicted stereotypically as dress/fashion designers.

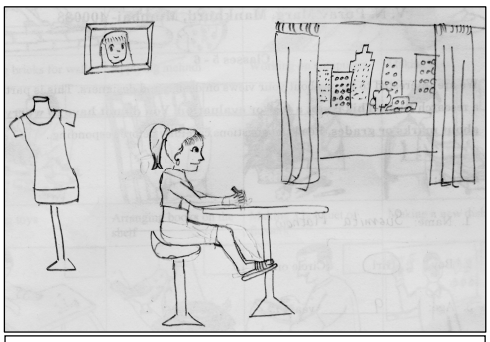


Fig 3.4: A female designer working indoor, in a city, seated at a desk, sketching; (a girl of class 6)

Most designers (87%) looked either young (Fig. 3.4) or middle aged (subjective analysis) with modern outfit (55%). Most designers were reported to be working indoors (69%) (Fig. 3.4), either offices (38%) or at home (29%) in cities (72%). Furniture (desk and chair) was the most common artefact depicted by students (45%). Girls were significantly higher in number than boys in depicting artefacts such as dress/cloth and mannequin/hangers, while boys were significantly higher in depicting artefacts such as vehicles. Other artefacts depicted were blueprint/2D design, civil structures, robots/machines, very few 3D models etc.

The designers were usually drawn working at a desk mostly standing (73%) or seated (19%) (Fig.3.4). The activities that were mostly depicted by students were designing (sketching/modelling), engaging in artistic work (painting, decorating), making or repairing things, displaying/advertising/walking on ramp, trying/testing (Fig. 3.3), laborers' work like painting buildings, laying bricks), and handling things.

Cross tabulations revealed that older students depicted their designers as designing (sketching mostly) more often than the younger students. Although a few students mentioned that their designer was designing, they actually depicted their designers as either painting a scenario or painting walls. The fact that many students depicted their designers engaged in artistic work represents their strong conflation of designers with artists. This finding confirms our findings in the written responses where students associated design mostly with art.

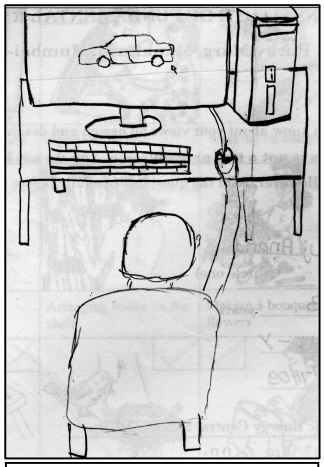


Fig. 3.5 A car designer designing on computers (a boy from Class 8)

The professional that was mostly portrayed by students as designers was dress/fashion designer (32%). It was found that more girls (41%) than boys (23%) depicted dress designer. Also except a few depictions, most of these dress designers were females. Other professionals depicted were artist, architect, labourer, interior designer, scientist, car designers and model. More boys than girls depicted their designers engaged in engineering work and depicted engineers mostly software, car, civil and robot engineers. About 6% (mostly boys) depicted their designers using computers for designing (Fig. 3.5).

Both boys and girls seemed to have assigned a gender and professional stereotype to their drawings by depicting more number of female dress designers. Interestingly, these stereotypes seem to grow progressively with age with older students depicting more female dress designers than younger students. A large number of students depicting dress/fashion designers could also be due to the influence of the strong association and use of the word design with dresses. Colloquially, the word design is used to represent any pattern or form of dresses. It is one of the most common words uttered in a conversation between a customer and a tailor in India. Thus it could be an influence of the colloquial use of the word of design.

Chapter 4

Development and trials of the design activities

The development of the design activities occurred through three trials (see Fig. 1.3). The first and the second trials were organized in the form of workshops and were similar since they both involved "one-group pre-post intervention" research design in which Class 7 students' ideas about design and designers were investigated before and after their engagements in specific design activities. The 'activity trial' (Fig. 1.3) involved testing of one specific design activity with Class 8 students. The aim of the 'activity trial' was not to see a change in students' ideas of design due to their engagement in the activity, but to test and develop an activity for Indian middle school students that can be included in the curriculum. The broad aim of trying out all the activities with the students was to explore the possibilities of developing them as units that can be incorporated in the curriculum for Indian middle school students.

4.1 Criteria for designing the design activities

Based on the review of literature and our own understanding of the Indian middle students' ideas about design and designers gained through the pilot survey, the following criteria were maintained while setting up the design activities for Indian middle school students.

- Begin with exploration of tangible products which can be handled, manipulated and analysed;
- Choose appropriate products, some of which are familiar and others which are unfamiliar to students;
- Design activities which would engage boys and girls equally throughout the extended period of the activities;
- Design activities which allow both 'hands-on' and 'minds-on' engagement;
- Make the activities 'authentic' by setting them in a context familiar to all the students;
- Provide opportunities for students to work in collaboration with each other and work for a common goal;
- Encourage students to communicate their ideas to others, allow for peer review and critical evaluation of each other's ideas;

- Provide opportunities for students to assume the 4 roles envisaged by Roberts (2005);
- Design activities which involve students to visualize their ideas on paper, plan, and construct their design with easy available materials;
- Choose a design problem that allows for multiple solutions;

4.2 Sample for Trials 1 and 2: For the first trial, 25 students of Class 7 (7 girls and 18 boys) and for the second trial 14 students (6 girls and 8 boys) from Class 7 were selected from two different urban schools. Both the schools were co-educational and located in the vicinity of the researchers' institution in Mumbai.

4.3 Sample for 'Activity trial': 6 students were drawn from Class 8 from an urban school. Two girls and 4 boys worked in 3 dyads for the activity. 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.

4.4 Methodology

In Trial 1 students were asked to form single sex groups of 3 or 4 members. In Activity trial students worked in single sex dyads while in Trial 2, seven dyads of single sex members were formed. Trials 1 and 2 had the following sequence of activities

1. Handling and analyzing a few familiar artefacts,
2. Reviewing the history of a familiar artefact,
3. Handling unfamiliar artefacts, exploring and identifying them,
4. Designing an artefact (without making in the 1st trial; with making in the 2nd trial)
5. Looking for design problems in the real world (in the 2nd trial only)

The design activities were developed keeping the 4 roles view of Robert's model and also developing our own framework of progressing from the domain of familiarity and maximum certainty (handling familiar artefacts) to a domain of unfamiliarity and least certainty (designing and making artefacts) with an evolution in the understanding of design.

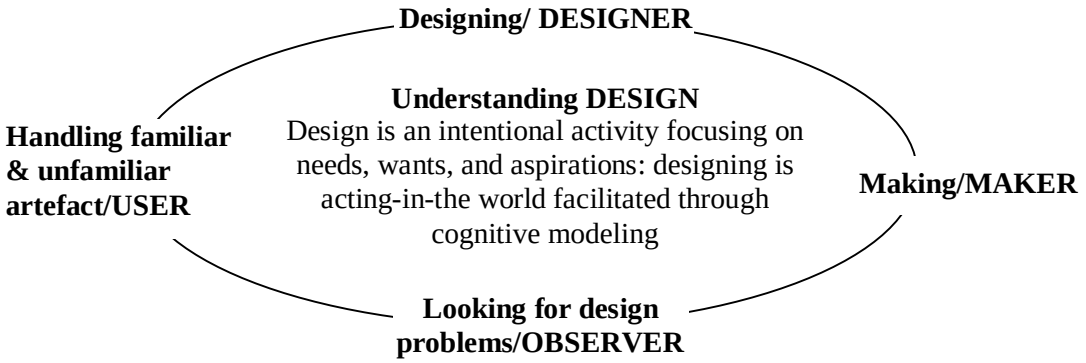


Fig 4.1: Four Roles of students in a design classroom. Adapted from Phil Roberts (2005)

In the Robert's model, each of the roles was identified with the design activities developed for the students (Fig. 4.1). For example, the role of the User was identified and related to the activities of handling familiar and unfamiliar artefacts and reflecting on the history of a familiar artefact. The roles of the Designer and the Maker were related to the activities of designing a solution for a real world problem and implementing the solution through

modeling, respectively. The role of the Observer was identified with the activity of actually coming up with real world problems that could be resolved by creating artefacts.

4.4.1 The design activities in Trial 1

The following table provides the details of the interaction in Trial 1.

Sessions	Researcher-student interaction Trial 1
Day-1	-Pre intervention survey of students' ideas about design and designers [~40 min] -Handling of 2 familiar artefacts (electric iron, fountain pen [~40 min] -Handling of 1 traditional artefact (hurricane lantern) [~30 min]
Day-2	-Recognizing 3 displayed unfamiliar artefacts. Students guessed the functions of these artefacts based on the structures from among the choices provided to them [~30 min] -History of a familiar artefact (writing tools) presented by the researcher [~40 min]
Day-3	-Handling of 2 familiar similar looking artefacts (ball-peen and 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 (3 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 the other groups who questioned, evaluated and provided feedback on the presented design solutions. [~80 min] -Post intervention survey on students' ideas about design and designers

Table 4.1: Researcher-student interaction Workshop 1

4.4.2 The design activities in Trial 2

Activity	Aim of the Activities	Role of students
Card sorting exercise	To explore how middle school students categorize a given set of pictures of technological artefacts	*Observer*
Handling familiar artefact	• Introduce students to the structure and function relationships of artefacts; • make them aware that the physical and structural properties of an artefact are consciously chosen by the designer such that the artefact can perform the desired function;	*User*
Discussing history of familiar artefacts	• Encourage students to question the development of the design aspects of artefacts; • make them appreciate that artefacts have undergone intentional and purposeful changes; • to humanize design; design is not given; the activity of design has an agent	*Observer*

Activity	Aim of the Activities	Role of students
Handling unfamiliar artefacts	• Sensitise students to the structure and function relationships of artefacts; • Provide opportunities to students to investigate the physical properties of the artefact and derive the possible function(s) of the artefact; • Introduce uncertainties in the tasks before the actual design tasks;	*User*
Designing artefacts	Provide opportunities to • Design a solution, in terms of artefacts, for a real world problem; • Generate ideas, sketch ideas, identify constraints, make design decisions, • Integrate concepts from different disciplines like scientific concepts • Evaluate their designed solutions in terms of the given criteria;	*Designer*
Making artefacts	Provide opportunities to, • To make what they have designed; • Choose and select materials for modelling; • Develop skills in making, fixing, using tools like hammer; • Evaluating their products in terms of the given criteria;	*Maker*
Look for design problems in the real world	Provide opportunities to • Look for design problems in the real world; • State the problem in terms of a design problem statement and write a design brief; • Identify criteria and constraints for the their proposed problem;	*Observer*

Table 4.2: Design activities in Trial 2

The researcher-students interactions for Trial 2 lasted for over 8 days.

4.4.3 The design activity in 'Activity trial'

The design activity in 'activity trial' involved handling and evaluation of two familiar/unfamiliar products: vessel lifting tongs. Students were being interviewed while they worked in dyads to evaluate the tongs and tested them on different kinds of vessels.

4.4.4 Data

Students' written and drawn responses to all the activities and audio and video recordings of all the sessions served as primary data. Other data included researcher's own reflections while observing the classrooms during the activities. The finished designed model made by the students in the Trial 2 was also used for analysis.

Chapter 5

Analysis of the design activities

5.1 Analytical framework

The philosophical stance on the nature of technical artefacts by Kroes & Meijers (2006) in their research program, ‘‘The Dual Nature of Artefacts’’, served as a framework for analyzing students’ handling of familiar and unfamiliar artefacts. According to them, technical artefacts have a dual nature: physical structures (having properties such as size, colour, shape, weight, smell) and functional properties. A full account of a technical artefact can only be given by describing both its function and its structure. This is so because even though a designer might intend to create an artefact which would serve some function (called the ‘proper function’), users might still identify some other functions that could be performed by the same artefact. These functions which were not intended by the designer are called the ‘accidental functions’. Thus both designers and users employ reasoning patterns to get from one nature of the artefact to the other.

In 2004, Barlex reported a framework for describing the design decisions made by students in the context of school-based designing and making (Barlex, 2007). This consisted of (a) conceptual (b) marketing (c) technical (d) aesthetic and (e) constructional decisions (Fig. 1.2). Conceptual decisions are related to the overall purpose of the design (what sort of product it will be). Marketing decisions are related to the user (who the design is for, where will it be used and where will it be sold). Technical decisions are concerned with how the design will work. Aesthetic decisions are concerned with what the design will look like. Constructional decisions are concerned with how the design will be put together. This framework was used to analyse students’ solutions to the design problem given to them.

5.2. Handling familiar artefacts:

In the trials of the design activities several familiar and unfamiliar artefacts were used to make students reflect on the physical and functional natures of that artefact and on the relations between these two natures.

The analysis of activities in Trial 1 revealed that while handling the familiar artefacts (electric iron, fountain pen, hurricane lantern), most groups could identify many of the parts of these artefacts, but were however, not aware of the materials used to make those parts. Based on the known functions of the parts of the artefacts, students introduced their own terms/phrases for describing the different parts of the artefacts, such as “part from where ink goes to nib”, “finger grip”, for the nib holder; “part where ink is put” for the ink holder in case of the fountain pen. 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 students moved to and from the structure and function of artefacts.

While handling the familiar artefact (retractable ball-point pen) in Trial 2, most dyads came up with several parts of the pen and also came up with different creative uses of the pen and its parts, based on the structure of the pen (such as used by tribals as a weapon, as an arrow, as a toy, as a whistle, or for digging earth for water). However, students related the structure of different parts of the pen to their functions in a very superficial way. For example, *‘body holds or protects the refill’*, *‘spring helps the refill to go up and down’*. The fact that a refill

itself can function as a pen but the body of the pen enables all the parts to be assembled together was only evident in 2 of the dyads' responses. Also that the main purpose of the spring is to actually pull back the refill when it is not in use was evident in only one of the dyads' responses. Most students wrote that the function of the pen was to write. The fact that a ball-point pen is designed to write only on papers was almost absent from the responses of students. This is understandable since most of our writings in classrooms happen on papers.

5.3 History of artefacts

Historical analysis was an activity that followed the activity of handling a familiar artefact. It was designed to make students sensitive to the considerations of designers (both ancient and modern) while designing writing tools to suit the surfaces available to write on. The fact that the nature of the writing surface available affects the development of the writing tool and vice versa was the basis of the historical analysis task. In the historical analysis of the writing instruments, students got the opportunity to actually relate the function of an artefact to its structure. A range of writing surfaces in pictures was provided to students starting from a stone slab to paper and cloth. They were asked to suggest the kind of writing tools that could be used to write on those surfaces. Students also had to consider the availability of materials in the concerned period. Most dyads could infer the structure of the writing instruments.

5.4 Handling unfamiliar artefacts:

While analyzing three different kinds of knife sharpeners (artefacts unfamiliar to students and performing the same function: A, B & C), in Trial 1, 3 out of 7 groups students could correctly infer the intended functions of the three sharpeners. The result of this activity has appeared in a peer reviewed international journal (Ara et al, 2009).

Fig. 5.1 Probing the slot of 'A' with handkerchief

Students working in groups adopted several strategies such as *cognitive strategies* (active discussions among group members) and *handling strategies* (handling and manipulation of the artefacts) while identifying the functions. The analysis suggests that interaction played an important role in identification of the intended function of the artefacts. Groups which were less interactive (also less critical of others' ideas, accepted ideas without objections and were less defensive of their own ideas) were unsuccessful in identifying the intended functions of the artefacts.

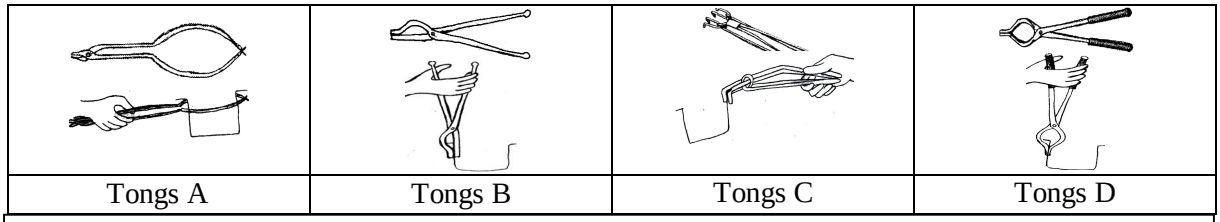
While handling the sharpener, students often probed them with whatever was available with them at the time, such as finger, pen, pencil, handkerchief and paper.

Accidental functions for the artefacts were suggested by all groups. Though based on the structures of the knife sharpeners, the accidental functions listed by students were typically related to their daily activities: *toy, pencil sharpener, paper weight, wrapping for cello tape or bandages, etc.* Some students found it difficult to come up with the intended functions of the artefacts possibly because knife sharpeners are not very common in Indian homes. All the knife sharpeners were unfamiliar to students but students suggested fewer accidental functions for the knife sharpener which offered less perceived affordances.

5.5 Students' evaluation strategies of familiar/unfamiliar artefacts

In Activity trial, 6 students from Class 8 were required to test, categorize, evaluate and redesign 4 pairs of utensil lifting tongs (Fig. 5.2). The result of this activity has appeared in a peer reviewed international conference publication (Ara et al. 2011). Students checked their predictions about the effectiveness of the pairs of tongs in lifting kinds of utensils. They evolved a few strategies for testing the pairs of tongs ranging from systematic (testing all the 4 pairs of tongs on all the 4 utensils and concluding about its performance) to unsystematic strategies (testing one pair of tongs on only one kind of utensil and concluding about its performance).

All dyads used the data obtained during testing in generating both the categorising and evaluative criteria. The 3 dyads sorted tongs into groups based on one or more than one of these different qualifying criteria such as *appearance*, *function* and *materials* and *ergonomics.* The criteria employed for evaluation were *functional efficiency*, *multi-functionality* and *ergonomics.*



Tongs A	Tongs B	Tongs C	Tongs D

Fig 5.2 The 4 pairs of tongs used with their working mechanisms

As improvements, student either suggested addition of a new component in their redesign or suggested modification. All the 3 dyads seemed to have assumed the perspectives of users and mainly focused on achieving functional efficiency and providing better ergonomics to users while using the tongs.

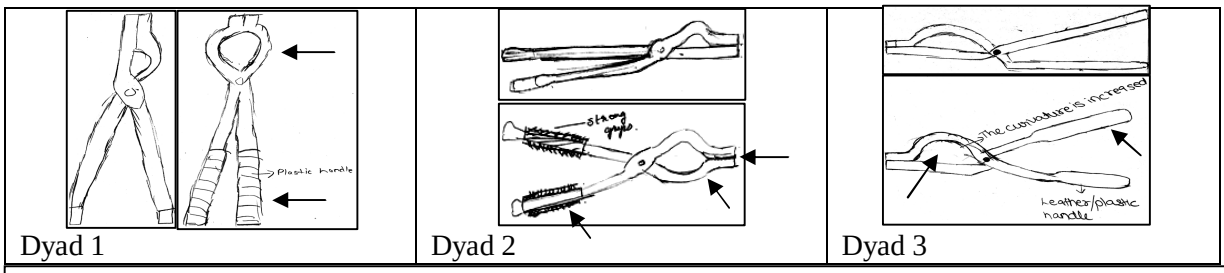


Fig. 5.3: The redesigned solutions of the 3 dyads

However 2 of the dyads adopted a linear approach to redesign and also tended to propose their redesign ideas around their selected best design (Fig. 5.3). Redesign activities provided opportunities for students to critically select features in the products that could be improved.

5.6 Students' solution to the design problem: Without make (Trial 1) and with make (Trial 2)

According to Schon (1987) designing is a holistic skill. It must be grasped as a whole, by experiencing it in action. Thus we relied on learning about design by "doing" design and providing opportunities to students to 'do' design. Design can be considered as a problem

solving process employed by professional designers who move through series of iterative steps to create solutions. Real-world problems are ill-structured with unclear goals and contain little information. These problems have multiple solutions and several ways of reaching them. These problems thus provide opportunities to students to take risks and deal with uncertainty unlike problems in physics and mathematics, that are well-structured, have single right answers and can be derived by following a logical step-by-step process.

5.7 The design problem in Trials 1 and 2

The design problem specified here came up in consultation with Prof. Bapat of Industrial Design Centre, IIT, Mumbai. The problem was modified for the purpose of this study.

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

In Trial 1 groups were asked to work collaboratively and make a sketch of an artefact to solve the given problem. Each group was asked to sketch two different solutions for the given problem. Students worked for three hours to sketch their solutions and write design proposals. Each group was asked to select their 'best' design to present to other groups.

In Trial 2, dyads were asked to first design one/more solutions for the same problem and then make a model of their design with easily available materials. They were asked to list the materials that they required for their model and hand them to the researchers at the end of their designing. Students in both the trials were asked to take into consideration, factors related to users (old aged women with poor vision and backache problem), materials of the needles (aluminium/plastic/knitting needles and iron sewing needles) the size of the needles (long knitting needles and small sewing needles).

5.7.1 Analysis of students' designed solutions

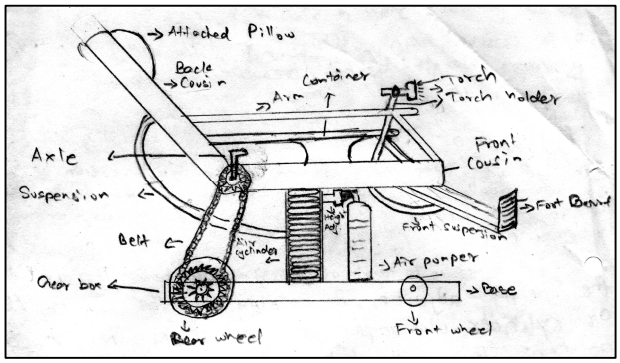
Creativity in students' design was observed with respect to the following features as mentioned in section 5.1, i.e. using imagination, pursuing purposes, being original, and being of value.

(i) Using imagination

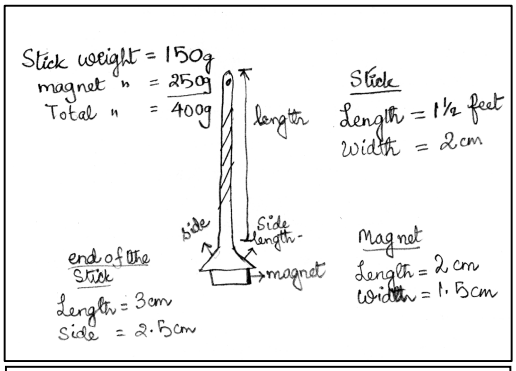
All the groups in Trial 1 (except 1 group) clearly drew and wrote about their best designed solution suggesting that they could mentally visualize the images of the product (Fig. 5.4). The imaginative thought was clearly evident in students' designed solution in design-with-make activity in Trial 2 (Fig. 5.5).

However, an important distinction in their designs was that while groups in Trial 1 imagined their products varying from the most complex to very simple designs, all dyads (except 1) in Trial 2 made very simple and easy to make designs. It was also observed that while modelling their ideas, Trial 2 students deviated very little from their design, in their models. Thus they had a clear picture of what they were making when they drew their designs.

Although technical drawing skills were taught to both the groups, only Trial 2 students attempted to depict their designs in at least two views, front and back.



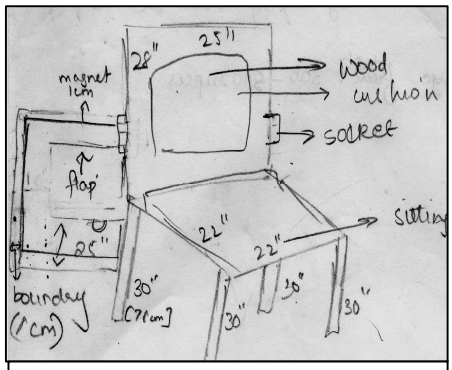
Fig, 5.4 A designed solution by a boys group in Trial 1



Fig, 5.5 A designed solution by a girl dyad in Trial 2

(ii) Pursuing purpose

Although the purpose was already elaborated in the design brief, all the groups designed their artefacts for all people with backache problem who need to pick needles from the floor. In Trial 1, out of 12 design ideas generated by 7 groups, 8 designs considered lifting both metallic and non-metallic needles. Lifting a metallic needle is easy since it just involves the use of magnet. However, lifting a knitting needle from the floor was a challenging task, which most of the designed solutions of Trial 1 aimed to do. A girls group in Trial 1 looked at the problem very differently. While others were trying to find a solution to lift the needles, this group tried to prevent the needles from falling by designing a chair with a 'flap' (Fig 5.6).



Fig, 5.6 A designed solution by a girls group in Trial 1

Trial 2 students also mentioned that their device could be used by any person having backache problem. It was interesting thing to observe that none of the designed solutions of Trial 2 attempted to lift the non-metallic knitting needle. All the dyads were concerned with lifting the metallic needles and all the dyads made use of magnets in their models.

(iii) Being original

Since students were unfamiliar with any artefact that can lift fallen needles, the design problem was new to students in both the trials. All groups and dyads in Trials 1 and 2 respectively, however, generated solutions that could therefore, be said to be original. An important difference between the designed solutions of Trials 1 and 2 students was that while these solutions of Trial 1 students varied from complex to simple designs and were all unique and different from each other, the designs of Trial 2 students were all very similar to each other except 1 designed solution of a boys' dyad who attached a controllable lighting mechanism into their design. Most designs in Trial 2 made use of an elongated stick/tube/telescopic rod, at one end of which was attached a powerful magnet.

(iv)Being of value

The designs of all groups aimed to improve people's quality of life. Two groups in Trial 1 also enhanced the quality of their design by increasing the possible uses of their artefacts. 2 dyads in Trial 2 also enhanced the value of their design by increasing their possible uses (used as a walking stick for old people).

Besides creativity, other elements (as described by Barlex, 2007) observed in students' designed solutions were elements of feasibility, use of scientific and technological concepts, evidences of conceptual, technical, aesthetic, constructional and marketing decisions made by students, as described below.

Elements of feasibility

Four groups in Trial 2 used magnets in their design but the complexity involved differed. Although all the groups kept the user in mind, only 4 out of 12 designs were easy to make and feasible. The other designs were either too ambitious/big (like the wheel chair design) or too expensive (80,000-1,20000 Indian rupees!) thereby indicating that these students not constrained by making what they had designed took more risk compared to the Trial 2 students who made their designs very simple and which could easily be modeled with every day and easily available materials.

Use of scientific and technological concepts

In Trial 1 compared to Trial 2, students showed evidences of using more scientific and technological concepts, such as magnetism, air pressure, air suspension, electricity, telecommunications and use of remote controlled car, telescopic rod, radio sensors, radar technology, pulley/gears, wheel chair, alarm and battery. Trial 2 students however did not seem to make of any scientific or technological concepts besides using magnets. Only I dyad showed a clear evidence of utilizing the concept of electricity in their model.

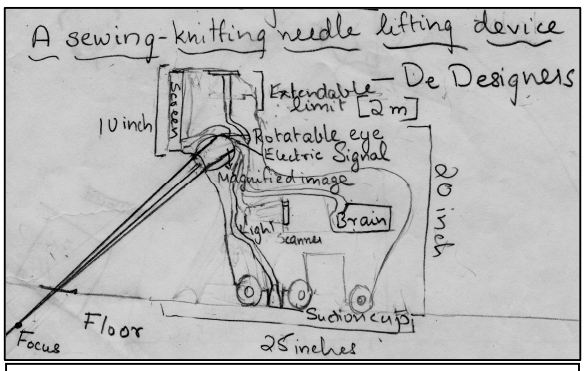


Fig 5.7: A boy dyad in Trial 1, using radio sensors and scanning technology

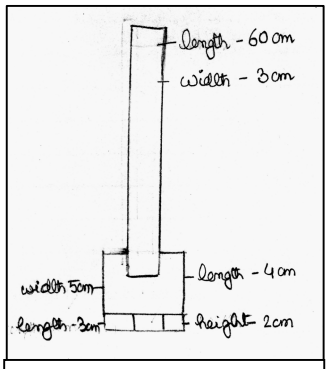


Fig 5.8: A girl dyad in Trial 2 using magnet

Evidence of conceptual decisions

Conceptual decisions are concerned with the overall purpose of the design, that is, what sort of product it will be. Since the design problem and design brief were already provided to the students, this was not applicable to the sample

Evidence of technical decisions

Technical decisions are concerned with how the design will work. In Trial 1, of the 7 groups, 5 groups indicated how their design will work. Two groups could not clearly indicate how their design will lift the needles from the floor. In Trial 2, all the dyads showed evidence of technical decisions taken by them. They clearly explained how their device will work on completion.

Evidence of aesthetic decisions

In Trial 1, students did not show any evidence of using aesthetic decisions. In Trial 2, except 1 dyad, all the dyads took aesthetic decisions, but this was not represented in their design but was evident in their modeled solutions.

Evidence of constructional decisions

Constructional decision involves how the design will be put together. Although Trial 1 students were not required to make their designs, of the 12 deigns, 4 designs could be constructed with everyday materials. 3 groups actually suggested ways of making their designs with easily available materials. In Trial 2 all the dyads clearly indicated how their designs will be put together by easily available materials.

Evidence of marketing decisions

Although the user was already indicated by the researchers, few groups/dyads in both the trials took marketing decisions regarding the cost of the product or limited warranty with the product.

Thus comparison of the designed solutions of Trial 1 and Trial 2 students indicated that students in Trial 1 showed more evidences of creativity and risk taking. Though most of the designs in Trial 1 were not possible to make in classrooms, it did provide students to incorporate latest technology that students were aware of. It also provided them an opportunity to apply scientific principles that they had read in their science classrooms. Design-with-make activity though produced less creative solutions, it did provide students to make important decisions like technical, constructional, aesthetic and marketing. Students in Trial 2 in compared to those in Trial 1 had to think hard about the materials that they could use in their models. The making of the artefacts allowed them to develop skills in designing and making.

Chapter 6

Influence of design activities: Pre and Post intervention survey (Pilot and Final)

6.1 Pre-post Intervention (before and after Trials 1 and 2)

The pre intervention survey was conducted during Trials 1 and 2 with the students participating in the activities. Following the pre-intervention survey, 8 students (4 boys and 4 girls) in Trial 1 and 4 (2 boys and 2 girls) in Trial 2 were interviewed. Results from the pre and post analysis of the both the pilot (Trial 1) and final (Trial 2) survey responses indicated that most students in the pre-intervention stage of both the trials, associated design with arts, such as, decorations, drawings, pictures/paintings and patterns. In the post-intervention stage

in both the trials, a notable decrease in students' association of design with art was seen. There was also an increase of ideas found in students' association of design with making or modelling things, planning and designing for a purpose, especially making useful products for people.

The frequency of students giving tautological response reduced in the post intervention phase. An interesting difference was that more number of ideas in the post intervention phase was associated with the purposes of design. Thus students in Trial 2, mostly wrote that designers *"designs or makes useful things for people"*, or *"which help people."*

When asked "Can animals design? there was a little difference in students' responses in the 2 stages in both the trials. More students in the post intervention phase of Trial 2 came up with English/Indian words for design mostly associated to plan, making (*banana*), creation (*aavishkar*) and less with art (*kala*).

While marking the subjects as related to design in Trial 2, an overall increase in the ratings of all the subjects as related to design was noted in the post intervention phase. However, subjects like painting was rated as designerly by fewer students in the post intervention phase than in the pre intervention phase. Although students in the post intervention phase selected most of the occupations as suitable for both the gender, there were certain occupations (automobile designing, civil engineering and carpentry) which were still considered as more suitable to a boy or a girl; while occupations such as fashion designing and jewelry designing were still considered more feminine professions. This could be due to the fact that the intervention did not aim to change or influence students' gender stereotypes regarding design occupations.

Overall there was a positive attitude towards design and design learning before and after the intervention in Trial 2. In the 'nature of design' question, there was an increase in students' agreement to the ideas that designers get their ideas by observing people and designers solve real world problems in both the trials. Students showed a little less association of design with art and a little more association with engineering. An interesting thing to observe was the decrease in the number of students who agreed with the statement that design is a daily activity that we all do. All the given skills were attributed to designers by all the students in the post intervention phase and students showed a tendency to select both the options for the skill-based traits in designers.

While rating the pictorial activities students in the post intervention phase showed a tendency to mark most of the activities as designing activities. Students' responses in the interview revealed the nature of their reasoning and a better understanding of design.

The drawings of the designers before and after the Trial 2 survey revealed that all boys mostly depicted male designers and all girls depicted female designers. While in the pre intervention phase students depicted their designers as either sketching or painting or making, students in the post intervention phase depicted their designers as sketching, working with 3D models/making and 'thinking'. In the post intervention phase students depicted a variety of designers, mostly architects, car/rocket designers and product designers, while in the pre intervention phase students mostly depicted artists, architects and fashion designers.

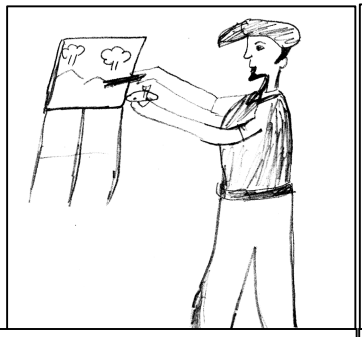


Fig. 6.1: A pre intervention drawing of a designer by a student

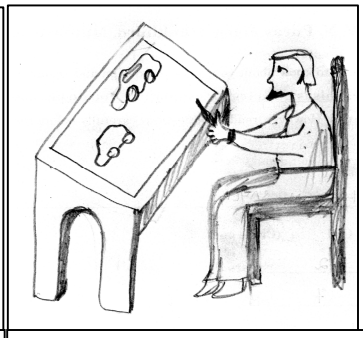


Fig. 6.2: A post intervention drawing of a designer by the same student

Chapter 7

Conclusions and Implications

The thesis included four parts- survey of elementary and middle school students', teachers' and designers' ideas about and attitude towards design and designers, development and trials of specific design activities for middle school students, the influence of the design activities on middle school students' ideas about and attitude towards design and designers and analyses of specific design activities to see how students relate structure and function of artefacts and find evidences of creativity, and design decisions skills in students' solutions to a real world problem.

The survey provides useful insights into Indian elementary and middle school students', teachers and designers ideas of and attitudes towards design and designers. The study sought to reveal ideas about design and designers among students and teachers who had no D&T education in their school curriculum and hence provides students' and teachers' preconceived ideas about design and designers.

Most of the ideas of students on design largely pertained to design as art, painting, decoration, and beautiful patterns or drawing. Very few ideas of design were related to design as planning before making. Teachers associated design very strongly with their own profession and mostly gave examples of lesson plan/curriculum/fate of students as things that are designed. Teachers mostly considered design of the intangibles and not as planning before making some tangible products. The contrast was true for students, who mostly gave examples of tangibles products like dress, buildings, cars that are designed. Designers revealed a sophisticated and holistic understanding of design.

Only a few students' ideas invoked two steps of the designing process (i.e., planning and making, or ideation and making. Teachers mostly emphasized the ideation phase of designing. Besides, other activities assigned to designers, were making art (such as painting, decorating etc), planning, making things, and inventing. Few ideas were actually associated with planning or imagining. Skills such as creativity, imagination, hard work and expertise were mostly associated with designers. The most commonly cited designers by students were fashion designers especially by the middle school students.

Interestingly while considering designing by animals and ancient humans, students focused on their making activities. However while considering design in general, they mainly thought of design as some artistic rendering process and in most students' responses, a designer

assumed the role of an artist. That a designer designs for a purpose, was evident only in a few of the students' responses and almost all of these purposes were related to employing aesthetic appeal. That an artist always enjoys the freedom of expression while, a designer works under constraints and for specific users, was almost absent from all students' and teachers' responses.

The skills that designers mostly associated with designers were observing skills, ability to integrate different knowledge and skills, ability to respond sensitively to the surroundings and communication skills.

The different word/meanings for the English word design in different Indian languages also reflected students' strong association of design with art since most of the Indian words generated were related to art or the meaning of art in different Indian languages. The strong association of design with art and not to craft suggests a strong visual aesthetic sense to design by students but less by teachers. The Indian words suggested by designers were closest to the meaning of design in English.

Students' and teachers' responses to the structured questions on the nature of designing also suggest that they consider designing as an artistic rendering process. However when explicitly stated, a large number of students also agreed that design is about improving things, giving shapes to things and involved working with hands. Students considered design as a modern activity (in terms of emerging new disciplines of design) on the one hand while also believing that ancient people had designed things for use.

Responses to the structured question also revealed students' gender-role stereotypes for certain professions such as cooking, teaching jewelery designing, fashion designing, tailoring, interior designing, carpentry and mechanical engineering.

Overall students and teachers showed a positive attitude towards designers and design learning. Both teachers and students believed that girls/women were better designers than boys/men and that more girls/women choose design professions. It was also found that more girls than boys showed interest in learning design and also reflected the attitude that girls could be better designers than boys. However, it appears that their positive attitude was aligned more with their idea of design as an artistic rendering process than as a problem solving one.

Students and teachers and designers attributed positive qualities to designers. While attributing skill based qualities, students and teachers assumed designers to be more interested in ideas, artistic and scientific. Students mostly thought that designers were female portraying their stereotype that design was a feminine profession. Both teachers and designers mostly attributed both the qualities to the designer.

Responses to students' images of designers revealed that students primarily conceptualized a designer as a fashion designer, artist, architects, engineer and a few as laborer and very few as scientist. Younger students strongly seem to conflate artists such as painters with designers. Older students are more likely to think that designers are involved in designing mostly dresses, less buildings and very few machines. According to students' depictions, the work of a designer was restricted to sketching, painting, making or fixing and designing artefacts such as dress materials and using tools such as writing tools and painting tools.

Students' images reflect gender and professional stereotypes which seem to grow progressively with age with older students depicting more female dress designers.

Students' response to the design activities revealed that students related the structure of an artefact to its function. Students were not very familiar with the materials of the artefacts. However, students did find an opportunity to switch from artefacts' structures to their functions and vice versa.

Students' designed solutions compared across trials revealed interesting differences. The design-without-make solutions showed more elements of creativity such as using imagination, being of purpose, being more original and being of value. The design-without-make solutions also demonstrated more use of scientific and technological concepts. However, they rated low on elements of feasibility, constructability, technicality and aesthetics. The design-with-make activity, on the other hand displayed lower level creativity in terms of originality. The design-with-make solutions demonstrated very little use of scientific and technological concepts. These solutions, however, rated high on feasibility, construability technicality and aesthetics.

Students' responses in both the post intervention surveys during Trials 1 and 2 respectively revealed that students in the post intervention survey mostly associated design with planning, making or inventing for a cause or a useful purpose and less with artistic endeavor. Students' responses to the structured questions and their probing in the interviews revealed that students now believed that design is for a purpose and the purpose is to either improve things or bring order into something which is chaotic. Students also recognized sketching and modelling and ideation as important aspects of design (as evident from their drawings of designers). However, some gender-role stereotypes were still found to exist despite the intervention.

In the present study, designers could be considered as experts in having a well-developed knowledge base about the nature of design and showing evidence of linking across knowledge forms. Teachers, on the other hand could be considered as novices demonstrating some level of understanding about the nature of design while students could be considered as naïve who displayed more fragmentary views about design. If we desire that our students should progress from naïve thinking about design to an expert thinking about design, we first need to be aware of the prior knowledge that students come with, to the classroom. This prior knowledge of students should be regarded as a raw material that needs to be refined and 'not replaced', through a transformative, restructuring process that produces integrative wholes (Roschelle, 1995).

It can be said that students, teachers and designers conceptualized design from their own experience and engagement in design in their daily lives. While these students engage in design in their daily life to the extent of sketching and drawing, they conceptualized design as mostly sketching, making beautiful patterns or decorating. Teachers on the other hand, need to prepare lesson plans and devise ways of teaching a concept, conceptualized design as organizing, ideating and related mostly to their own professions of teaching. Designers, who were actually involved in designing conceptualized design as a holistic problem solving process. Literature suggests that both philosophers and designers are grappling with the meaning of the word design though it is one of the most common words uttered in our day-to-day life. Richard Seymour (1999) for example, said that design is "a word you think you know the meaning of until you try to define it". As a creative pursuit, design has fuzzy edges around its established practices. However, we must understand that the aim of design

education, should not be to negate any aspect of the range of activities that students understand by the term ‘design’ but to extend and broaden this range of what they understand by this term.

Student’s ideas about any profession and their practicing professionals are very important since students’ perceptions of professions are closely related to the choice of their careers. Thus in this stage perceptions about different professions might play an important role in making appropriate decisions. If students believe that designers usually decorate or make things attractive then certain groups of students (such as technically oriented students) are less likely to consider design as important for their career. As Heskett (2002) pointed out that the part should not be mistaken for the whole, educating these students that designing is not just about decoration may lead more students to consider design as an option of study for their careers.

The design activities provided students to be creative problem solvers and connect and respond creatively to real life issues by designing and creating artefacts. The activities enabled them to assume the roles of an observer, user, designer and a maker. Students made important design decisions very similar to a professional designer. It also provided them an opportunity to integrate scientific and technological knowledge in their designs.

Handling artefacts have implications for students’ learning of science since it provides them concrete experience of observing the working mechanisms of products. Expose students’ conceptions and misconception in science.

7.1 Self reflections and a way forward

The limitations that were identified in this study were:

1. The data was collected from urban elementary and middle school students. Students from rural and tribal schools were not investigated due to researcher’s unfamiliarity with Marathi, the local language of the state of Maharashtra. However, it would be interesting to study rural and tribal students’ understanding of design since they are directly involved in making things at home, in contrast to urban students who usually choose and use products designed by others.

2. Data from teachers were collected from both pre-service and in service teachers, the number of teachers not exceeding 38, a sample that needs to be built upon in further studies.

3. Only 5 design students were interviewed due to availability issues.

4. The design activities were carried out with only 14 students who voluntarily participated. The aspect of the study was exploratory, with several activities being tried on same/different students. For this reason, these findings cannot be generalized to the broader community based on this study alone. However, it serves as an important case study and a large number of such cases may help in forming a trend. Repeating the study with other products would also be valuable.

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List of publications

1. Ara, F., Chunawala, S. & Natarajan, C. (2011). A Study Investigating Indian Middle School Students' Ideas of Design and Designers. *Design and Technology Education: An International Journal*, 16.3, 62-73. http://ojs.lboro.ac.uk/ojs/index.php/DATE/article/view/1676/1571
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