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

A Thesis

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by

Farhat Ara

Homi Bhabha Centre for Science Education

Tata Institute of Fundamental Research

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DECLARATION

This thesis is a presentation of my original research work. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature, and acknowledgement of collaborative research and discussions.

The work was done under the guidance of Professor Sugra Chunawala, at the Tata Institute of Fundamental Research, Mumbai.

Farhat Ara

In my capacity as supervisor of the candidate's thesis, I certify that the above statements are true to the best of my knowledge.

Sugra Chunawala
Thesis Supervisor

Date:

Dedication

I would like to dedicate this piece of work to the three most important people in my life:

To my father, late Haji Anwarul Haque for believing in me, inspiring, supporting, guiding, and encouraging me to pursue higher education.

To my husband, Ashraf, for lending unconditional support and encouragement throughout my Ph.D journey.

To my son, Atif, my pride and joy, who showed immense patience and spent countless hours waiting for his *‘mumma’* to complete her *‘homework’*.

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Notwithstanding all the support that I have received for this venture, I bear the sole responsibilities for any mistakes or problems that this thesis may contain.

List of Publications

1. Ara, F., Chunawala, S. and Natarajan, C. (in press). Investigating Indian Elementary and Middle School Students' Images of Designers. *Design and Technology Education: An International Journal.*

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4. Ara, F., Natarajan, C. and Chunawala, S. (2011). Students as users and designers: Product evaluation and redesign by Indian middle school students. In Chunawala, S. and Kharatmal, M. (eds). (2011). *International Conference to Review Research on Science, Technology and Mathematics Education*, epiSTEME 4 Conference Proceedings. India: Macmillan. http://episteme4.hbcse.tifr.res.in/proceedings/strand-ii-cognitive-and-affective-studies-of-stme/ara-natarajan-chunawala

5. Ara, F., Natarajan, C. and Chunawala, S. (2010). Naïve Designers: A study describing Indian middle school students' creative design solutions to a real world problem. *In electronic Proceedings of International Conference on "Designing for children'- with focus on 'play' and 'learn"* at Industrial Design Centre, IIT, Mumbai, Feb 2-6, 2010. http://www.designingforchildren.net/papers/farhat-ara-designingforchildren.pdf

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8. Ara, F., Khunyakari, R. and Natarajan, C. (2007). A study of middle school students' depictions of routes based on verbal descriptions and cues. In Natarajan, C. and Choksi, B. (eds), *Proceedings of Conference epiSTEME- 2: International Conference to Review Research in Science, Technology and Mathematics Education*, Mumbai, India, Feb 2007. http://www.hbcse.tifr.res.in/episteme/episteme-2/e-proceedings/ara

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Chapter 1

INTRODUCTION

'You see things, and you say: `Why?'
But I dream things that never were,
and I say `Why not?''

George Bernard Shaw

1.1 Introduction

Our world has a hostile environment to live in but we have so far managed to survive in this world; thanks to our innate ability to design. Starting from the simplest and crude stone tools, we have developed tools with increasing sophistication that have facilitated our survival in the most dubious of environments. As humans we are continuously designing our environment in order to adapt to it, by finding the best possible solutions to our basic needs. Even in our everyday acts, we constantly change our environment from what we want to wear or cook for an occasion to arranging furniture for creating spaces in rooms.

The word 'design' is a commonly used word in our everyday life. If design is so pervasive and all-encompassing our lives how do we perceive it? Do we see it as a plan, a product, a process or an applied art? Do we perceive it as Bruce Archer suggests as *a goal directed problem-solving activity?* (Archer in Jones, 1970) Or as Victor Papanek suggests *a conscious effort to impose meaningful order?* (Papanek, 1972) Or as McCracken puts it, *the creative soul of technology?* (McCracken, 2000)

The research reported in this thesis has two parts. The first part of the thesis corresponds to the above concern. What are students', teachers' and designers' ideas about design? With a multitude of meanings of design around, it is important to learn what individuals understand by design and their attitudes towards it and its practitioners. It would be interesting as well as important (from the curricular point of view) to document Indian students' and teachers' spontaneous and unschooled ideas about design and designers and compare them to those of designers.

The ability to design has been looked upon as a mystical gift possessed by a selected few. However, design-educators and design-philosophers have emphasized that design ability is possessed by everyone at least to some extent (Archer, 2005; Cross, 2006; Baynes, 1982). It has been shown that the highly complex skills of the professional engineer or designer are simply the development of abilities that we all have (Baynes, 1985).

Design is increasingly being recognized as a basic human ability with design philosophers and educators arguing the need to include it in general education instead of restricting it to specialists such as designers and engineers. Bruce Archer in the 1970's (in Cross, 2006) distinguished design as the third missing area in education, to be placed alongside the established areas of science and humanities and proposed that design be included in general education in the UK. Cross (2006) also explored ways in which design in education can further our appreciation of what it is to be human. He distinguished between the aims of specialist and general education highlighting that while the former had extrinsic aims which contribute to instrumental learning, the latter had the intrinsic aims which contribute to the individual's self-realization and basic life skills.

Design is now fast becoming established as a subject in schools in various countries throughout the world. In most of these countries design education is possible through subjects such as Design and Technology education (D&T) (England and Wales) or Technology education in (USA, Australia, New Zealand, Japan etc.). As most of the design education literature coincides with the D&T education literature, the researcher from henceforth would use the terminology 'D&T' education or design education interchangeably.

The second part of the research study reported here deals with the research question: What specific activities can be developed for Indian middle school students to engage them in designing? In order to address this question, several design activities were developed and their trials were carried out with Indian middle school students.

This introductory chapter provides information about the background and the motivations of the study. It also describes the aim and the research questions that guided the study. Finally the overall methodology that has been used in the study is described and the chapter concludes with the organization of this thesis.

1.2 Research background and motivation

The following contexts serve as the background and were the motivation for undertaking the research study reported in this thesis.

1.2.1 Previous research in D&T Education in India

The research reported here stems from interests in the previous studies conducted by researchers at the Homi Bhabha Centre for Science Education (HBCSE) in Mumbai (Choksi, Chunawala and Natarajan, 2006; Khunyakari, 2008; Mehrotra, 2008). HBCSE is a National Centre of Tata Institute of Fundamental Research and devoted to research and development in science, technology and mathematics education. The broad aim of this researchers' team was to explore the possibility of introducing D&T in Indian schools. The research involved two linked studies. The first involved investigation of Indian middle school students' ideas about technology through surveys, while the second involved the development of 3 D&T education units through a collaborative designing approach and their trials among students from 3 socio-cultural settings. Based on the findings from these studies, the researchers proposed a framework for D&T education in Indian schools by laying out its content and pedagogic aspects at different school levels.

These studies provided insights into Indian students' ideas about technology suggesting that students have a narrow view of technology- predominantly as electronic objects (Khunyakari, Chunawala and Natarajan, 2009; Mehrotra, Khunyakari, Chunawala and Natarajan, 2007). The above studies motivated the present research to focus on Indian students' ideas of design. What associations do Indian students with no formal design education, make with design? This research also attempted to explore teachers' and designers' ideas of design and compare them with each other. Trials of design activities were carried out with middle school students and their ideas about design were probed again post the activities to see if they were evidences of any change in their ideas.

A review of the literature indicates that studies on students' and teachers' understanding of design and designers are few. Also these studies are mostly limited to those 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 has not yet been introduced as a subject in the Indian school curriculum. In this context it is to be noted that de Klerk Wolters (1989) suggests that it is essential 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 changes in them.

1.2.2 Approach to design in the present scenario

According to Heskett (2002) design today is assigned a lightweight and decorative role for fun and entertainment, and is considered useful only in the economic sector. It has been transformed to something banal and inconsequential by the widespread media coverage. This is just a small part of what design is all about. However, as Heskett pointed out that part should not be mistaken for the whole. Our students are future consumers, manufacturers, engineers or designers. Hence they need to develop a critical understanding of the issues associated with design and go beyond the superficial appearance of the products. Informed and critical attitudes of individuals would produce better and more discriminating buyers (McLaren, 1997). A discriminating buyer in turn, would demand for a better environment to live in and more appropriate application of technologies. Thinking critically is a challenge and involves appraisal of products and systems. So if a product is designed well, a critical thinker would note that it is a well-designed product. D&T thus should not be considered as a luxury and confined to only the specialists but should also be taught to the general masses. In the present day world of energy crisis where the issue of environmental sustainability is a responsibility of every individual, we do not need just a population of scientists, engineers and mathematicians but also responsible design and technology literate individuals.

Undoubtedly, ideas about design and designers are a part of technology education and being sensitive and critical to designed products is one of the aims of technological literacy (Martin, 2007). Since design and technology are so closely linked, it is essential that in this increasingly scientific and technological world, every student have an understanding of design and go beyond the superficial appearance of everyday products that they purchase and use.

1.2.3 Towards inclusion of design education in schools

As mentioned above, the Indian school curriculum neither includes design nor technology education. In India design is considered to be a specialist education meant for designers. Motivated by Mahatma Gandhi's philosophy of Basic Education (according to which primary education should be centred around craft work or some socially useful productive work), the Education Commission in 1966 introduced Work Education and socially useful productive work (SUPW) in the curriculum (Choksi et al., 2006). These courses were meant to be purely vocational and aimed at promoting self-reliance and dignity of labour. Although these subjects have the potential for providing students opportunities to design and innovate (Natarajan, 2004), they have become meaningless and an adjunct to the already lopsided literacy-numeracy curriculum, because they rely more on recipes and non-reflective practices, rather than on creativity and reflective practices. According to Natarajan (2004), even the higher technical institutes such as the Polytechnics and the Industrial Training Institutes (ITIs) provide no scope for designing to their students and the curricula seems best at preparing individuals who are passive recipients of technology and who can only 'deal' with technology instead of creating new technologies.

1.2.4 From decontexualised to contextualized learning in schools

Traditional pedagogical patterns of education, such as authoritative, teacher-centric and lecture-based approaches, have continued for most of the last century at least in developing nations like India. The Indian education system today 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 tend to memorise the content taught in schools. If authentic learning has to take place, it requires the active and constructive involvement of the learner. The educational philosophies of Gandhi 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. Design problems which match the real world problems sustain the interest of students and allow for authentic learning since students manipulate or work with real data and make personal meaning of the entire situation. The study reported here aims to develop design activities for middle school students and provide them opportunities to engage in real world issues and problems.

1.2.5 Towards an integrated curricular approach

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). If students in today's world are taught in a compartmentalized manner with each subject matter being taught discretely, then they might find it difficult to cope with the real world complex issues which require them to think in an integrated manner. Throughout the entire educational experience, Indian schools emphasize compartmentalization of disciplines with each subject being taught in a respective 'period' without any attempt to bridge the gap among them. There is also no effort to integrate theory and practical experimentation in Indian schools. 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'. The interdisciplinary nature of design problems provides students opportunities to integrate knowledge, skills and values from several disciplines such as mathematics, sciences, fine art and humanities in a holistic way.

1.2.6 From an era of information acquisition to knowledge application

In the 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. In the Indian school scenario, students hardly get an opportunity to apply their knowledge (Cheney, Ruzzi and Muralidharan, 2006). There has been an increased recognition that design activities provide an opportunity to shift from this era of ‘information acquisition’ to ‘knowledge application’ that would lead to meaningful learning.

1.2.7 Creativity and design education

According to Lewis (2005) technology education is a special place in the school curriculum where creativity can be fostered among all students. Within technology education, he emphasizes the role of design in giving opportunities for enhancing creativity in students since design has a special characteristic of being open-ended, interdisciplinary and ill-structuredness. A design problem can also have multiple divergent solutions in contrast to problems in sciences that are well-structured, have single right answers and can be derived by following a logical step-by-step process. The need to develop creativity among Indian students is still in its infancy stage in the educational policy documents (Madan, 2011). In India, research on creativity is limited to the construction of tests for creativity and correlational studies of creativity with self-concept, intelligence, personality, gender etc. There have been limited studies on the effects of schooling on creativity, promoting creativity in students.

1.2.8 Thinking with hands

Educators and philosophers have always stressed the need to engage students 'actively' in the learning process. Hands-on learning is one of the ways in which students can actively get involved in their own learning process. Working with hands provides students with direct experiences of materials, objects, or phenomena and help them build a better understanding of the subject matter. Dewey (1938) and Bruner (1966) have emphasized the importance of learning by doing. The craft-centred Basic School of Mahatma Gandhi was similar to Dewey's Laboratory School where hands-on activities were imperative for learning to happen. Design activities have the scope to provide students an opportunity to work with hands through all the stages of the design process, i.e. planning (through sketching), making (working with actual materials to make 3D models/mock-ups) and testing (the final product).

1.3 Context of the study

The research for this study took place in the city of Mumbai in India. India has the second largest education system in the world, the first being China. Education in India is provided by the public sector or the government as well as the private sector. The Indian constitution makes it mandatory for the government to provide free and basic education to all children up to the age of fourteen years **(**RTE, 2012). The education system in India follows the British structure and consists of primary school (grades 1-5; ages 6-11) and middle school (grades 6-8; ages 11-14) (Cheney et al., 2006). According to these authors, the emphasis in the government schools is laid on students' school attendance rather than on expected learning outcome. Also private schools are better than the government run schools but they charge higher fees making them accessible to only the middle class and higher class families. The country continues to face serious challenges in providing basic education to children. Despite growing investments in educations, India continues to be the country with the largest number of illiterate people in the world (Cheney et al., 2006). The illiteracy rate of girls is higher than boys.

The National Policy on Education (NPE, 1986) considers science and technology education as important for the economy of the country. However, the curricular changes do not correspond with the new ways of teaching and assessing students. The curriculum is often criticized for burdening the students and encouraging rote learning in all the school subjects. Students have few opportunities to relate their experiences outside of school with the experiences behind the four walls of the school. Besides, students are not prepared for any career selection, that is, little connection is made between the world of work and the world of school.

Rapid globalization and economic restructuring have led the government to realize the significance of technology education in India (Ramadas, 2003). This is evident in the recent rechristening of the middle school science textbooks as ‘Science and Technology'. Earlier in the 1960's, based on Mahatma Gandhi's philosophy of Basic education according to which education should be centred around the world of work, subjects like Craft and Work Education were introduced at school level. However, lately craft work is usually associated with the activity of producing ‘junk’ products which as the name suggests are of low priority or of little value and the 'work' in work education is usually associated to the economically weaker and academically backward students. Both these subjects which have the potential for fostering design thinking among students are way away from design. Currently they do not serve the purpose for which they were introduced in the curriculum in the first place (introducing students to the world of work), leave alone design and design thinking.

1.4 The Study

The research study reported in this thesis investigates elementary and middle school students', teachers' and designers' ideas about design and designers. The study consists of two parts.

Part 1

It consists of studying students', teachers' and designers' ideas of design through a survey. Questionnaires aimed at understanding ideas about design and designers were developed separately for elementary, middle school students, teachers and designers. The questionnaires for each of the sample were slightly different from each other, with the questionnaire for the elementary students being simpler and shorter and consisting more of pictorial elements and the questionnaire for teachers and designers being more descriptive and longer.

Part 2

The second part of the study consists of three workshops conducted with middle school students wherein varied design activities were developed and tried with them. Students participating in the workshops were investigated for their ideas on design and designers before and after the trials through a questionnaire that was similar to the one used in the survey. Students' responses to the questionnaire were analysed to see if there were any influence of the design activities on their ideas about design and designers. Students' responses to the activities were also analysed to look for aspects of their creativity and cognition.

1.5 Methodology

This section provides an outline to the research methodology and the procedures used for data collection in this study.

As there are few design and technology studies done in the Indian context, the endeavour of studying students', teachers' and designers' ideas about design was something new, undertaken by the researcher. This research study was thus exploratory in nature. An exploratory research is a preliminary research which may be conducted to get a better understanding of a phenomenon or concept or to help set the definition of a problem (Phillips and Pugh, 1987; Creswell, 2003). An exploratory research is best suited when the research problem or the issue is not well understood, the researcher does not know the important variables that need to be examined, since the topic is new or has never been addressed with a certain sample or a group of people (Creswell, 2003). An exploraroty research therefore warrants a qualitative approach that allows for in-depth analysis of the issues and is flexible enough to address open-ended research questions, data collection procedures and analysis (Butin, 2010). Design education being not a formal subject in Indian schools, the researcher sought to develop design activities for students, based on the insights from the survey and the literature available on design education mostly based in UK (Lewis, 1996).

In order to understand the research problem more completely, this study used a mixed methods design, which is a procedure for collecting, analyzing and 'mixing' both quantitative and qualitative data at some stage of the research process within a single study (Creswell, 2002). The rationale for mixing is that neither quantitative nor qualitative methods are sufficient by themselves to capture details of the situation. When used in combination, quantitative and qualitative methods complement each other and allow for complete analysis.

In a mixed methods approach, researchers employ strategies of inquiry that involve collecting data either simultaneously or sequentially to understand the problem at its best (Creswell, 2002). Data collection involves gathering numeric information (example, on instruments) as well as text information (example in interviews) so that the final database represents both quantitative and qualitative information.

The details of the methodology for the survey part of the research have been discussed in Chapter 3, while that for the trials and development of the design activities has been presented in Chapter 4.

1.6 Objectives of the Study

The purpose of the study is four-fold:

- To study urban elementary and middle school students', teachers' and designers' ideas about design and designers;
- To develop design-based activities through trials among urban middle school students;
- To assess the influence of design-based activities on middle school students' ideas about design and designers; and
- To analyse aspects of structure-function relation of artefacts, creativity and design decision skills in students' responses to the design-based activities.

1.7 Research Questions

The research addressed the following main questions:

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

1.8 Significance of the study

The researcher assumes that the study is significant in terms of the following three aspects: ***scope, methods*** and ***participants.***

1.8.1 Scope

The results of this study can be valuable to researchers in design and technology, curriculum developers or practitioners. Literature shows that in the past two decades, with the introduction of D&T education as a school subject in the West, there have been studies focussed on students' perceptions of and attitude towards technology. However, the studies investigating students' ideas of design are few and limited to those students who already had some basic and formal design experience in their schools. This study aims to explore Indian school students' and teachers' spontaneous and unschooled ideas of design and designers and thus aims to contribute to the existing body of research literature. Researchers willing to pursue their research in design education can benefit from this work. The study is significant to the research community as it aims to compare students' and teachers' spontaneous ideas of design with the professional understanding of design among designers. Very few studies in literature have focussed on the comparison between students’ and teachers’ ideas in any educational context. However, to the best of our knowledge, none of the studies in the existing literature shows any systematic comparison of unschooled ideas of teachers and students with those of the designers. This study aims to provide a rich documentation on the commonality or the points of overlap among students’, teachers’ and designers’ understanding of design. The study thus presents a new element into the design education research literature.

As there is no formal design or technology education in Indian schools, the aim of the study to develop appropriate design-based activities for Indian middle school students would contribute to bringing into the curriculum such activities. The study also gives insights into students' creative design potentials. In the light of this study curriculum developers or practitioners can try to organise the curriculum materials or lesson plans around the activities developed and can design activities or workshops which have the potential for introducing concepts of design. Curriculum developers or practitioners can also get insight into teachers’ ideas of design.

1.8.2 Method

The second area of significance of this study lies in the methods adopted in the research: methods for collecting, analysing and interpreting the data in the study. For example, one of the methods used to investigate students' ideas of design was through their drawings of designers. Their ideas about designers were also investigated through their writings. Both the written and drawn data from the students, helped in establishing the internal validity of the study. Also, the use of the similar (but not the same) instrument for gathering students', teachers' and designers' ideas were found to be purposeful since it enabled a comparison of their ideas.

1.8.3 Participants

Thirdly the study provided opportunities to the students who participated in the workshops and engaged in several design activities. Their engagements in the activities facilitated a change in their ideas about design and designers. These students also got evidences of their own creative potentials while designing solutions for a real world problem.

1.9 Organization of the thesis

This thesis is organized into seven chapters. Chapter 1 has provided an introduction to the thesis with the background, motivation and the context in which this research was undertaken. It also presents the aims of the study and the methodology adopted in the research study. The research questions guiding the study are discussed.

Chapter 2 discusses the relevant literature in the field of design and technology education in India and other countries across the globe. The chapter discusses the aim of doing the review of literature and tries to connect relevant literature associated with the study and then builds on the theoretical framework in the light of the literature.

Chapter 3 discusses the survey of students', teachers and designers' ideas on design and designers. It highlights the objectives 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. It includes the methodology in detail along with learning objectives of each activity and the lessons learnt at the end of every trial.

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, before and after their engagement in the design activities.

Chapter 7 is the concluding chapter where the results of the studies are discussed in line with the research questions raised. Finally the implications and recommendations for future research work are addressed.

Chapter 2

LITERATURE REVIEW

It takes a great deal of history to produce a little literature

Henry James

2.1 Introduction

The aim of this thesis is to investigate students', teachers' and designers' ideas of design and designers and to develop design activities through interventions for middle school students. In order to achieve these aims, the relevant literature was examined. The literature review has been divided into four main sections as follows:

- Conceptualisation of design from philosophical, historical and educational perspectives;
- A review of research on students', teachers' and designers' ideas of design;
- The cognitive aspects of design;
- The pedagogical approaches to design;

Because very few studies have been conducted on design education or D&T education in India, this literature review primarily focuses on research from UK where design is taught as Design and Technology Education (D&T). However, an attempt has been made to integrate most of the studies on design education done in the Indian context as well as other countries.

There is a strong reason for reviewing design education literature from UK and less so from USA or other countries. A review of literature reveals that USA also has Technology education as a compulsory subject in the curriculum. However, Technology education in the US is primarily content-based where more emphasis is laid on 'understanding' technology rather than ‘doing’ technology which involve designing and making (Lewis, 1996). British curriculum, on the other hand, is process-based and the technological activities in D&T are centred around design. That is, the main foci of design and technological activities are designing and making. Most literature revolving around design education was UK-based. Hence the review of literature cites most studies on design from UK and less so from other countries.

2.2 Aim of the literature review

The aim of this literature review was three fold. Firstly the researcher aimed at acquiring a conceptual understanding of the nature of design from studies that dealt with this area. Secondly the intent was to review the literature in order to locate areas that were under researched in the context of design education, especially in the Indian context. Finally as a researcher in design education, it is imperative that one is acquainted with the philosophy of design. This has a direct implication for the nature of design activities developed for students. The literature on D&T education was thus reviewed to provide a strong theoretical framework for the conceptual, methodological, pedagogical and analytical aspects of this research study.

2.3 Design from a philosophical, historical and educational perspectives

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 investigations. Notable designers, historians, design theorists and educators have contributed to establishing a better understanding of design methodologies, activities and products. The concepts of design in the literature vary from simple to broad prescriptive formulation for designers.

What is design? What is its nature? Why is it done? How can it be done? What distinguishes design as a discipline from other professional disciplines such as law or medicine, or other intellectual endeavours as science, art or technology? How can designed products be made better? How are the form and function of designed products related? These are some of the persistent questions that have been the subject of discussion among design philosophers and theorists since the establishment of design as a discipline. However, most philosophies of design are related to the guiding principles that dictate how a designer should approach her practice or prescribe specific methodologies for designers to follow. The discussion in this section would begin with a review of the everyday meanings of the word design in English and different world languages and then focus on some of the philosophical arguments in design.

2.3.1 The everyday meanings of design

According to Mitcham and Holbrook (2006), the classical Hebrew or Greek language does not have any etymological counterpart for the word 'design' indicating that it is a modern concept. Design in English language, can serve either as a noun or a verb. As a noun, design can mean a form, arrangement, outline, pattern, blueprint, plan, sketch, artistic shape, plot, scheme or intent (Definitions.net). In fact in the English vernacular sense, design also means a devious or an improper scheme. In this sense it does imply intent but, an intention which is contrived or improper (Ibid).

As a verb, design may mean to conceive or fashion in the mind; invent; devise; draw (Ibid); 'to mark out, nominate, appoint'; 'to plan, propose, intend'; and 'to sketch' (Mitcham, 2001).

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 such as 'designer clothes'. In fact we presume that 'designer' artefacts, even when mass produced, represent in some way the distinctive creative flair of the designer (Raizman, 2003).

To demonstrate the ambiguity and the many levels of the meanings of design, (Heskett, 2002: 3), presented the following example of a statement:

'Design is to design a design to produce a design.'

Every use of the word is grammatically correct. As evident from the statement, the word design is conceived as a noun with three different meanings: the field of design, a conceptual proposal and a finished product. It is also conceived as a verb indicating an activity or process. The first noun indicates a general concept of a field as a whole (Example: 'Design has different meanings in different domains'). The second noun signifies a concept or proposal (Example: ‘The client was not satisfied with the design presented to her’). The third noun indicates a finished product of some kind, the concept made actual (Example: ‘I like the design of my chair’) while the verb indicates action or process (Example: ‘A team of designers were assigned to design a new car for the company’).

Realizing the ambiguous nature of the word design, attempts have been made by theorists to reduce this ambiguity. As for example, differentiating between the noun and verb forms, Love (2002: 356-357) provided a sound definition of design as follows:

“Design’ - a noun referring to a specification or plan for making a particular artefact or for undertaking a particular activity.’ He makes a distinction between a design and an artefact suggesting *‘a design is the basis for, and precursor to, the making of an artefact.’*

2.3.2 Design in other languages

The word design is closely related to Latin *designare* which means ‘to mark out,’ ‘trace,’ ‘devise’ or ‘denote’. It is translated in Italian *disegno* and French *dessien,* as ‘plan,’ ‘purpose,’ and French *dessin,* as ‘drawings’ or ‘sketching’ (Mitcham and Holbrook, 2006). In German, design is translated as 'gestaltning' which means figuration or formation (Huldén, 2011). In Japanese, it is related to two words: *Isho* and *Zuan* (Fujita, 2008). *Isho* was an old concept used before the Industrial Revolution and most often utilized by writers and artists. *‘I’* of *Isho* means ‘idea’ or ‘thought,’ while *‘sho’* means ‘master’ or ‘craftsmanship.’ *Zuan*, on the other hand, is relatively a new concept more closely related to design as it breaks into two words, ‘Zu’ which means ‘drawing,’ and ‘an’ which means ‘plan’ or ‘idea.’

According to (Vyas, 2000) the traditional design thinking in India is rooted in the Sanskrit word called *'kala'* which means art. However, the recent translation of design in Hindi language suggests words such as *'abhikalpana'* or *'parikalpana'* both of which mean, forethought or hypothesis. Another word which comes close to design in the western sense is *'yojna'* which means scheme or plan. The word design is also commonly used by laypeople in India as it is and is pronounced as *'deezaain'* or *'deejaain'*.

This review of the definitions of design suggests that although design is conceived of in several ways in the English language, European languages have few equivalents for it. The presence of design equivalents in United Kingdom, America, Europe and Japan does indicate that these countries were influenced by the Industrial Revolution, the period when design emerged as a new discipline for the first time in history.

2.3.3 Conceptualizations of design: Philosophical perspective

Defining design is a slippery task since it can be understood differently by lay people, design professionals and even philosophers. However, there seems to be a lack of any systematic study which has examined lay people's understanding of design. Design can be broadly as well as narrowly defined**.** Baynes (1976) has suggested that the way we define design depends on what we intend to achieve and that definitions of design having certain meanings and utilities in one area of study might not be applicable for another. Similarly Love (2002: 347) stated that design has '*different meanings in different domains, [is] used in different ways by researchers in the same domain, and [is] found in the literature referring to concepts at different levels of abstraction.*'

Literature shows that philosophers have tended to conceptualize design from a variety of perspectives and this diversity of conceptualization has added to the already confused and fuzzy arena of design. Some of the most commonly occurring definitions and conceptualization of design in literature are listed below:

'Design is a goal directed problem-solving activity'- (Archer in Jones, 1970: 3)

'[Design is] *to initiate change in man-made things'* - (Jones, 1970: 4)

'All men [sic] *are designers. All that we do, almost all the time, is design, for design is basic to all human activity. ...Design is a conscious effort to impose meaningful order'* - (Papanek, 1972: 3)

'Design is composing an epic poem, executing a mural, painting a masterpiece, writing a concerto. But design is also cleaning and reorganizing a desk drawer, pulling an impacted tooth, baking an apple pie, choosing sides for a back lot baseball game, and educating a child' (Papanek, 1972: 3)

‘Everyone designs who devises courses of action aimed at changing existing situations into preferred ones’- (Simon, 1996: 111)

‘Every human being is a designer. Many also earn their living by design’- (Potter, 2002: 10)

The common elements among all these ideas or definitions of design are their breadth and their inclusivity. These definitions extend the boundary of design from the strict confines of the professional designing world to the designing in our everyday life. Through these broad definitions, design does not remain as the activity performed only by a few creative professionals but it indicates an ability that is itself basic to all human activity. Following these broad definitions, almost all intentional acts of making (or not making) can be considered as design.

Additionally some of these definitions have gone to the extent of including not just tangible or material artefacts as the products resulting from the act of design but also intangible artefacts such as poems, environment or systems. Design conceptualized in such overarching ways is synonymous with the term: to plan. The significant point is that design then becomes a core of all professions and even includes the ones that are not usually considered as design such as medicine, law or politics.

The breadth of these definitions creates a host of questions that become critiques of these definitions. If design is the core of all professions, how can it be a separate discipline? Today we see design as a separate discipline incorporating many sub disciplines such as industrial design, product design, graphic design, fashion design etc. How are these disciplines different from other disciplines? In addition, it creates problems for design institutions during curriculum development: what should be taught to design students? These broad definitions of design usually pose problems if one wishes to conceptualize design as a professional activity. It was only in the twentieth century that design emerged as a professional enterprise and became distinguished from mere 'doing' or 'giving form'.

2.3.3.1 Professional design versus Everyday design

A significant divergence between a professional designer and an everyday designer is the baggage of training experience, a body of knowledge and skills that professional designers bring along with them during the process of designing which lay people do not have access to. Another important difference between an everyday designer and a professional designer is the *need* for designing. In the case of an everyday designer, the need arises from within herself. She herself is a designer and the user. However, in the case of a professional designer, the need is always of the other, that is the user.

In this context Krippendorff (2006) suggest that *'design as a professional practice differs from design in everyday life'*. He claims that designers unlike other people are motivated to design due to the following three reasons: a) *Challenges*, troublesome conditions, problems or conflicts that have escaped (re)solution, b) *Opportunities* not seen by others to do something, to improve one's own or other people's lives, c) *Possibilities of introducing variations* into the world that others may not realise or do not dare to consider. He claims that professional designers engage in *human-centred* design where they need to understand how others (their users) understand their world, at least in the aspects that are relevant to their design. He calls this recurring understanding of understanding as the 'second-order understanding' which is required by professional designers (Krippendorff, 2007).

Another essential difference between everyday designing and professional designing is the *conscious and deliberate* use of materials, tools and methods during the process of designing. A designer intentionally uses a specific tool or a method for designing constantly reflecting on her designerly activities. A lay person on the other hand may intend to design but may not reflect on her choice of specific tools or methods for designing. This deliberation on the part of the professional designer results from training in designing.

In a similar context, Archer (1984) attempted to isolate design from non-design as well as from other profession, by setting three criteria:

- prior formulation of a prescription or a model, before the product is actually made,
- intention of embodiment as an artefact/hardware and
- presence of a creative step.

According to him, an architect preparing a plan for a house is clearly designing but a sculptor shaping a figure or a musician composing a song is not (Archer, 1984). If the sculptor makes a cartoon or a figure prior to her sculpturing work, she is designing, otherwise not. Similarly inventing a new chemical formula in not designing but prescribing a formula for making a new plastic material is designing. A musician is not designing since she does not fulfil the second criteria of 'embodiment' as hardware. Her composition does not get translated into a product.

Although the purpose of Archer's criteria was to narrow the boundaries of what includes design and what it excludes, today with such diversification and specialization in the design fields, Archer criteria are doomed to be criticised. If Archer's criteria are strictly taken into account, the areas of graphic and software designing can be swapped off the design discipline, since it fails to fulfil his second criteria of creating a plan which gets translated into an artefact. In fact in graphic and software designing, the resultant *blueprint* or the *plan* is the final product. This is true for music as well. Today we hear of music being *designed* to affect the listener in specific ways (McCraty, Barrios-Choplin, Atkinson and Tomasino, 1998) and *sound designers* providing sound effects in plays and movies.

Moreover, the task of drawing boundaries within different design disciplines appears increasingly difficult since there are different motivations leading to a design project (from purely aesthetic to purely engineering, problem-solving) and the kinds of knowledge that designers rely on (e.g. rational and deductive knowledge for engineering designers while subjective and expressive knowledge for graphic designers) (D'Ippolito, 2012). Friedman (2003) offers three attributes that distinguishes the commonality among all the design fields, namely that (i) design refers to a process, (ii) the process is goal-oriented, and (iii) the goal of design is to solve problem, meet needs, improve situations, create something new and useful.

Thomas and Carroll (1984) suggested a broader perspective of what is design by claiming that any activity can be looked at as a design activity. According to them, design is a *way of looking at a problem* rather than *a type of a problem*. Thus for them, designing a house, composing a symphony and even planning a research programme to study design, are all designing. In contrast, problems which are 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 she applies in her plans.

While the debate regarding the nature of design continues in literature, we can be certain that designing by professionals and designing by lay people are two sides of the same coin. These two views are not actually conflicting nor are they incorrect. Design in the professional world could be considered as more 'objective' with professional designers, consciously and intentionally, making decisions on their choices. The everyday design performed by lay people could be viewed as more subjective since it involves highly individual and subjective aspects. However, these two views can be linked through education. Design education can play a significant role in developing design awareness, understanding and ability at all levels of schooling in children and thereby link the two aspects of designing: the specialist professional with the basic everyday designer (Standen and Cormac, 1990).

2.3.3.2 Design paradigms: Rational Problem-Solving versus Reflection-in-action

An ongoing debate which keeps recurring in design philosophy literature and which is relevant for this study, is the nature of design process. There are numerous theories and philosophies that guide a designer in the design process (Lawson, 2005). A host of research appeared from 1950s onward that aimed to understand the processes employed by successful designers in designing activities which in turn would lead to the development of improved design methods (Jones, 1984). The development of the Industrial Design Research Unit at the Royal College of Arts in the 1960s led by Bruce Archer was a major leap towards design research (Cross, 2001). In 1962 a Conference on Design Methods led to the establishment of the Design Research Society (DRS) in UK in 1966. The main area of concern in DRS was the characterization of design. Related objectives in these researches included a comparison of design methods with the scientific methods.

Out of the broad philosophical perspectives available in literature, Dorst and Dijkhuis (1995) identified two major design paradigms or conceptual orientations towards methods or processes of design. The first paradigm tends to conceptualise design in terms of the *rational problem-solving process* which was first introduced by Herbert Simon in the 1970s. The second paradigm, first proposed by Donald Schön in 1983, was a radically different paradigm in which Schön conceptualized design as a *process of reflection-in-*

action (Schön, 1983). These two paradigms provide two fundamentally different ways of looking at design. The *rational problem-solving* paradigm is based on *positivism* which claims that the world can be interpreted objectively through our senses, using scientific methods. The *reflection-in-action* paradigm, on the other hand is based on *constructive philosophy,* where the person is a dynamic and social being who makes meanings of things based on her own experiences (Dorst and Dijkhuis, 1995).

2.3.3.3 Design as a rational problem-solving process

Simon's theory of the rational problem-solving process represented the positivistic framework of science, where much emphasis is laid on the rigour of the analysis of the design processes, observation and the generalizability of the findings (Dorst and Dijkhuis, 1995). This approach views the design process as a scientific process, where design is considered as a problem which can be solved through a series of steps. Simon in 1969 (in Simon, 1996) suggests that a designer goes through a series of steps namely, analysis, synthesis, simulation and evaluation in order to find solutions for the design problem. The main objectives of the stage-wise design process, as expressed by theorists were to reduce the frequency of design error, redesign and delay and thus facilitate the designers in coming up with more imaginative and successful designs (Jones, 1984).

At the same time, Rittel and Webber (1984) argued that real-world problems are wicked problems and different from the problems in sciences and mathematics which are 'tame' problems. They claim that design problems can be characterized as ill-defined and wicked since they are inherently difficult to define, have unclear goals, can have multiple solutions and can have multiple ways of resolving them.

Simon (1996) acknowledges that design problems are highly complex and ill-structured. Therefore he suggests heuristics rather than algorithms. In the Information Processing theory, means-end analysis is considered to be a standard heuristic for solving difficult problems (Simon, 1996). The Ends are defined while means to those ends are specified. If means are not apparent then the problem is deconstructed into a hierarchy of sub-problems. This deconstruction continues until means are discovered to solve the sub-problems. Design simply becomes a matter of finding the best description of the problem.

2.3.3.4 *Criticism of the design as the rational problem-solving paradigm*

The main criticism of the paradigm of rational problem-solving process was that designers do not work as this paradigm suggests (Schön, 1983). The paradigm failed to acknowledge that designers may not strictly adhere to the sequence of stages in their respective orders, but may iteratively go back and forth through the stages. Though Simon claims that the process is iterative, in the sense that a designer goes through several loops of these stages, however, the process is sequential and fixed. This paradigm also does not provide any basis for the study of design problems and their structures, being more focused on the process-component of design decisions (Dorst and Dijkhuis, 1995). The paradigm also lacks the analysis of creative behaviour as it is fixed and inflexible to new ideas that a designer may come up during the process. It also assumes that the designer is aware of all the problems and the necessary steps required to solve them in the design process. The paradigm does not incorporate the realistic situation where a designer has to work collaboratively with other people for support during the design process. Moreover, design problems which are real world and complex problems cannot be easily decomposed into sub problems.

2.3.3.5 *Design as a process of reflection-in-action*

Schön, 1983 explicitly challenged the positivistic claims of Simon and instead proposed a constructivist paradigm for understanding the design process (Dorst and Dijkhuis, 1995). Schön’s main assertion was that designers deal with fundamentally *unique problems.* The everyday work of a professional designer involves the tacit *knowing-in-action* when she does things automatically without consciously thinking about the situation. However when the designer encounters an unexpected or unknown situation in her professional practice, she tries to make sense of the situation by reflecting upon the ‘*understandings, which have been implicit in his* [her] *action’.* Schön claims that this method of inquiry by the designers, while handling uncertain situations is *‘a reflective conversation with the situation’.*

He further asserts that design problems are never *given* to the designers. They have to actively structure or 'frame' the design problem and then take actions to improve the current situation. Through testing of solutions, the problems get defined and in turn again invite new solutions to be tried out. Hence problems and solutions evolve simultaneously. This paradigm considers design in a more holistic approach which is largely informed by the experiences and practices of the designer and demonstrates design-as-experienced and acknowledges the presence of aspects of irrationality in the design process.

Since Schön first published his writing, there seems to be a change in the research focus from viewing design as reducible into a series of stages to considering it as a holistic process. More attention is now being paid to the subjective experiences of the designers in their real situations than on a developing a universal design methodology.

2.3.3.6 Criticism of the design as the reflection-in-action paradigm

The main criticism against this paradigm was its treatment of the design problems (Dorst and Dijkhuis, 1995). There seemed to be no theory on the structure of the design problems and no explanation of how the designers evaluated the appropriateness of one 'frame' in which the problem would be structured, from another. Schön also never suggested how these frames were made, and what the properties of a good frame were. There was also a criticism on the lack of clarity and rigor which was achieved by the rational problem-solving paradigm (Dorst and Dijkhuis, 1995).

2.3.3.7 A way forward

Dorst and Dijkhuis (1995) make use of the two paradigms in analysing design activities and conclude that the two paradigms have complementary strengths in understanding an overview of the entire design process. Considering design as a rational problem-solving process is appropriate when the design problem is well laid out or clear cut, the designer understands the problem completely and is aware of the appropriate steps that are required to deconstruct the problem and solve it.

The strength of design as reflection-in-action paradigm lies in its consideration during the conceptual stage of the design process when the designer has no fixed strategies to follow and is exploring different options in framing or structuring the problem and the solutions.

Another important dimension of design that was the focus of discussion between these two paradigms was the nature of design as a discipline. Is design more science-like or art-like or separate from the two. The following section deals with a short review on this aspect as it leads to establishing design as a separate discipline distinct from the sciences and the humanities. This review further discusses the distinctions between design and other allied fields such as arts, crafts, technology and engineering.

2.3.3.8 Design: Science, Art, Distinct discipline

An attempt to 'scienticise' design goes back to as early as 1920s (Cross, 2001). There was a concern among the design researchers to propose an objective and rational 'design method' very akin to the 'scientific method'. However, it was only in 1969 that Simon's publication of *The Sciences of the Artificial* very explicitly proposed the foundations of the 'science of design'. Simon did acknowledge the fundamental distinctions between the aims of science and design by stating *'The natural sciences are concerned with how things are,'* whereas *'design, on the other hand, is concerned with how things ought to be'* (Simon, 1996: 114). However, he considered 'the science of design’ as *'a body of intellectually tough, analytic, partly formalizable, partly empirical, teachable doctrine about the design process'* (Simon, 1996: 113). Considering design as a rational problem-solving process, Simon proposed a design method based on rationality and objectivity, that is, on the values of science. By doing so, Simon claimed he was bridging the gap between the natural sciences and design practice with a science of design (Dorst, 2003).

Schön, on the other hand criticised Simon's 'science of design'. He claimed that the constrained application of the scientific theory and techniques (that he termed as technical rationality) can only be applied to well-formed problems while professional practitioners from all domains have to actually face 'messy' and 'problematic' situations (Schön, 1983). In these messy situations the scientific methods may not be suitable and may even cause problems to the designers. Schön argued that the technical rationality taught to students in textbooks is different from what designers practice in the real situation. Schön then proposed an entirely new 'epistemology of practice' which he called 'reflection-in-action' and which aimed to explain how professional designers or any professionals engage in designing or in other practice.

Schön’s theory that designers work differently from scientists was substantiated by the empirical findings by Lawson in his research study with architects and scientists. Lawson, 1979 (in Lawson, 2005) reported that that there were important differences in the strategies adopted by each group i.e. scientists and architects in solving problems. While scientists were found to be 'problem-focused', and largely analysed the problems by discovering some general rules/principles, architects were found to be 'solution-focused' and relied more on coming up with alternate solutions until they found an appropriate one.

Archer in 1979 (in Cross, 2006) asserted that design was different from the scientific and scholarly ways of thinking and communicating. He recognized design as the 'third culture' distinct from the established cultures of sciences and the humanities. The idea of ‘designerly ways of knowing’ is further developed by Cross (2006). He views design as an area that is searching for ‘intellectual independence.’ Based on the work of Archer, Cross sets out to highlight the significant differences among the sciences, humanities and design. He demonstrates the differences between the three cultures in the following way:

Table 2.1: Characterization of the three cultures (Cross, 2006)

The three cultures	***Phenomenon of study***	***Appropriate methods***	***Values of each culture***
Sciences	The natural world	Controlled experiment, classification, analysis	Objectivity, rationality, neutrality, concern for ‘truth’
Humanities	Human experience	Analogy, metaphor, evaluation	Subjectivity, imagination, commitment, and a concern for ‘justice’
Design	The artificial world	Modelling, pattern-forming, synthesis	Practicality, ingenuity, empathy and a concern for ‘appropriateness’

He argues that while the sciences study the natural world and the humanities the human experience, the subject of design is the artificial world. Again while the scientific process involves *controlled experiment, validation, classification, and analysis* and the humanities involve analogy, metaphor and criticism, design process involves *modelling, pattern-forming and synthesis.* According to the report the values that guide science are *objectivity, rationality, neutrality, and a concern for ‘truth’* while in design the values are: *practicality, ingenuity, empathy, and a concern for ‘appropriateness*

Cross (2007) claims that design indeed deserves to be a discipline in its own right, rather than being a science.

2.3.3.9 Design as distinct from other allied domains

Design and Technology

According to Owen-Jackson (2002), an industrial setting for design brings up the need to consider the distinction between the words ‘design’ and ‘technology’. In order to see the relationship between design and technology one must first understand what is meant by technology. The term ‘technology’ refers to ‘the human-made world’ in contrast to science which is concerned with ‘the natural world’. Technology in the broad sense refers to the human activity that transforms the natural environment to make it fit better with human needs.

In the first instance it seems that technology and design are one and the same, or as though one subsumes the other. However, there are aspects of technology that are not part of design: for example, the process of making stainless steel and aspects of design that are not part of technology: for example, designing logo or lettering (Owen-Jackson, 2002).

Design is the primary problem-solving process (other problem-solving approaches being troubleshooting, research and development, experimentation etc.) which is employed in technology to achieve desired human needs. Since the Industrial Revolution design has progressively become associated with engineering and technology, which means that engineers and designers make use of the design process to design products, processes and systems. Williams (2000: 52) wrote,

‘*In the real world it* [design] *is a significant process in the development of technology in many disciplines from engineering to architecture, and from an educational perspective it is an ideal methodology to use as a vehicle to achieve the desired competencies.*’

Designers in different disciplines rely on different technologies (such as, CAD, simulation techniques etc.) to meet their design criteria. Technology, in this sense becomes a resource to the designer. Thus Design and Technology ‘*consists in using technology to achieve solutions that satisfy sound design criteria and using design to achieve solutions that satisfy sound technological criteria’* (Eggleston, 1994: 21).

McCracken (2000) refers to design as ‘the creative soul of technology’. McCracken elaborated on the relationship of design and technology by stating:

'As a human soul is to the body, design is to technology. It is important to understand the interdependence and complimentary [sic] *nature of technology and design. Like the inseparable relationship between body and soul, technology is incomplete without design. Design cannot be fully appreciated without an understanding of technology. If technology is to be fully understood, then the concepts of design need to be understood.'* (p. 87)

Design and Art

From time to time one finds people interchangeably using the word design and art, as if they were synonyms. According to Rieber (2001), designing entails a planned intervention to solve a problem, fill a need, or realize an opportunity and is constrained by purpose and parameters, while art is not bounded by such constraints. This implies that design is something which is utilitarian and is involved with 'how a thing should be' whereas art is not utilitarian. In design, the goals are determined by other stakeholders, such as the buyer. Art, on the other hand is not concerned with the desires of the buyer or the customer. Thus a designer may employ artistic ways of visualizing, thinking or processing, but unlike, artists, they are required to solve the problem of their clients and not present their own view of the world. Although one commonly hears of the phrase, 'design in art', this is different from 'design in technology'. In technological design the designer always keeps the users in mind and the ideal that she tries to achieve is efficiency while in art the artist expresses her own expression without keeping in mind the users and the ideal that she aims to achieve is beauty (Mitcham, 1994). Technological design is considered to be more rational in comparison to artistic design which is thought to be more intuitive.

Meiert (2007), while comparing art, design and decoration, wrote,

'Art hides. Art has a meaning, and it hides it, on purpose. Art delivers a message, and that message is hidden, on purpose. It is an art to create art. Art is unusable, by definition.'

'Design reveals. Design reveals meaning, design reveals a message, design reveals function. Bad design does the opposite: It obscures, it hides. The reason why that almost never makes bad design art is that the subject is supposed to be revealed.'

Decoration according to him is *'Anything else that doesn't have meaning is just decoration, at most.'*

Design and Craft

The Merriam-Webster online Encyclopaedia defines craft as (i) skill in planning, making, or executing: dexterity, and (ii) an occupation or trade requiring manual dexterity or artistic skill (Merriam-Webster Encyclopaedia). According to the International Encyclopaedia of the Social Sciences, the term ‘craft’ is derived from the Anglo-Saxon word *crseft*, meaning ‘strength, skill, or cunning’ (Encyclopedia.com). Crafts, thus, include all activities that produce or modify objects by manual means, with or without the use of mechanical aids, such as looms or potters’ wheels.

The primary difference between design and craft is that while craft is something which is handmade, design emerged to serve the needs of the industries. Designing implies separation from making. Thus products need to be ‘designed’ before they are manufactured or made. This implies that a craftsperson may fabricate the materials intuitively while design involves creating a blueprint or the plan of action before any event of making. Moreover, while a designer’s aim is to solve a problem and create usable products, a craftsperson may just produce a decorative product without any utilitarian value, for example a decorative lamp or a teapot.

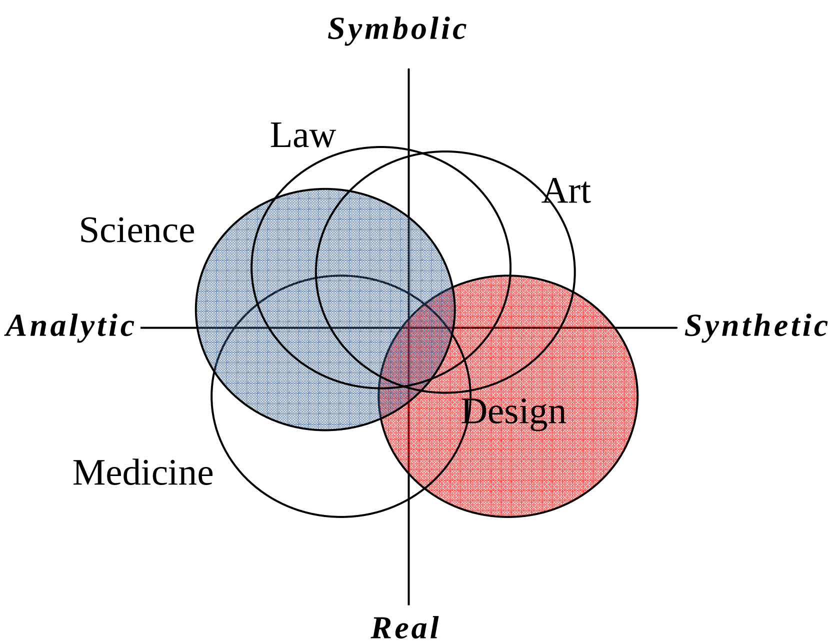
Design and Engineering

Since the Industrial revolution, design has become closely associated with modern engineering and technology (Mitcham and Holbrook, 2006). While design consists in creating the specification of requirements (e.g. functional, aesthetic, etc.) needed to satisfy the customer/client, engineering consists of the translation of these requirements into a technical specification describing a system which match with these requirements. Thus while the designer is concerned with the context and other human factors such as aesthetics, functionality, ease-of-use, fitness for purpose, and quality; the engineer can make decisions without keeping the context in mind. Leahy, Gaughran and Seery (2009), provide a distinction between design and engineering with respect to four features: *activity, types, strategy* and *design processes*. With respect to the feature of *activity,* the authors suggests that while engineering is the application of scientific theory in the design, creation, and maintenance of technology, design as a process can take many forms depending on the object being designed and the individual or individuals participating.

Again both engineering and design have distinct *types* of sub disciplines. For example, there are many *types* of engineering such as electrical engineering, mechanical engineering, civil engineering, and biomedical engineering. Similarly there are many *types* of design such as product design, interior design, furniture design, urban design, fashion design etc. With respect to *strategy*, the author argues that a design activity is primarily carried out to fulfil a human need, engineering applies to advances in technology very often to fulfil a human need. Furthermore both disciplines make use of design processes; however, engineering design processes are more clearly structured (Jones 1984).

Owen (1998) compares design with some other disciplines by making use of the *'Map of Disciplines'*. The map consists of two axes- the horizontal axis of *Analytic Synthetic* and the vertical axis of *Symbolic Real*. The *Map of Disciplines* presents interesting differences among traditional fields of study and practice. According to Owen, the disciplines placed to the left of centre are more concerned with 'finding' or discovering; disciplines to the right are concerned with 'making' and inventing. Disciplines in the upper half of the map are more concerned with the abstract world while those in the lower half work with the real world and the artefacts and systems that enable us to operate in the physical world.

Figure 2.1: Map of Disciplines (Owen, 1998)



Although the positioning of the disciplines on the axes might be subjective and relative, the map provides an overall comparison based on two very fundamental ideas: content and procedure. As indicated in the map (Figure 2.1), science is placed to the left of the axis due to its use of analytic process and its content being more symbolic than real. Law is concerned with the symbolic content of institutions, policies and thus is placed higher on the axis and towards the right since it involves creation of laws. Art is also high on the content axis, since it is symbolic, and is little more synthetic than analytic. Medicine on the other hand is concerned with the real problems of human health and involves analytic diagnostic processes. In contrast to most of these fields, Owen argues that design is highly synthetic and is strongly concerned to the real world problems. Since some design disciplines deal with communications and symbolism, design has a symbolic component too. Design also involves analysis to perform synthesis hence it has analytic component also.

2.3.4 Conceptualizations of design: Historical perspective

Humans have been ‘designing’ since pre-historic times. However, this idea of design was associated more in terms of 'giving form' or ‘making’. It was only in the middle of the nineteenth century during the Industrial Revolution, that design got separated from the activity of 'making', and in the early twentieth century it got recognition as a distinct discipline.

2.3.4.1 The separation of design from making

Middle Age Europe was essentially a craft-based society. Craftspersons usually worked in their workshops in groups, including pupils or apprentices working under them, who learnt the skills from their master. A single crafts person 'designed' and made the products all by herself. This 'design' was however, ‘hidden’ in the act of making (Mitcham and Holbrook, 2006). Craftspersons were themselves the designers, the makers as well as the users. There was nothing like thinking out, planning or modelling before undertaking the actual work. Designing always remained within the mind and the hands of the maker and took place in the course of construction. The maker could take spontaneous decision about the look of the final product right at the time of making. Thus testing occurred while in the actual making phase itself and then again during the using phase. These crafts persons worked on a limited range of products and each piece of designed article was individual and often a little bit different from each other. The craft-based works also tended to serve personal, local or regional demands.

However, with the invention of mechanical processes of production and division of labour during the Industrial Revolution, it was now possible for manufacturers to produce large quantities of similar and low-priced products. This gave rise to a whole range of specialists called designers who would contemplate about the structures of the products and how it could be designed using technology such that it is mass-produced. This was the period when the design process became explicit, becoming separate from the acts of making and using. The traditional limited works of the crafts-person were pushed aside and were rendered irrelevant by the emerging expertise of the professional designer.

According to Jones (1970), this separation of thinking from making had three significant effects:

- Firstly it led to the division of labour. Contemplating about the structure of the product and specifying its dimensions in advance of the manufacturing process made it possible to *split up the production work* into several pieces which can be made by different people.
- The drawing-before-making became advantageous since it made possible to plan things/products that were *too big for a single craftsperson* to make on her own.
- The division of labour in turn not only led to the increase in the size of the products but also their rate of production. A product which a single craftsperson took several days to make was reduced into smaller standardised components that could be made simultaneously within short time by repetitive hand labour or by machine.

Thus central to the new thinking in design was the idea of division of labour, with the separation of mental and physical effort. Design became the means of constructing the final product without undergoing trial and error which incurs huge amount of labour, money and time.

2.3.4.2 Problems with mass-produced, designed products

However, with increased mechanization, the mass-produced products were cheaper but lacked style and product uniqueness. The first reaction against the mass-produced, machine-made products was the Arts and Crafts Movement which sprang during the second half of the nineteenth century (Hauffe, 1998). The adherents of this movement believed that the excesses of industry had resulted in the debasement of art, aesthetic and creativity (Heskett, 2002). They refused to make any reconciliation between art and industry and instead promoted the crafts persons and artisans to return to the past and replace the poor quality, cheap, monotonous, machine-made products with the qualitatively better products of their skilled, craft-based productions (Hauffe, 1998).

The second reaction against the quality of machine-made products was to improve the quality of industrialized products by accommodating their form to the requirements of industrial productions. The Bauhaus school in German was founded in 1919 by Walter Gropius, who aimed at unifying art and craft with industry and developed a new style of machine production termed as ‘machine’ or ‘industrial’ aesthetic (Buchanan, 1995). The Bauhaus followed the motto; *form follows function* according to which the shape of an object should be primarily based upon its intended function or purpose. Thus it was able to free itself from the shackles of mere 'styling' and lay down new principles for productions.

2.3.4.3 Formation of the discipline of design

Designers were now given a new status and recognition as discrete profession. In this period the Governments in UK too began to show awareness of the economic role and the future developmental possibilities of this new profession, with the formation of the Council of Art Industry in 1932 followed by the Council for Industrial Design in 1944.

While design emerged as a distinct discipline in the West during Industrial Revolution, it emerged in India, only in the late 1940's and 1950's (Balaram, 1998). In Indian tradition, there has always been a direct association between art and craft. They are considered a unified whole. After the country's independence in 1947, several manufacturing units were started with the help of foreign collaboration. These manufacturing units not only borrowed the technology but also design to modify certain goods/ items to suit Indian needs. Within no time, Indian industries started their own research and design units in India.

2.3.5 Conceptualizations of design: Educational perspective

The Industrial Revolution led to an unprecedented escalation in demand, both with regard to quantity and quality of products. Thus the size of the activity as well as the efficiency of operation had to be enlarged. This created the need for industrial designers who would not only contemplate about the structures of the products but also would anticipate how it could be designed to be mass-produced. It then became apparent that a high school education was not sufficient for the new skills needed by these designers who would develop the concepts for manufacturing mass-products.

As mentioned earlier, Walter Gropius (a German architect) in 1919 and few others in Germany tried to merge art, craft and technology at the Bauhaus. The preliminary course at the Bauhaus consisted of art and architecture with the basics of material characteristics, composition, and colour (Hannah, 2002). Within a matter of 10 years, many design schools were then opened up.

Another school of design that impacted the development of design as an academic discipline was the Ulm School of Design or the Hochschule für Gestaltung (Ranjan, 2005). Max Bill, a former student at the Bauhaus opened a design school in Ulm, Germany known as the Hochschule für Gestaltung. The Ulm school contributed to the integration of scientific methods into the design process. Thus while the Bauhaus tried to integrate Art, Craft and Technology, the Ulm school attempted to develop design as an analytical and research-based activity. It also aimed at integrating many other disciplines such as humanities, psychology, economics, thus enabling a confluence of natural social sciences into the curriculum. The important point to note was that all these institutions trained individuals to become specialists in design. No need was felt at that time to include design in general education for all people.

2.3.5.1 Design in general education: From the crafts to D&T

The early models of practical education in schools in Britain and other countries were largely craft-based (like woodwork and metalwork) with the aim of producing skilled individuals contributing to the workforce for industries (Penfold, 1987). However, these practical works were mostly relegated to lower strata and associated mostly with students who were academically poor. Design work consisted of activities related to styling, shaping and decoration (Penfold, 1987).

A significant change, however, was witnessed in 1959 with the publication of the Crowther Report which acknowledged the importance of cognitive processes of 'thought and exploration' in practical education (Morley, 2002). The report, being a first initiative in bridging the gap between education and industry, advocated for an 'alternate road' approach to education by rehabilitating the word 'practical' in educational context (Penfold, 1987).

It is argued by Roberts and Norman (1999) that in these craft-based activities, designing competences among students grew 'naturally' out of craft experiences. However there were no significant attempts at developing general models of designing that would serve as a theoretical framework for all these activities. It was only in 1971 with the completion of two projects, Project Technology (1967) and the Keele Project (1969) that generic models of designing began to emerge.

Project Technology, led by Geoffrey Harrison set out to establish engineering in general education and to develop appropriate curriculum materials for the teachers (Robert and Norman, 1999). The 'Keele' Project led by John Eggleston (Stables and Kimbell, 2006) served to re-examine the craft-based teaching and learning and aimed at enhancing their status in schools (Roberts and Norman, 1999).

A related area of growth in Britain that 'was stealing the march on design and technology education' was that of design research (Stables and Kimbell, 2006). As mentioned earlier the research on Design Methods emerged during the 1950's and 1960's. There were also the formulation of the Design Research Society in 1967 and the birth of Design Studies Journal in 1979 (Stables and Kimbell, 2006). These had a direct and significant effect on the development of design education in schools. For example in 1967, Kate and Ken Baynes published their articles in *'Design'* journal, examining the state of design education in schools (Penfold, 1987). The two significant take-home points of these articles were the concern for an appropriate education in an industrialised society and the need to progress from the vocational models of practical education (Morley, 2002).

A significant step along these lines was the research on 'Design in General Education Project' headed by Archer and others in 1979 (Stables and Kimbell, 2006). Archer distinguished specific characteristics of design that made it a discipline which should be at the core of education by describing design as being Useful, Productive, Intentional, Integrative, Inventive and Expedient. While characterising design from other forms of knowledge such as the sciences and the humanities, Archer, in this research project, made the case for design as the missing ‘third area’ of education, the first two areas being the sciences and the humanities. Archer argued in the report that the sciences and the humanities have been dominating the social, cultural and educational system, while technology centred around design has been neglected since it has not been identified and appropriately named (Cross, 2006).

Archer asserted in the report that this third culture has a different language in comparison to the sciences and the humanities. If numeracy is the language of the sciences and literacy the language of the humanities, then modelling is the language of design. Even the subject of interrogation differs among the three domains. As mentioned earlier in Section 2.3.3.8 in Table 2.1, Cross (2006) working on Archer's report, neatly compares the three traditions of culture.

In the report, Archer calls this Design with a capital D and defined it as the ‘the collected experience of the material culture, and the collected body of experience, skill and understanding embodied in the arts of planning, inventing, making and doing’.

Cross (2006) drew the following four conclusions from the report, in relation to Design with a capital D:

- The central concern of Design is ‘the conception and realization of new things’;
- It encompasses the appreciation of ‘material culture’ and the application of ‘the arts of planning, inventing, making and doing’;
- At its core is the language of modelling; it is possible to develop students’ aptitudes in this language, equivalent to aptitudes in the language of the sciences- numeracy and the language of humanities- literacy;
- Design has its own distinct ‘things to know, ways of knowing them, and ways of finding out about them’;

While critiquing the inquiry report of Royal College of Art, Anita Cross from the Open University raised concern about the role of design in general education (in Morley, 2002) by arguing that:

'If Design then, is to be considered as basic to general education, it must be amenable to the usual meanings of basic or general education, i.e. an education which is, in principle, non-technical and non-vocational' (in Morley, 2002: 8).

She asserted that design could only achieve parity with other disciplines by:

'(a) being organized as an area of study not unlike the Science and Humanities (b) providing instruction in concepts and methods of enquiry appropriate to life-long learning, and (c) attempting to foster an understanding and appreciation of the contributions that design activities and specialisms make to the individual's life and the lives of others' (in Penfold, 1987: 42).

According to Morley (2002), several significant points emerge from Cross's critique. Firstly design as conceptualized for general education should be distinct, that is, have aims distinct from the sciences and the humanities which are already established subjects in the school curriculum. Secondly it should have the wider aim of providing basic life skills to students like other school subjects rather than mere vocational objectives. Finally, design education should aim to foster skills that should be of lifelong relevance to students' lives.

In response to Anita Cross's criticism, Cross (2007) attempted to propose design as a part of general education by seeking to differentiate between the intrinsic and extrinsic aims of general and professional education respectively. He believed that while general education aims at developing an individual's self-realization and basic life skills, the goals of professional education are extrinsic and aim at equipping individuals with vocational skills. While every individual in school is taught science, not all of them become scientists. He argued that the intrinsic aim of science education is thus to instil scientific ways of knowing and thinking. An understanding of the nature of design ability reveals that design education similarly has intrinsic values that need to be developed among students. Drawing upon the field of design research, Cross claims that there are indeed 'designerly ways of knowing' that are at the core of the design area of education. These ways of knowing which can only be achieved through design education are:

- Designers tackle ‘ill-defined’ problems;
- Their mode of problem-solving is ‘solution-focused;
- Their mode of thinking is ‘constructive’;
- They use ‘codes’ that translate abstract requirements into concrete object;
- They use these codes to both ‘read’ and ‘write’ in ‘object languages’;

From these ways of knowing, Cross drew three main areas of justification for design in general education:

- Design develops innate abilities in solving real world, ill-defined problems;
- Design sustains cognitive development in the concrete/iconic modes of cognition;
- Design offers opportunities for development of a wide range of abilities in nonverbal thought and communication;

In 1985, Baynes too attempted to make a case of a design education for all by suggesting that design in general education should be aimed at developing two intimately linked capacities of all people (Baynes, 2008):

***Design awareness**:* knowing about design and
***Design Ability**:* being able to design

He suggests that while design awareness involves an understanding of the environment; how *it was* shaped or changed and how *it can be* shaped or changed in future, design ability involves the development of skills that brings about those changes. Baynes claims that design awareness would allow an individual to:

- Enjoy with understanding and insight the made world of places, products and images;
- Take part in the personal and public design decisions that affect their lives and the life of the community;
- Design and criticize design at their own level for their own material and spiritual needs;
- Bring an understanding of design into their work;

He further claims that developing design ability among individuals would provide a foundation for the development of a range of future professional designers – planners, architects, technologists, engineers, and industrial, fashion and graphic designers.

Baynes reiterated that design awareness and design ability are inherent capacities of all human beings and can be developed by education.

2.3.5.2 Design in the curriculum

The reform in general education in UK benefited largely from the 'design-in-general-education' movement (Cross, 1976) and led to the establishment of design education through Craft, Design and Technology (CDT) education in the early 1980s. Various reforms have taken place after this due to which the subject was rechristened many times, being named as ‘Design and Technology’ in the late 1980s, ‘Technology’ in the early 1990s and finally returned to ‘Design and Technology’ in the present (Holdsworth, 2000).

Most nations worldwide have introduced design or design and technology education in primary schools including the Republic of Korea, the U.K., the Netherlands, Australia, New Zealand, Sweden, Japan, and the U.S.A (Lewis, 1996). Today D&T education is variously named throughout the world. For example, in England it is known as Design and Technology, in Ontario as Science and Technology, in Australia as Technology, and in California as Industrial and Technology Education (Sharkawy, Barlex, McDuff, Craig and Welch, 2008). However, the differences in the names suggest important distinctions among the curricular aims and emphasis in these countries. The names suggest the amount of emphasis laid on design in these curricula. While D&T in British curriculum is driven by the processes of design and problem-solving, the American Technology education curriculum aims at developing technologically literate individuals by emphasizing concepts related to technology (Lewis, 1996). This is not to say that American and other curricula aimed at developing conceptual understanding about technology do not teach design, but the issue is of emphasis. Design is taught as a process in technology as evident from the definition provided by the International Technology Education Association (ITEA, 2007), ‘[Design is] *an iterative decision-making process that produces plans by which resources are converted into products or systems that meet human needs and wants or solve problems’* (p. 237).

2.3.5.3 The impact of the design paradigms on D&T education

The notion that the act of design could be reduced to 'objectively' observable discrete sequence of stages, found a wide acceptance among researchers and philosophers in design research and education (Visser, 2010). In education, engineering and computer science fields were the first to employ problem-solving methods (Kimbell, 2009). Researchers have found an increased attention to the role of problem-solving as an important aspect in D&T education (McCormick, Murphy and Hennessy, 1994; Hennessy and Murphy, 1999; Todd, 1999; Mawson, 2007). Lewis, Petrina and Hill (1998) provided an extensive summary of the use of problem-solving process in the teachings of design in technology education over the past two decades. There is a lot of emphasis on teaching design problem-solving to students through step-wise design methods. Research studies in problem-solving domains have also explored the possibilities of seeking one universal and best method for solving design problem-solving. However, literature abounds with different models of design problem-solving with Johnsey (1995) identifying at least seventeen different versions of design problem-solving models in schools across England and Wales. Williams (2000) suggest the words design and problem-solving are often interchangeably used in the design and technology literature, to indicate that they are one and the same process. However he argues that they are different processes all together. Mawson (2007) suggests that the main rationale behind the acceptance of problem-solving process and thus the linear step-wise design process was to make teaching and learning effective by imposing an order and structure to the design activity which itself is a highly complex process. Mawson recognized an existence of confusions regarding the nature of the processes in design, technology and problem-solving with the models of these three processes being represented by the usage of similar terminologies and sequences of activities involved in these.

The importance of reflective learning and practice has also been identified in design and technology learning. In fact most of the above mentioned design process models have tried to incorporate reflection in terms of evaluation being carried out at various stage of the design process (Mawson, 2007). However, it has been reported that even though reflection is a significant aspect of design problem-solving process models, students do not question and reflect on their processes (Mawson, 2007; Jones and Carr, 1994). Students work in a linear step-wise way without reflecting between the different stages. It is important that students understand the iterative process of design. However, Benenson (2001) argues that the difficulty in teaching design as an iterative and reflective process is that it ‘*runs counter to the prevailing paradigm in education that holds that an answer is either right or wrong, leaving little or no room for students to work their own way toward better solutions*’ (p.64). It is also argued that the adherence to the design process models hinders reflective thinking by students (Mawson, 2007; Jones and Carr, 1994).

Many researchers have suggested ways of developing reflective thinking in design through different ways. For example, Lewis et al. (1998) suggests that a shift in emphasis from the design process or problem-solving approach to the problem posing approach by students can promote reflective thinking among students. Some teachers have reported that recording of events by students in their process diary and logs can facilitate reflection (Rogers and Clare, 1994) while some others (Jones and Carr, 1994) have suggested that an explicit instruction to reflect on their own processes and the link between the different stages can promote reflective thinking.

2.3.5.4 Design education in India for the specialists

Design as an activity in India is as old as its culture but the modern concept of professional design had its origin in the various art schools that got established in the 1800’s. The first Art Schools, the Bombay Art School was established in Mumbai in 1857. These schools mainly included courses in fine arts, pottery, tile making, metal crafts and so on.

In 1913, Rabindra Nath Tagore set up Shantiniketan which expanded into a university in 1921. Among various schools in Shantiniketan, he started *Kala Bhavana*, an Art College and *Shilpa Sadan*, a centre for rural craft and cottage industries. While similar to the Bauhaus, Shantiniketan stood for the cultivation of art and crafts bringing about total education (Balaram, 2005). The Bauhaus and Shantiniketan were similar in terms of synthesising the work of artisans and crafts people. However while the Bauhaus practiced machine aesthetics oriented to mass production, Shantiniketan practiced and taught the language of the hand and considered it significant for craft production.

While several art schools were opened subsequent to this throughout the country, it was only in the 1950’s that design emerged as a modern profession in India. Immediately after the independence of India in 1947, Jawaharlal Nehru, the then Indian Prime Minister invited the designer couple, Charles and Ray Eames to make recommendations for an appropriate design activity that would support the development of the large craft sector and the small scale industries of India and help them survive through industrialization Balaram, 2005). Based on 'The Indian Report' by Charles and Ray Eames, the Government of India, set up the National Institute of Design in 1961, in Ahmedabad. The aim of this institute was to provide graduation in design to students and prepare responsible designers. The institute started with programs in basic Design and a few years later with programmes in Industrial Design and Visual Communication. In 1969, Industrial Design Centre (IDC) was set up by the Government of India and which initiated graduate and post graduate programmes in Industrial design.

2.3.5.5 Design education in India for general population

Design or technology education is not there in the Indian school curriculum. However, some form of vocational education is present in the curriculum but as mentioned earlier in Section 1.2.3, these subjects have become ineffective in providing students to either develop vocational interests or creativity as they follow teacher prescribed methods and processes or mainly involve making of products which have no relevance to students' real life situation.

2.3.5.6 Research initiatives in D&T education

In the recent past, there have been efforts on the part of Indian researchers, to bring D&T into the Indian Curriculum. Homi Bhabha Centre for Science Education (HBCSE), a National Centre of Tata Institute of Fundamental Research is devoted to research and development in science, technology and mathematics education. At HBCSE, research carried out on D&T education attempts to explore the possibility of introducing D&T in Indian classrooms (Khunyakari, 2008; Mehrotra 2008; Choksi et al., 2006). Mainly centred around design-make-appraise (DMA) approach, these researchers 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, Chunawala and Natarajan, 2009a; Ara, Natarajan and Chunawala, 2010;

Shome, Shastri, Khunyakari and Natarajan, 2011) and teachers' designing ability (Shastri, Khunyakari, Chunawala and Natarajan, 2011).

2.3.5.7 Global initiatives

Realizing the importance of design in the current scenario, the Industrial Design Centre (IDC) hosted a National meet in Mumbai in February in 2010 (IDC, 2010). The aim of the meet was to come up with a set of recommendations and formulate guidelines for introducing 'Design and Innovation' in the Indian school curriculum. The guidelines were prepared and presented to the Ministry of Human Resources and Development, to the various directorates of school education and to the knowledge commission of India.

The basis to include 'Design and Innovation' in schools were formulated as follows:

- Design can play a very significant role in finding appropriate solutions to problems;
- Design is creative, collaborative and multidisciplinary;
- Hands on experience through design can make a difference to the process of learning other subjects in schools;
- Design involves problem-solving and leads to experiential learning;
- Design can bring sensitivity and awareness to Indian arts, crafts, culture and environment;
- Design can help students develop values, attitudes, sensorial skills and critical thinking;
- Design can make students realize their creative and innovative potentials;
- Design and Innovation can make a big difference to the expected growth of creative needs in our country;

The effort on the part of IDC is significant since it is one of the first initiatives towards inclusion of design in the curriculum. The report seems to balance between the aims of developing individual's competence in innovating products and services for business and their basic design ability and awareness.

2.3.5.8 Local initiatives

There also have been efforts by Indian organizations such as SRISTI (Society for Research and Initiatives for Sustainable Technologies and Institutions) founded by Anil Gupta (www.sristi.org/cms/). The aim of this organization 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. The strength of this approach lies in its success in bridging a gap between local innovations by poor crafts persons and industries. However the drawback of the initiatives taken by SRISTI is that it is localized and mostly aims at adding value to the local innovation done by people or children especially in villages. There are no teaching and learning programs to become successful innovators.

2.3.6 Researcher's own conceptualization of design: Personal disposition

As demonstrated in the above sections, literature provides varied definitions and meanings of design, sometimes conflicting with each other. An attempt was made by the researcher to use the literature and form her own conceptions of design.

As noted in literature, design has been conceived at various levels of abstractions. While some consider poetry and music as design (Papanek, 1972), others conceive any products created as design including the works of art or as decoration or styling, while still others, go to the extent of considering all knowledge as design (Perkins, 1986). Schön contends that by broadening design to such extent we tend to '*risk ignoring or underestimating significant differences in media, contexts, goals, and bodies of knowledge specific to the [different] professions*' (p. 77). The researcher believes that poetry, music and work of art can be considered design to the extent that they involve problem-solving to serve human needs and desires. However, not all problem-solving is design. Hence the researcher limits her notion of design and considers design from the technological point of view.

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. Design is a discipline with a not so long history but which has developed into many areas of speciality within a very short time period. Design as a professional discipline is different from other professions which also might involve problem-solving and creativity such as law or engineering. The researcher shares the views of Dan Saffer (2010), an interaction designer, who argues that designers are different from other professionals in six aspects. They

- Focus on customers/users for whom they are designing the product;
- Create alternatives and choose the best from them;
- Ideate and prototype solutions to evaluate their ideas;
- Solve wicked problems which are ill-structured, without a single clear solution and involving many stakeholders;
- Bring multi-disciplinary spectrum of ideas to resolve the problem;
- Incorporate emotion while making design decisions in order to connect with their users;

As a process it refers to the intentional, iterative problem-solving process that converts ideas into systems or products. However, the researcher is careful and supposes the problem-solving process and the design process as two distinct processes. This understanding of design process reflects what Barlex considers as the decision-making process. It reflects design process as INVOLVING iterative problem-solving processes where individuals are required to make a series of interconnected decisions regarding every feature of the design. The researcher shares Buchanan’s disposition on design thinking, that is, while design thinking is partly rational and cognitive on one hand, it is irrational, emotive, intuitive and non-cognitive on the other (Buchanan, 1995). It is rational to the extent that designers have a conscious understanding of the principles that they apply in their design, that is, they take conscious and intentional decisions with clear reasons for those decisions. Design is irrational and non-cognitive to the extent that designers rely on intuitions and emotions for their choice of design decisions.

As a product it may refer to the outcome of the design process such as specifications, sketches, models or shape of the products. Designed products could be tangibles like clothes, furniture, hardware or intangibles such as policy documents or services.

For the researcher, design is a natural ability possessed by all human beings to some extent. This ability comprises of the ability to shape and use materials to create tools to satisfy our needs, which the researcher believes can be fostered through appropriate design education.

2.3.7 Summary of the Philosophical perspectives of design

Through analysing the meanings and definitions of the word design in this review, it can easily be recognized that it is variously understood by philosophers and theorists. While some consider it strictly as the practice among specialists, others have transcended the boundaries and have acknowledged designing by even lay people in their everyday life. However, it is understood completely differently by lay people which might not be equivalent to philosophers' and designers' understandings. This suggests that a student may not automatically understand design by just observing, using or buying designed products. They need to have education in design to have a better understanding and an awareness of design.

From among the various philosophical approaches in literature, two of them have not only influenced theories about design but have also affected the practice of design among professionals and design educators. The two paradigms identified are the *design as a rational problem-solving process* and *design as a reflection-in-action process*. The former paradigm, essentially aspiring to achieve the rigour and values of science, considers that design problems can be resolved through the rationalized stages of the problem-solving process. Although this paradigm has been criticized for its excessive rigour and process-oriented approach to design, it is a widely accepted approach to design. The design as a reflection-in-action paradigm considered design to consist of aspect of irrationality such as intuition and emotion. Taking a more holistic approach to design, this paradigm considers every design problem as unique and situation-specific where a designer is in *'a reflective conversation with the situation.'* The role of problem framing and complex nature of design problems are considered relevant.

An important point that the researcher notes (which can be contentious) is that although both the paradigms proposed their theories in relation to professionals in actions, the presence of science-like processes such as design methods, rationality, objectivity and rigour in the problem-solving paradigm makes it appears more attuned to the domain of professional and trained designers. This is so because in real-life situations, a non-designer does not follow a linear process while solving an ill-structured problem. On the other hand, the presence of experienced-based processes such as subjectivity, reflections, irrationality, emotions and intuition in Schön' reflective paradigm makes it appear more aligned with the everyday act of designing. A non-designer instead of following any predetermined steps, invent her own processes based on her experiences, the context and the task in hand. However, both Simon and Schön considered design by professionals as well as by non-professionals.

The review also highlights some of the important distinctions between design and its other allied fields such as art, technology, engineering and science. While attempts have been made by philosophers to 'scienticise design', there have been others who claim that design deserves to be a discipline in its own right.

An understanding of why and how design originated as a discipline has a direct implications on how it is perceived today by philosophers and lay people. This leads to the review of how design originated. Design as an activity of giving form has been practiced since pre historic times. However, there was no separate 'thinking out' process before the actual making process. However, it was only during the Industrial Revolution when a process of 'thinking out' before the actual making became indispensable. Increased mechanization and a need to mass produce led to the division of labour. A prior formulation of product before the act of making was deemed important to save money, time and labour. Design as a distinct discipline was established by the early twentieth century.

A review of the history of educational reforms in Britain, reveal that design emerged from the craft based practical education. Three landmark policy documents that eventually led to the introduction of design in schools were the Project technology Report, the Keele Project and the Design in general education movement led by Archer and Cross.

Archer and Cross advocated for design in general education by claiming that it was a third area in education besides science and art in the curriculum. They both asserted that design has distinct ways of knowing and learning, different from the sciences and arts and thus should be introduced in the general curriculum for all children. Design educators claim that design education has both intrinsic and extrinsic or instrumental aims that would facilitate both design awareness and design ability among students.

While design is being taught through Design and Technology education since the past two decades in Britain, Indian education system neither includes design or technology education for school students. A few research organisations like Homi Bhabha Centre for Science Education and the Industrial Design Centre are exploring the possibilities of introducing design and technology education or its equivalent in Indian schools.

2.4 Design and Technology: Perception and images

One of aims of the present study is to study students', teachers' and designers' ideas of design. To this effect, it was necessary to examine research studies on students', teachers' and designers' ideas of design.

2.4.1 Students' perception and images of design and designers

A review of literature revealed that investigations of students' perception of science and scientists began around 1950s. These investigations are extensive and have been done globally in most nations of the world interested in developing science education. Researchers probing ideas about scientists, nature of relation between science and technology, and ideas pertaining to Science-Technology-Society have also shown interests in exploring students' ideas about technology (Aikenhead, Fleming and Ryan, 1987; Sjoberg, 2002; Chunawala and Ladage, 1998). Research on students' ideas about technology is more than two decades old. In order to take account of students' interests and need in technology curriculum, the Pupil's Attitude towards Technology (PATT) project was initiated (Ratt and de Vries, 1986), adapted and used across various countries and has provided useful insights into students' perceptions of technology (de Klerk Wolters, 1989; Rennie and Jarvis, 1995; Jarvis and Rennie, 1998; Rajput, Pant and Subramaniam, 1987; Khunyakari, Mehrotra, Chunawala and Natarajan, 2009; Mehrotra, Khunyakari, Chunawala and Natarajan, 2007). Most of these researchers reported similar findings across the globe. For example, most students associated technology with computers, phones, electrical equipments, hi-tech machinery. These studies also reported that most students considered technology to be modern and associated it with the usage of modern equipments and gadgets. Most students were also found to exhibit a positive attitude towards technology since they considered it useful for their future.

In the recent past, there has been an increased interest in integrating engineering education into technology education in the US and UK primary and secondary schools (Hynes, 2010; ITEA, 2007). This has simultaneously attracted researchers to study students' perceptions, attitudes and understanding of engineering and engineers (Karatas, Micklos and Bodner, 2010; Fralick, Kearn, Thompson and Lyons, 2009). The common findings from these studies indicate that students consider engineers as males 'building buildings' and 'fixing engines'.

An extensive review of literature indicates a lack of studies on students' ideas of design. Only a few studies have been devoted to this aim. Also these studies are limited to those students who either have D&T education in their curriculum or are adult students who had an exposure to the process of design. The following few collections of studies are indicated below.

Hill and Anning's study (2001) is relevant to the research reported in this thesis, since they attempted to compare students', teachers and designers' understanding of design. They characterised the students' and teachers' conceptions of design as 'school situated design' while those of the designers as 'workplace design. The students had been studying D&T in their schools and belonged to four age groups namely, four-to-five year olds, six-to-seven year olds, eight-to-nine year olds and eleven-to-twelve year olds. The teachers were the four respective D&T teachers of these students.

Not surprisingly, they found that four-to-five year old students found it difficult to articulate their ideas about design. These students considered design to be 'inside my [their] heads.' The six-to-seven year olds had already studied D&T for two years. Hence their responses were based on their live experiences of designing in the classrooms. They considered design as 'using pattern to make something' and 'making things' or as 'drawing', or 'drawing on a piece of paper and making it 3-D'.

The eight-to-nine year olds and eleven-to-twelve year olds had clearer understanding of design and even regarded a plan and a sketch as different from each other by suggesting that a plan was more 'like a recipe'.

This study provides useful insights into students understanding of design. However the limitation of the study with regard to the present study in the thesis is that it involved students and teachers who had D&T already in their curriculum and their conceptions was based on their lived experiences in their classrooms. Secondly, the sample was very small including eight students, four teachers and four designers. Thirdly, the methods of investigation involved interviewing all the three samples. Although it provided depth, it lacked breadth in exploration. The present study aims to study a larger sample of students and teachers through a survey which involves utilizing a similar tool for the three samples. Another shortcoming of the Hill and Anning's study in relation to the present study is that it involved examining students' concept of only in relation to design as they practiced in their classroom. There was no probing for other aspects of design, such as the nature of design, attitude towards design, attitude towards designers, differences in perception of design based on gender, etc. The present study aims to investigate students' ideas of design on many aspects through the use of structured questionnaire and interviews.

In another context, Newstetter and McCracken (2001) studied computer science and engineering students' conception of design. They found that novice design students had well-developed prior theories and [mis]conceptions about the nature of design and these conceptions were in conflict with the conceptions of expert designers. Newstetter and McCracken refers to Chi, Glaser and Farr (1988) who suggested that although prior conceptions are imperative for students to learn something, these prior knowledge among students are often incorrect. Chi, Glaser and Farr (1988) suggested three types of misconceptions held by students: incorrect, inconsistent, or incompatible. According to them, incorrect misconceptions are relatively easy to change because they are incomplete and fragmentary. Inconsistent misconceptions are resistant to change because they are part of a larger mental model which already has a structure. Incompatible misconceptions are incompatible with experts' conceptions and are most resistant to change because they are fully developed and need the most radical form of conceptual change. Newstetter and McCracken found that all freshman design students in their sample had prior misconception about design and most of these belonged to the inconsistent category. They claim that while these students' misconceptions can be changed through direct confrontation, they are robust and have a structure. Newstetter and McCracken believed that for effective teaching strategies to develop, it is necessary to determine the level of misconceptions or prior knowledge of these students. To this effect they developed qualitative and quantitative tests to ascertain the level of students' understanding of design.

Their results indicate that most graduate students in their sample held the view of design as a product or product domain and not as an activity. Designing was associated with creativity, invention and brainstorming. Their data also revealed that these students considered design as equivalent with invention or arts. Students were found to report the top most important design activities as: 1) understanding the problem, 2) using creativity, 3) visualizing, 4) brainstorming, and 5) making decisions. The top least important activities for the design students, included: 1) making trade-offs, 2) decomposing, 3) synthesizing, 4) generating alternatives, and 5) sketching. Newstetter and McCracken acknowledged that while the top most important activities as listed by students are important in design, they are generally not considered critical design activities. On the other hand, the list of least important design activities is more enlightening. Newstetter and McCracken suggested that these activities were generally viewed by design experts as very important. This study provides useful insights into computer science and engineering graduate students but the results pertain to adult students already having an experience in design through their courses.

Welch, Barlex and O'Donnell (2006) are one of the earliest researchers who have reported a systematic study of students' beliefs about design and designers. Welch et al. studied elementary students' naïve beliefs about design and designers before and after intervention through two years. They found that students have robust perceptions of design and designers which remain rigid even after completing designing and making activities. However, despite not being trained in D&T education, the authors claim that their sample demonstrated considerable knowledge of what designers do and what skills they need to have. Students ascribed positive qualities to a designer. There were no stereotypical ideas associated with designers. Students demonstrated that the designer could be young or old, male or female. Welch et al. asserted that this finding is in contrast to that of students' perception of scientists who are perceived to have negative qualities in many countries and have several stereotypical associations. Trebell (2009) complemented and reported findings similar to Welch at al.'s study.

Recent study on Indian students' understanding on design and designers revealed that students often did not understand what designers do (Ara, Chunawala and Natarajan, 2011b). The findings were based on students' responses to both open-ended and closed ended questions. The authors found that these students assumed an artistic role for the designer who was more concerned with making things attractive, beautiful and fashionable for the users. Though students showed a fair understanding of the skills associated with designers in the structured part of the questionnaire, most of them failed to recognize planning as the central feature of designing. The researchers echoed what de Klerk Wolters (1989) suggested that curriculum developers should 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. Students' intuitive ideas can also help the teachers know about the diverse knowledge that students might bring into the classrooms situations, which in turn might help her organize her lessons accordingly. This study indicated above is a part of this thesis and the results have been discussed in detail in the next chapter.

2.4.2 Students' images of design and designers

Besides the literature on students' ideas of design, the current thesis also aims to understand students' images of designers. There is no evidence of any literature suggesting the same.

Students' drawings have been largely used in the perception research literature to explore their ideas and images about various people and professions. Drawings have been useful, since they require little or no language mediation for their expression. Henrion in (Picker and Berry, 2001) suggest that imagery can provide useful insights into students' underlying beliefs, assumptions and expectations. Alder 1982 (in Hargreaves and Goodson, 1996) considers drawing as an important projective technique which provides an opportunity to people to reflect their personal feelings and attitudes toward other people and situations and also help them express the group values that is prevalent in their cultural environment. Several studies have used students' drawings to understand their perceptions about the gender and role of scientists, astronomers, mathematicians, accountants, engineers etc.

An early study on students' images of other people dates back to the mid 1950's and which was particularly meant to study students' view of science and scientists. This was Mead and Metraux's pilot study on thousands of American high school students. The data collected was mostly qualitative and revealed that high school students perceived scientists as being elderly or middle-aged males wearing white lab coats and eye glasses, working in the laboratory and surrounded by chemicals and test tubes. Overall students were found to carry a negative image of a scientist. Following Mead and Metraux's initial study, Chambers in 1983, attempted to probe students' images of science and scientists by developing the 'Draw-a-Scientist-Test' (DAST) wherein students were asked to draw a scientist. In DAST, Chambers studied a large number of students at different age groups and identified seven key features in the stereotypical images which were produced: white lab coat, eyeglasses, facial hair, symbols of research (scientific instruments and equipment), symbols of knowledge (books), products of science (technology), relevant captions (formulae, 'Eureka!'). He noted that the number of these indicators increased with the age of the child, so that by the time children reach the end of their elementary school, they had already formed a stereotypical image of a scientist. Chambers also asserted that the stereotypic images of scientists held by students are powerful and stable and appear to get reinforced with age. Newton and Newton (1998) confirmed that these images about professions remain constant despite changes in the curriculum.

Later a series of studies have been conducted to learn students' images of scientists with more refined instruments (Finson, Beaver and Cramond, 1995). The DAST has been adapted to various country settings and reported positive views held by students about scientists (Rampal, 1992; Chunawala and Ladage, 1998; Turkmen, 2008). In 2004, the DAST was adapted by Knight and Cunningham into a test known as the Draw-an-Engineer-Test (DAET) to probe students' images of engineers (Knight and Cunningham, 2004). They found that younger students get cued by the word 'engine' in engineer and think that engineers use tools to fix car 'engines' and build buildings. Older students however, were found to consider that engineers designed buildings and machines. Similarly, Cunningham, Lachapelle and Lindgren-Streicher (2005) found that students associated fixing, building, and vehicles with engineering. The findings from other studies on students' perception of engineering confirmed that students tend to associate engineering with fixing, building and working on things and depicted engineers as physical labourers (Oware, Capobianco and Diefes-Dux, 2007; Karatas, Micklos and Bodner, 2010). DAET has also been adapted to compare students' images of scientists and engineers (Fralick, Kearn, Thompson and Lyons, 2009). Most of these above studies indicated that students' perceived engineers to be mostly males.

It is important to ask why we should be concerned with the images that students hold about different professionals; where these images come from, and what they say about students' ideas and attitudes towards any profession or professionals. With respect to mathematics education, Rock and Shaw (2000) argued that if the images of mathematicians held by students reflected a negative attitude of students toward the subject of mathematics then the process of teaching mathematics would become more challenging, and there would be less enrolment of students in mathematics courses (Berry and Picker 2000). Rock and Straw also asserted that understanding students' perceptions about mathematicians and changing those perceptions may 'facilitate and broaden students' thinking about their roles as future mathematicians.'

Since D&T education is not yet a part of the Indian school curriculum, it is more likely that students' ideas and images about design and designers are spontaneous and not learnt in school. Their ideas would be influenced by several factors other than schools such as media, peers, parents, etc. The documentation of the naïve ideas held by these non-tutored D&T students have implications for curriculum development. It is important to know what images students hold of designers, and whether they have formed any stereotypical images of designers.

2.4.3 Teachers' perception of design and designers

Just as students' intuitive ideas have important implications for curriculum development, it is equally important to study teachers' understanding of design because teachers' background knowledge and understanding in any curriculum area will determine their attitude while teaching. Literature indicates few published work specifically aimed at studying teachers' ideas of design.

One study mentioned above was Hill and Anning's (2001) study where eight teachers were interviewed and their ideas of design on three parameters were: their personal knowledge of designing, their understanding of how children learn to design, and their curriculum and pedagogical subject knowledge of design.

Results showed that there were similarities in teachers' understanding of design and they considered design as a problem-solving activity in which designers strive to 'develop a new or better way to create or make something' and 'find the best solutions to a need'. However, Hill and Anning noted that teachers' understanding of the context in which design was done in schools differed. The teacher of the 4-5 year-olds considered providing students with a close-ended, teacher-assigned project context while the teachers of the older students considered real-life contexts as important for designing. Hill and Anning note that teachers' understanding of design influenced how they taught design to students in their classrooms. This study provides insights into D&T teachers' understanding and practice of design.

The ITEA (2001) found that most adults associated the term 'design' with blueprints or drawings rather than with a creative process of problem-solving (de Vries, 2005). It can be assumed that the same could be true for teachers who themselves have not undergone training in technology education. Stein, Ginns and McDonald (2007) has referred to Jarvis and Rennie (1996) who found that teachers' limited understanding of technology caused problems in their teaching and learning. Also Mittel and Penny (1997) argued that teachers found it difficult to bridge a link between D&T and the curriculum requirements and many teachers 'constructed' their D&T program within a 'craft' paradigm. These findings point to the fact that teachers are facing challenges in conceptualizing teaching and learning within the paradigm of a new subject area that is D&T education (Stein et al., 2007).

A pilot study was conducted by the researcher with middle school and higher secondary teachers in order to study their perception of design. Of the twenty five teachers who responded, 15 were female teachers, 6 males and 3 remained unidentified. These responses indicated that most of the teachers associated design with '*arrangement of patterns*', '*giving some artistic shape or form to a product'*, or '*decoration'*. Few teachers also considered '*leaves, flowers and butterflies'* as design and '*God as the ultimate designer'*.

2.4.4 Designers' perception of design and designers

According to Cross and Lawson (2005), studying professional designers of outstanding ability gives insights and understanding about design as an activity. It becomes useful in guiding pedagogy for the development of 'better-than-average-designers'. It also leads to developing better practice in D&T education for facilitating the transition from naïve designer to expert designer.

The study by Hill and Anning (2001) mentioned above provided insights into practicing designers' understanding of design. They categorised designers' ideas as 'workplace design' and studied four different designers (fashion designer, graphic designer, mechanical engineer and architect) revealing similarities and differences in their ideas of design and practices. They interviewed the four designers on two parameters: their beliefs about designing and how designing is learnt.

The authors characterised the designers' description of design into a continuum from creator to copier. They reported significant findings on three parameters, discussing how the designers were similar to, and different from each other on these parameters. These parameters were: *ideation phase, communication phase* and *the use of model for ideation and communication.*

Firstly in the *'ideation phase'* the similarity among these designers was that they believed that *'design begins with the inception of an idea and is complete after working out of ideas in materials, and with tools and processes to complete a prototype.'* The difference, however, was in their use and need of different skills and knowledge, materials, tools and process.

Secondly while *'communicating'* their ideas to other, Hill and Anning state that while designers needed to communicate their ideas, the difference was in their choice of media to communicate their ideas (such as 2D, 3D, produced by hand or computer etc.).

Thirdly they all agreed with regard to ideation and communication that they did not 'always' make use of scale models for the development and communication of ideas (researcher's emphasis).

Hill and Anning also concluded that designers emphasized that students in design education should be given opportunities to physically explore ideas, materials, tools and processes. They also believed that designing could not be segregated into design and make activities; according to them it is a single continuous process. They also emphasized situating design tasks in real life contexts and providing opportunities for students to visualize in their ‘mind’s eye’.

2.4.5 Summary of students’, teachers’ and designers’ perception of design

Not many studies have been undertaken to investigating students’, teachers’ and designers’ ideas of design. While there are a few studies which indicated students’ ideas of design, such systematic studies of teachers’ and designers’ ideas are rare. More so, the studies on students’ ideas of design were limited to those who already had D&T in their curriculum or who have had the experience of design and the design process. From among the few studies that set out to study students’ ideas about design, there appears to be mixed results. While Hill and Anning reported that younger students have little understanding of design, older students demonstrated a clearer understanding about design. Newstetter and McCracken’s (2001) study with computer science and engineering students showed inconsistent misconceptions of design. Despite having a background in design from their courses such as computer science and engineering, Newstetter and McCracken’s sample demonstrated prior misconceptions which were robust and structured. Welch et al.’s longitudinal study with Class 6 students showed that they have a considerable knowledge about design and designers and they demonstrated a positive attitude towards designers. Welch et al. however, reported their findings based on close ended responses from students.

2.5 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. Jones (1970) claimed that designing is considered a ‘black box’ since a designer was unable to explain how she came up with creative solutions. From the early works of Simon on design problem-solving process, there has been a great interest in studying design activity and design cognition (Cross, Christiaans and Dorst, 1996). A literature review suggests that 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 design. These studies aim to reveal how designers execute design, what kind of knowledge they have, how they approach the design problems and so on.

2.5.1 The aims of design cognition research

A number of rationales have been identified in literature for studying design cognition. Firstly, from the point of view of basic research, design cognition aims to produce scientific theories of design thinking. Its purpose is to demystify design which, for years would remain 'hidden' in the heads of the designers and makers and reveal aspects of design that would otherwise remain unknown.

Secondly such studies help in the theoretical development of cognitive science and facilitate the further development of research in cognition. These studies help in discovering the capabilities and the extent of the human mind and contribute to the body of knowledge on human brain capabilities especially problem-solving and creative abilities.

Thirdly, design cognition research can facilitate the development of design methodology. These researches aim to study design methods objectively and thereby facilitates the development and proposal of systematic and better models of the design process that would lead practicing designers towards good solutions (Cross, 2006). Although methodologies studying systematic approaches to designing have been criticized, it is argued that cognitive studies of the design practices of good designers would be useful in generating better methods of design which can be tested and then eventually developed.

Fourthly, findings from the studies in design cognition research aims to inform design educators and design theorists whose objective is to enhance the design process and improve the level of creativity of design solutions among students.

Last but not the least, fields such as Artificial Intelligence and computer science have also benefited from advances in design cognition. For example, Cross (2006) claims that findings from the human cognitive behaviour in design is significant for the development of interactive systems and tools that support designers and enable them to use these systems in ways that are cognitively feasible.

2.5.2 Design as a 'way of thinking'

The notion of design as a way of thinking goes back to as early as Plato (in Archer, 2005). Many other theoreticians have suggested how designer's mode of thinking is different from other modes of thinking:

'The scientific method is a pattern of problem-solving behaviour employed in finding out the nature of what exists, whereas the design method is a pattern of behaviour employed in inventing things of value which do not yet exist. Science is analytic; design is constructive.'' (Gregory in Cross, 2006: 24)

Archer (1984) described the concept of 'designerly mode of inquiry' in literature in the following way:

'… there exists a *designerly way of thinking and communicating* that is both different from scientific and scholarly ways of thinking and communicating, and as powerful as scientific and scholarly methods of enquiry, when applied to its own kinds of problems' (pp. 348) (researcher's emphasis).

In 1982, Cross characterised and explicated what this *designerly way of thinking* consisted and what it enabled one to do. He introduced the term 'designerly ways of knowing' (in Cross, 2006).

The notion of design as 'a way of thinking' has been explicated further by various design philosophers such as Schön (1983), Lawson (2005) and Cross (1995; 2001; 2006; 2011). Studies in design thinking have also explored how designers frame or structure the problems (Cross 2004), design ability in novices and experts (Cross and Lawson, 2005; Cross 2004; Dorst and Reymen, 2004), strategies employed by designers (problem-driven/solution-driven) (Lawson, 2005) and creativity in design (Cross, 2006).

Studies attempting to examine design thinking usually employ methodologies such as observation of designers at work, protocol analysis (where designers are instructed to 'think-aloud' while solving design problems), questionnaires, and interviews.

2.5.3 Characterization of design thinking

Elaborating on Cross's analysis of designerly ways of knowing and from a review of literature, the researcher summarises a few key aspects that characterizes design thinking. Without going into details of each, the researcher presents a review of each of these aspects briefly. Thus design thinking:

- ***Is a process of solving ill-defined problems***

Problem-solving has long been associated with cognitive psychology which studies the processes involved in solving a problem. Design is differentiated from other kinds of problem-solving, such as those in the sciences or mathematics, by the fact that it is chiefly concerned with ill-defined or ‘wicked’ problems. Design problems are considered as ill-defined or ill-structured due to the complexity inherent in them and the difficulties associated in determining their constraints and requirements.

An important aspect of problem-solving is problem framing as suggested by Schön (1983). Problem framing involves making sense of the problem by the designer by imposing a frame on the situation of the design problem and discovering consequences and implications of those chosen frames. In this way the designer is constantly reflecting on her actions as she proceeds through designing.

- ***Involves synthetic thinking in contrast to analytic thinking***

Analytical thinking, mostly employed in the domain of sciences consists in the ability to understand the whole by understanding its parts and how those parts are assembled to form the whole. Synthetic thinking, on the other hand, consists in the ability to extract meaningful patterns from all of the collected information present. Design thinking is considered to be synthetic and creative as the designer create new forms through conjectured solutions grounded in reality. A scientist on the other hand may form abstract forms created by logic. However it has been argued that both analytical and synthetic thinking can be manifested in a design process (Tovey, 1986**).** A designer may use both analysis and synthesis to understand the different aspects of the design problem and the relations of how those aspects interact with each other.

- ***Involves solution-focused strategies as opposed to problem-focused strategies***

This aspect of design thinking follows from the analytic-synthetic distinction. A designer is focused in generating a number of solutions and only gathers information that is relevant to develop a solution (Kruger and Cross, 2006). This also corresponds to the synthetic thinking where the designer is focused on generating solutions. A problem-focused strategy, on the other hand, involves focusing closely on the problem and only using knowledge and information that are strictly needed to solve the problem. The main emphasis here lies on defining the problem before generating any solutions. This can be said to correspond to the analytic thinking described above. As discussed in the earlier section, Lawson, in his empirical study with designers and scientists found that while the scientists were more problem-focused, the designers were more solution-focused.

- ***Involves divergent thinking in contrast to convergent thinking***

Convergent thinking involves deductive logic with the aim of arriving at one single correct solution for a given problem. This kind of thinking is quite typical of science and mathematical problems where one correct answer solves the purpose. Divergent thinking, in contrast, requires a more open ended approach to problems and is involved in producing alternative possible solutions for a given design problem. There are no correct or incorrect solutions, just better solutions which serve the purpose in hand. The nature of design problems warrants alternate solutions and hence requires divergent thinking. However, it has been argued by Lawson that *'Design clearly involves both convergent and divergent productive thinking and studies of good designers at work have shown that they are able to develop and maintain several lines of thought in parallel,'* (Lawson 2005: 143).

- ***Relies on non-verbal, graphical/spatial/modelling media***

According to Cross, the very nature of the design problems (ill-structured and ill-defined) calls for a heavy reliance upon the media of sketching, drawing or modelling as aids to the generation of the solutions and to the very process of thinking about the problem and its solution. There are many ways designers can visually represent ideas, for example: drawings/sketches, prototypes or models, computer-aided design (CAD). From all the modelling techniques available, sketching is considered an integral part and the most important thinking tool for the designer (Goel, 1995; Suwa and Tversky, 1997). Sketching enables the designer to visualize her ideas externally. Externalizing the ideas not only facilitates the generation of new ideas but also off loads the designer’s working memory which can then be utilized for other cognitive activities. Schön (1983) who observed designers at work, described design activity as a reflection-in-action, where the designer is engaged in a visual conversation with the situation in hand by sketching and reflecting on those sketches and then revising. Thus ideas are developed in visual form before the completion of design and these:

- help the designer communicate the ideas to other designers, clients or manufacturers;
- serve as an analysis tool by highlighting design issues that needs to be resolved in the final design;
- off loads the designer’s visuo-spatial working memory;

- ***Involves parallel lines of thought***

One of the aspects of design thinking is the ability to sustain parallel lines of thought (Lawson in Cross, 2011). This is not analogous to generating multiple and alternate solutions but simultaneously exploring and detailing multiple alternatives for multiple aspects of the design problem (Hegeman, 2008). Lawson pointed out that the difficulty for a designer emerges when she tries to reconcile all the ideas or lines of thought, together, which are developing. If the designer tries to resolve these ideas too early in the design process, she may lose the ideas which are just developing. However, there is also a risk of these ideas getting fossilized and rigid if she sustains them for a long period of time (Lawson in Cross, 2011).

- ***Involves creativity***

Design as a problem-solving activity has been strongly associated with creativity. According to Casakin (2007) the nature of design problems warrants a creative approach. Design problems are characterized as being ill-structured and ill-defined (Rittel and Webber, 1984) and thus cannot be solved through the application of algorithms but require the designer to *transcend conventional knowledge domain so as to investigate new ideas and concepts which may lead to innovative solutions* (Casakin, 2007). Creativity in design has been defined in terms of a number of factors dealing with: fluency, flexibility, elaboration, innovation, usefulness, aesthetic skills in design representation, fulfilment of design requirements, and reference to context (Casakin and Kreitler, 2006). According to Dorst and Cross (2001) creativity can be identified in every design project, even if creativity is not apparent in the form of a distinct creative output or event, it might be reflected in the evolution of a unique solution to the problem.

2.5.4 Implications of design thinking on design education

Cross (1995) claims that one of the most significant developments in the design study research has been the growth of respect for design due to the inherent strengths of design ability. Design which had been considered as an 'ineffable art' and was thus proposed to elevate its eminence by emulating science has now been raised to a distinct status in its own right. Cross asserts that this matured view of design has grown from an understanding of the distinct and unique nature of design abilities.

Design thinking research has shown that design involves solving real world, ill-structured problems through analytic and synthetic thinking, divergent and convergent thinking, solution-focused and problem-focused strategies. More so it relies heavily on non-verbal modes of thinking such as sketching and modelling and provides opportunities to be creative.

Design thinking research also suggests that design education needs to change its objectives from being instrumental in producing specialist designers to being generalist and fostering basic and inherent abilities of design among all individuals through general education. It thus implies that design can provide students opportunities to develop their basic and intrinsic abilities to be constructive, creative, to think in ways different from the scientific and literary ways of thinking, to look for problems and become good problem solvers. Thus the distinctive qualities of design offer opportunities to students to think in ways which no other area in their school curriculum provides.

2.5.5 Summary of the Cognitive aspects of design

The aim of this section of review was to examine design from the human cognition point of view. Design has been recognized as a complex cognitive activity as it involves elements of cognition such as reasoning, imagination, problem-solving and creativity. Early works on design cognition research aimed at identifying aspects of design which were unique and specific to it. Archer and Cross first claimed that design was distinct from the sciences and humanities since it has its own ways of knowing and doing things. Cross and others have attempted to characterise the nature of design thinking by suggesting that design thinking involves solving ill-structured problems through divergent, solution-focussing strategies, involving heavy reliance on non-verbal modes of thinking such as sketching and modelling. An understanding of the nature of design thinking reveals that design has a unique mode of thinking and is therefore worthy of study in its own right. The culture of design needs to be integrated into general education just as the cultures of science and the arts.

2.6 Pedagogical approaches to promote design learning in schools

One of the aims of the research study described in this thesis is to develop design activities for middle school students. The other aim relates to examining the influence of these design activities on students' understanding of design. This necessitated a review of literature on the different kinds of design activities available and the different pedagogical approaches adopted to foster designerly thinking among students.

A review of the literature suggests that the primary aims of D&T education have been to develop students' design and technological abilities and awareness. For example the National Curriculum for England (1999) spelt out the ambitions for D&T education as follows:

- D&T prepares pupils to participate in tomorrow's rapidly changing technologies;
- They learn to think and intervene creatively to improve the quality of life;
- The subject calls for pupils to become autonomous and creative problem solvers, as individuals and members of a team;
- Students must look for needs, wants and opportunities and respond to them by developing a range of ideas and making products and systems;
- Students combine practical skill with an understanding of aesthetics, social and environmental issues, function and industrial practices. As they do so they reflect

on and evaluate present and past design and technology, its uses and effects;

- Through D&T, all pupils can become discriminating and informed users of products, and become innovators;

The curriculum identified pedagogic ways of developing design and technology capability in students, through the following activities:

- Investigative, disassembly and evaluative activities (IDEAs) or Product analysis which provide opportunities for children to explore existing products and to gain skills, knowledge and understanding which can be applied in a design and make assignment.
- Focused practical tasks that develop a range of techniques, skills, processes and knowledge
- Design and make assignments in different contexts which provide an opportunity for students to combine their skills, knowledge and understanding to develop products that meet a real need.

2.6.1 Towards appropriate pedagogy for teaching design

Literature reveals that in order to find an appropriate pedagogy, D&T educators have looked towards professional designers' practices for inspiration. Davies (1996) reported that children and designers share similarities in their thought processes and approaches to the design process. For example, he suggested that both of them explore the designed world through play. Both are 'future oriented' in that they use mental images to decide what the future will be like. Both make use of drawings as visual note-taking. Both tell stories about the users of the products they are designing and use knowledge from their whole experience in approaching the design task.

However there have been many educators and researchers who argue that design by students in schools is different from design by professional designers in their workplace. The next section reviews some studies which suggest difference in school and workplace designs.

2.6.2 Design by students in school versus design by professionals

In this context, Roberts (2001) recognized three arenas of design related activities. The first involves those design specific contexts which we engage in our day-to-day life, without having a formal education in design. The second involves design activities occurring in schools, the objective of which is the development of design ability among students while the third relates to the activities in the formal education of specialist professional designers, the objective of which is the development of knowledge and understanding of and competence in designing. Roberts asserts that though the word 'design' is used in all the three arenas, the activities encompassed in them do not serve the same functions and neither do the meanings of one arena necessarily transfer into another.

Anning, Jenkins and Whitelaw (1996) contended that the constraints present in schools are different from those in the workplace. Schools have constraints such as curricular organization, timetabling, examination and assessment requirements and also face a lack of resources. Anning et al. mention that although the activities in schools are aimed at individual students, the resources are shared among twenty or more students. In the workplace, however, a designer works either alone or in a small team with resources committed to their specialized needs.

It has also been observed that while designers work on real problems in a highly contextualised situation for which they have a considerable knowledge (Anning et al. 1996; Hennessy and McCormick, 1994; Hennessy and McCormick, 2002; Hennessy, McCormick and Murphy, 1993) and thereby have predefined goals to resolve, the design problems in schools are artificially constructed and are not relevant to students, thereby becoming meaningless to them. Students also may not be as goal oriented as professional designers.

Archer and Roberts (1979) claim that design in schools is different from design in profession because of their different aims. They assert that while professional design activity involves manipulation of things and systems to achieve a fit between human desires and needs and means to fulfil those desires, design educational activity basically involves the development of design and technological awareness, wherein students' attention are directed *to the purpose, the self, and the means and significance of Man's* [sic] *intervention in his habitat.* They suggest that the aims of design-educational activities are not to produce things and devices but the development of knowledge and understanding about design and the technological world.

2.6.3 Pedagogic approaches specific to design education in schools

The present study is aimed at exploring as well as developing students' ideas of design. This led the researcher to review literature on design-specific pedagogies which were aimed at developing design abilities and awareness among Indian students. The next few sections present a review of some of the common pedagogic approaches used in teaching design to school students. To name a few, the ones described in this review are:

- Design as a problem-solving process;
- Design as interaction between mind and hand;
- Design as a decision-making process;
- Design as a way of bringing about intended change;

The way design is viewed has a direct bearing on the practices adopted by teachers in the classrooms.

2.6.4 Design as a problem-solving process

While examining the literature on design pedagogy closely, it is apparent that many theorists, design educators, educational policy and curricular documents have adopted the problem-solving process as the framework for teaching design to students.

Design as a problem-solving process seems to be transposed directly from the problem-solving paradigm conceived by Simon. The term 'problem-solving' in design education was easily accepted by other groups in practical education and got popularised to the larger mass through the Keele Project in 1971 (Morley, 2002). The idea that design is a problem-solving activity has led to the development of stage models of the design process. This model of the design process is reflected in Eggleston's conception of the design process in the following statements:

‘At the heart of the matter is the design process. This is the process of problem-solving which begins with a detailed preliminary identification of a problem and a diagnosis of

needs that have to be met by a solution, and goes through a series of stages in which various solutions are conceived.' (Eggleston, 1994: 26)

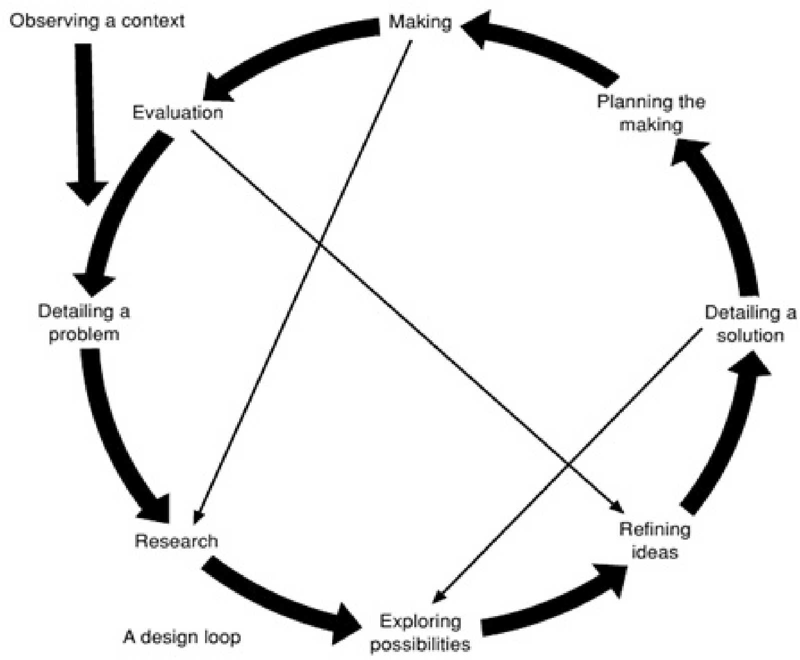
An important distinction that needs to be made between design and problem-solving is that though the skills of design and problem-solving are interconnected, they are distinct and separate. As for example, most aesthetic designs do not address any 'problem.' They might follow the design process, but they are not created to address a perceived problem. On the other hand, problem-solving can happen without the involvement of any design process and commonly occurs in many daily situations. As for example, an untied shoe is certainly a problem, however, one would typically not require a design process to solve this problem. Design involves a special kind of problem-solving as it resolves ill-structured problems by converting ideas into products or systems. McCade (1990) observed that besides design, there are different forms of problem-solving in technology e.g. troubleshooting and technology assessment.

The problem-solving approach to design continues to be advocated as essential basic skills to improve industrial performance and as a significant pedagogic and learning tool in design education (McCormick et al., 1994). Since problem-solving is seen as an algorithm, design has also been considered as consisting of algorithms or a series of stages. For example the design process is shown to be consisting of a series of stages: recognising a problem, generating and implementing a resolution, and evaluating the results. A variety of design process models have been proposed in the literature ranging from simple linear models (Figure 2.2) to cyclical and interactive cyclical models (Figure 2.3). A linear and simplistic model of the design problem-solving process is shown as:

Figure 2.2: A simple linear model of the design process (APU in Banks, 1994)

All these models prescribe the steps of the problem-solving process in various levels of detail. The prescribed stages of the design process are expected to 'done' by the students (Kimbell and Stables, 2007).

Figure 2.3: The interactive design loop (Kimbell, 1986 in Banks, 1994)



The problem-solving approach appeals to design educators and teachers for a number of reasons. Firstly, problem-solving is conceived of as a process consisting of a series of stages. Thus if this is applied to design activity it makes the whole design activity apparent and more explicit in terms of those processes (Liddament, 1996). Conceiving design in this way enables one to understand and analyse each of the processes involved and thus can be easily defined and replicated.

Secondly, as mentioned earlier, Mawson (2007) suggested that the main rationale behind the wide acceptance of the step-wise problem-solving process in design is to provide an order and structure to the highly complex process of design. If design is visualised in terms of stages, the abstract process becomes explicit and accessible to pedagogic treatment (Liddament, 1996). Giving order and structure to the process enables the teacher in teaching those stages as a way of teaching design.

Thirdly acceptance of the design problem-solving process proves helpful in assessing the performance of students. A teacher can easily get evidence of students' performance as they go through each stage of the process. Further, problem-solving proponents claim that it involves a general strategy which can be applied in a variety of differing contexts, and even differing domains (Hennessy and McCormick, 2002).

Although problem-solving process approach has been regarded as a significant approach towards teaching design, conflicts abound in literature regarding the use of this process in design education and its generalizability to a variety of context and domains.

Baynes (1982) warns educators against considering design activity strictly as a problem-solving process. Baynes argues *'it is easy to agree with those who say that designers are essentially problem solvers but it is equally easy to see that in terms of education this begs a whole series of crucial questions. Whose problems? Can designers solve all kinds of problems? Are some problems insolvable anyway?'* (pp. 113)

McCormick (1997) claims that the term problem-solving has been greatly abused in D&T. Hennessy and McCormick (2002) provide several problematic concerns when teaching design through a general problem-solving approach.

Firstly, they assert that step-wise problem-solving in classroom settings is based on the practices of expert designers. However, there is little empirical evidence regarding the use of a transferable problem-solving process. The criticism that was reflected in Simon's conception of design as a problem-solving process among professionals was also true in the context of designing by students. Thus as expert designers themselves disagree about using a generalised decontexualised design process, students too show a rejection of the design process while designing in classrooms.

Studies indicate that expert designers' work and processes are highly context dependent. They also have considerable knowledge about the problem area, work in teams and have predefined goals to achieve. In contrast, students who are novice problem solvers work in unfamiliar contexts where they may lack an understanding of the nature of the problems and may also lack the necessary knowledge in the problem area. Also they do not work under similar constraints as the designers and may not be as goal oriented as professional designers.

Another argument made by Hennessy and McCormick (2002) regarding the problem-solving approach is the missing link between the problem-solving in and out of schools. Assuming a situated perspective approach, they claim that problem-solving outside of school involves resolution of problems arising from personal experience and familiar contexts. These problems are authentic and relevant to the designers in contrast to the artificially created problems presented to students in a design classroom.

An important implication of the stage process approach to design is that teachers tend to focus on the process of design and not on the conceptual knowledge and skill development.

McCormick, Hennessy and Murphy (1993) contend that: *‘the design process underlying the curriculum is highly complex and not easily communicated. Children encounter different problems, requiring different approaches, according to the kind of task and the stage reached in its solution’* (pp. 8).

A study which supported McCormick et al.'s claim about nature of the design process being dependent on the context of the design problem and the expertise of the designer is a study by Welch and Lim (2000). They compared the design strategies adopted by ‘novice designers’ (students from Year 7) from two different studies. They found that novice designers sequenced the sub processes of designing quite differently than the prescribed models in literature. These students did not generate several possible solutions and choose the most effective solutions. They made greater use of three-dimensional modelling than the two-dimensional modelling, suggested by textbooks and finally they constantly evaluated their design proposal from the earliest moments of the design process. Welch and Lim (2000) concluded that:

‘…[there is a] good reason to doubt the efficacy of requiring students to follow any form of a linear or sequential design process model, as found in many textbooks and curricular documents.... untutored designers do engage in many of the sub processes of theoretical models but do not prioritize or sequence these sub processes as suggested by the models.’

A point well made by Harahan (in Arnold, 1989) quite early in the design and technology education literature but relevant even in today's context, emphasises the role of student ownership of the design process and which is also emphasized by Lawson (2005) who confirmed that designers create their own process:

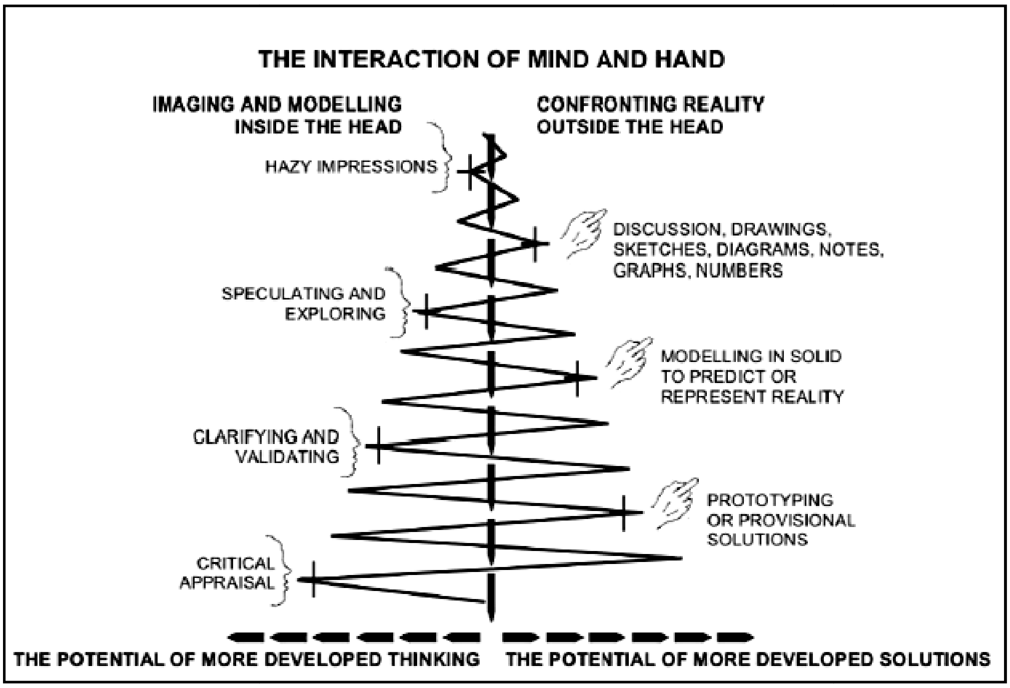
‘... a student must be helped to develop his own methodology, in contrast to the frequent instances in which students and teachers see methodology as a closed prescription rather than an encouragement to look for further possibilities.’ (Harahan in Arnold, 1989: 65)

2.6.5 The APU model of interaction between mind and hand

Dissatisfied with the models of the design process available in D&T education literature, the Assessment of Performance Unit (led by Richard Kimbell and Kay Stables) in

England began a project in 1985 to assess the development of students' capability and performance in D&T. They claimed that most of the design models were based on the analysis of the behaviours that were considered important for designers at particular points in the designing activity and not on the intellectual processes involved in designing (Kimbell and Stables, 2007). They developed a different model of the design process that was dynamic and interactive and based on the idea of design as an interaction of mind and hand (in Kimbell, Stables and Green, 1996). They considered the design process to begin with a 'hazy' idea that needs to get externally expressed in concrete forms either through drawings, writings, modelling or even talking! As the ideas get a concrete form, they become amenable to exploration and analysis, subsequently influencing further development of the ideas in the mind (Figure 2.4).

Figure 2.4: The APU model of interaction between mind & hand (Kimbell et al., 1996)



According to Kimbell and Stables (2007), these processes in design cannot be prescribed in advance. Instead, these are determined by the responsive engagement of the student, the demand of the task and the design problem.

The APU model emphasised the interaction between the processes 'inside' and 'outside' the head. An important component of designer's work is communication. Not only do designers need to work with their clients, but also need to work in teams with the manufacturers, other designers and engineers to achieve the desirable solutions. However, the APU model failed to acknowledge the social nature of a designing activity (Rowell, 2002).

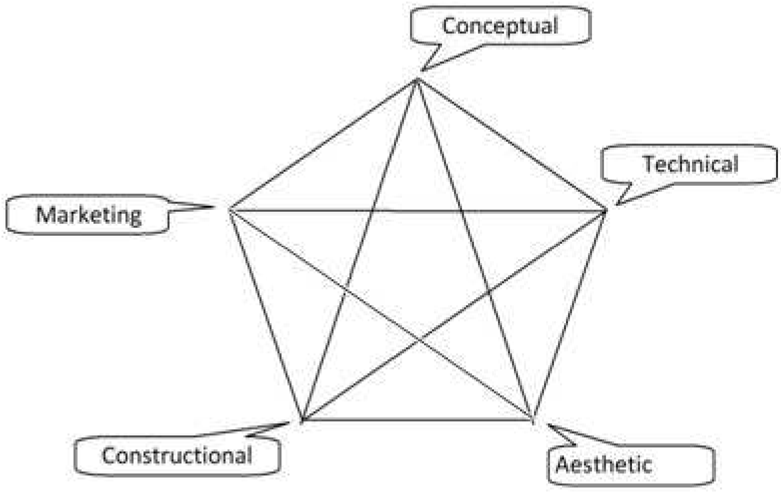
2.6.6 Design as a decision-making process

In 2004, while exploring the effectiveness of a curriculum on the development of design ability and design teaching skills, Barlex and Rutland, proposed to audit or make a record of the kind of decisions that students make during a design and make activity (Barlex and Rutland, 2004). They considered design in schools as a decision-making process. In D&T education students faces a variety of options. For example they need to decide about processes to use, materials to construct, the look of the product that they design and so on. Barlex and Rutland proposed that design in school involves making at least five different types of design decisions. They are:

- Conceptual decisions require the student to think about the overall purpose of the design, or what sort of product it will be;
- Technical decisions require the student to consider 'how the product will work' and the nature of the components and materials required to achieve this;
- Aesthetic decisions involves students to think of 'ways in which the product will appeal to the senses' – sight, hearing, touch, taste and smell;
- Constructional decisions requires the student to consider ‘how the product will be made’ and the tools and processes needed to achieve this and;
- Marketing decisions requires the students to consider ‘who the product is for’, what is its cost’, where will it be sold.

The five key areas of the design decisions can be visually represented as a pentagon with each of the design decision being connected to one another (Figure 2.5).

Figure 2.5: The design decision pentagon (Barlex and Rutland, 2004)



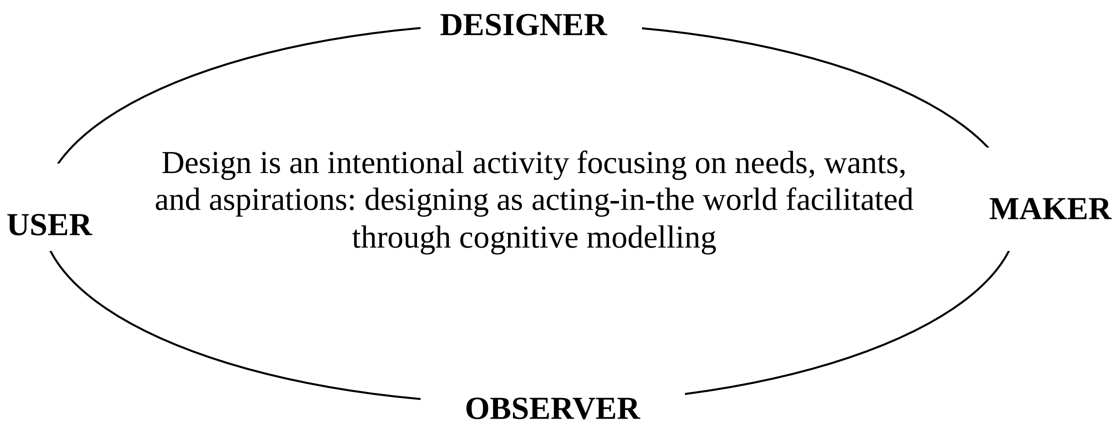
Barlex (2007) argues that this interconnectedness is of utmost importance and a change of decision within one area of the design decision will affect some, if not all of the other design decisions. Welch et al. (2006) claim that this interconnectedness reflects design as the *reflection-in-action* paradigm, which was earlier suggested by Dorst and Dijkhuis (1995). In this framework, a student can be thought of making a series of reflective ‘what if I did this’ moves (as suggested by Schön, 1983) as she makes decisions about a certain aspect of the design and then evaluates how that decision might lead to a change in other decision areas. Welch et al. claim that these ‘what if I did this’ moves are not just mere ad hoc tools that a designer might use while facing complex problems. Instead, their repeated use might lead to a better understanding of the entire design situation.

Design conceived in such a way not only serves as a pedagogic tool but is also useful for assessment. Also if students have some difficulty while making decisions at any point of time during the design process, the teacher can scaffold student with the required knowledge or skill.

2.6.7 Design as a way of bringing intended change

Phil Roberts at the Royal College of Art, in an attempt to bridge the gap between the specialist and the generalist views of design, proposed a model which recognized both (Roberts, 2005). The model is essentially concerned with bringing about intended change both in the designer as well as in the world out there. Roberts claimed that design activity did not necessarily entail the production of an artefact. For him, the essential thing was to effect change, or to move from the original state of affairs to the acceptable one.

Figure 2.6: Four roles of students offering complementary perspectives on learning-through-designing (Roberts, 2005)



Roberts suggested that in the classroom context, design-as-learning can be viewed through four different but complementary perspectives: the designer, the maker, the user and the observer (Figure 2.6). According to Roberts, the four role-views are intended to provide working perspectives towards the better comprehension of design and technological activity.

The roles of the designer and the maker involve overt modes of design activity which means that as designer and maker, students plan, make mock ups, test and evaluate and make artefacts in the design classrooms. The roles of the user and the observer, on the other hand involves covert modes of design activity, which means that as observer and user, students get involved in continuous judgment and evaluation of existing realities and state of affairs. These two modes are however, complementary to each other.

He asserts that the covert form of design activity (as user and observer) is often under-valued in schools and not even recognized as a designing activity. He argues that this activity has enormous and beneficial values since they provide an understating of design in its entirety. In a design classroom, schools primarily focus on the making of products while the experience of design activity as a covert form is often neglected and even considered inferior to the former. Providing exemplars from the professional field, he argues that user's and the observer's participation in professional designing is as active and as fundamental as the designer's and the maker's.

2.6.8 Summary of the pedagogical approaches to design

This section of the review begins by presenting the views of researchers on the difference between the designing happening in school and the workplace. It is important to distinguish designing by professional designers and that done by students. One of the basic difference is that a designer earns her living from designing, while a student does designing because she is told by the teacher to do or because it is in the syllabus. This is important to recognize because it serves as the first motivation to design for both, the professional and the student, and the first question that can be asked by both: ‘why should I design?’

The review highlights the four main pedagogical approaches to design, that are practiced in UK schools. Design as a problem-solving process has been dominant in teaching design to students. This approach has led to the development of various stage-wise, algorithmic processes of design, from linear design processes to complex loops of interactive processes. This approach has been criticised for promoting a belief among educators that there exists a general problem-solving process which can be applied to any design problem. It has also led to teachers’ emphasis on teaching the procedural understanding rather than the conceptual understanding of design. The APU model of interaction between mind and hand resolves these issues to some extent as it visualizes design as an intellectual process which emphasizes the interaction between the processes inside the head with those outside the head. This model is however criticized for overlooking the social nature of the activity of design. The design as a decision-making process involves students to make a series of interconnected decisions about the features of design. It reflects Schön’s theory of design as a reflective practice where a designer reflects on her moves through the design process. This model serves as a pedagogic as well as an assessment tool for not only the ‘design and make’ activities but all design based activities such as product identification and evaluation, redesign, product sorting etc. This model served as an analytical tool for the present research study. Last but not the least, the fourth model assumes design essentially as bringing intended changes and considers design from four different but complementary perspectives: that of the designer, the maker, the user and the observer. This model asserts that students should be given opportunities to exercise these roles in the classroom to have a complete understanding of design. This model served as a vehicle for creating appropriate and effective design activities for Indian middle school students in the study reported in this thesis.

2.7 Summary of the Literature review

The research studies examined for this literature review have provided conceptual, theoretical, methodological, pedagogical and analytical directions to the research study reported in this thesis. The review consisted of studies from four interconnected aspects namely, conceptualization of design from the philosophical, historical and educational perspective, students', teachers and designers' perceptions of design, cognitive aspects of design and lastly the pedagogical approaches to design teaching and learning.

A need to understand design as a concept, its origin and its implications to education led to a philosophical and historical investigation into this concept and its relation to education. As evident from the literature, design is variously understood by philosophers and theorists and it seems to have become a fuzzy arena. However, there have been efforts on the part of the philosophers as well as the educators to give a structure and 'design' their ideas of design into a coherent whole. The major paradigm which subsumes most of the ideas about design are: *design as a rational problem-solving process* and *design as a reflection-in-action process*. These two paradigms have not only influenced research on design methodologies but have also affected professional designers' actual practice of design. These two paradigms have also had an impact on the pedagogical approaches to design in schools.

While D&T education has already been introduced in most countries throughout the globe, Indian education system neither teaches design nor technology education. A need to study students' and teachers' ideas of design arises from the basic assumption that an understanding of their ideas would help in the development of the curriculum. de Klerk Wolters (1989) suggested that student' interests, needs and opinions about D&T should be taken into account if one desires to develop D&T curriculum. The intuitive concepts of students and teachers must be accounted for in order to bring about change in those concepts.

Literature reveals that there is a lack of studies on investigating, students', teachers' and designers' ideas of design. While there are a few studies which indicate students' ideas of design, such systematic studies of teachers' and designers' ideas of design are rare. More so, studies on students' ideas of design were limited to those who already had design and technology education in their curriculum or who have had the experience of design and the design process.

The review on design from the human cognition point of view, acknowledges design as a basic ability which can be developed among people. It does recognize this ability as a complex cognitive activity involving elements of cognition and thinking such as reasoning, imagination, problem-solving and creativity. Literature could be identified which aimed at establishing that design thinking is unique and distinct from the thinking required in scientific or literary activities which are the two dominating cultures of thinking in schools. Attempts have been on the part of the researcher to bring about all the studies which have characterised design thinking. An understanding of the nature of design thinking reveals that design has a unique mode of thinking and is therefore worthy of study in its own right.

The need to intervene and widen students' ideas of design warranted a review of the design activities developed for students and the various pedagogical approaches implemented to foster design ability and awareness in students. The review identified four pedagogical approaches to design in UK schools: design as a problem-solving process, APU model of interaction between mind and hand, design as a decision-making process and design as bringing about an intended change. While the first model has been dominant in teaching design for a long time, it has led to stage-wise, algorithmic processes in design. The other three approaches have developed in response to the first model and aim to resolve the difficulties faced by it.

2.8 Theoretical Framework of the Study

This literature review concludes by providing a theoretical framework upon which the study is based. A theoretical framework serves as a base for the study and provides rationales for the research methods used. The central features of this research study were the survey of students', teachers' and designers' ideas of design and the trials and development of design activities for middle school students.

A survey of students', teachers' and designers' ideas of design was conducted through questionnaires that also involved drawings. The theory guiding students' survey of ideas was the constructivist theory which supports the belief that even if Indian students have no formal education in design, they do not enter into classes empty headed, but have their own ideas about design and technology and teachers and curriculum decision makers 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 design rests on the assumption that they have a great influence on teachers' own thinking and teaching practices. It is the teacher who organise the learning experiences of their students and thus has a direct influence on their concepts, views and attitudes (de Vries, 2005). In an absence of design education, we hardly know teachers' views on design leave aside the relations between their views and their students' views.

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, Barlex's pedagogical approach to design as decision-making process and Robert's (2005) model of design as initiating change and the four roles views of design.

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 or 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 (Figure 2.6). 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 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.

Lastly, Barlex and Rutland (2004) pedagogical approach to design as a decision-making process was used to develop and even analyse most, if not all of the design activities. The design activities developed for students required them to make design decisions, either as users, observers, designers or makers.

Chapter 3

A SURVEY ON INDIAN STUDENTS', TEACHERS' AND DESIGNERS' IDEAS OF DESIGN

Human knowledge is a constructed form of experience and therefore, a reflection of mind, as well as nature: Knowledge is made, not simply discovered

Eisner (1991)

3.1 Introduction

This chapter describes the survey of students', teachers' and designers' ideas about design and designers. The chapter begins by describing the rationales for studying each of the chosen samples' ideas. It also describes the objectives of the survey and the methodology employed to achieve those objectives. The chapter then explains how the tools for the survey were developed giving details about the questionnaires that were used to gather data from the samples. Lastly, it presents the results of the study and finally ends with a discussion of the analysis.

The study was conducted with Indian elementary students of classes 5 and 6 (average age- 10 years), middle school students of classes 7, 8, 9 (average age-12.3 years), pre-service and in-service school teachers and post doctoral design students.

3.1.1 Rationale for studying students' ideas of design

Following are the rationales for studying students' ideas of design and designers:

- We live in a designed world and find ourselves surrounded by things that are designed; the houses we live in, the clothes we wear, the chairs, pen and books we use, the buses we travel in, and even the food we eat. Since design seems to be so much a part of our everyday life, it is worthwhile and also interesting to know how it is understood and perceived by students.

- The research study reported in this thesis is based on the constructivist approach of teaching and learning. The researcher believes that students are not empty headed about the concepts of design; but have prior conceptions about what design is and what designers do. Since design and technology (D&T) education is not yet a part of the Indian school curriculum, it is more likely that their ideas and images about design and designers are spontaneous and not learnt in school. Their ideas would be influenced by several factors other than schools like media, peers, parents, etc. The researcher acknowledges those ideas of students and aim to utilize them in planning design activities.
- The documentation of the naïve ideas held by these non-tutored D&T students have implications for curriculum development. Curriculum planners can get insights into students' design ideas through this study. They would have an opportunity to address the present study and shape the curriculum in an appropriate way.

3.1.2 Rationale for studying teachers' ideas of design

Following are the rationales for studying teachers' ideas of design and designers:

- Teachers' background knowledge and understanding in any curriculum area will determine the kind of attitude they take for teaching/learning. Thus it was considered equally important to study teachers' ideas to evaluate their disposition towards the subject of design.
- In countries already having D&T education in the curriculum, teachers are found to have difficulties in conceptualizing teaching and learning within the paradigm of a new subject area of D&T education (Stein et al, 2007; Mittel and Penny, 1997). Thus it is assumed that Indian teachers, not trained in design or technology education may certainly have alternate conceptions about design. Knowing about teachers' understanding would not only help in the development of curriculum but also the professional development of teachers.

3.1.3 Rationale for studying designers' ideas of design

- It is significant to know about the perceptions of designers who are actually involved in the act of designing. Designers' understanding of design enables the researcher to contextualize students' and teachers' ideas and thereby serve as a yardstick for the comparison of ideas held by students and teachers.
- Determining the characteristics of designers' ideas also enables comparison within different design disciplines.
- Determining the nature of designers' attitude to design education and its implementation in general education could be useful to curriculum developers interested in developing D&T education or its equivalent as a subject in Indian schools.

3.2 Objectives of the survey

The broad objective of the survey was to study elementary and middle school students', teachers' and designers' ideas about design. The responses from the survey also served as a precursor to the development of design activities that were planned for the intervention among middle school students. The survey aimed at comparing the ideas of design across and within each sample, that is, students, teachers and designers. The following research questions were addressed through the survey.

3.3 Research questions

- What do students, teachers and designers understand by the term *'design'*? What ideas, activities, artefacts and occupations do they associate with '*design'*?
- What activities, values, skills and qualities do they associate with designers?
- What are students', teachers' and designers' ideas of design and design learning/teaching and how do these ideas of students, teachers and designers vary from each other?
- Do students' ideas of design and design learning differ by gender or grade?
- How do elementary and middle school students pictorially depict a designer and his/her workplace and how do these images vary by grade level and gender?

3.4 Methodology

As the objective of the study was to explore and gain insights into students', teachers' and designers' ideas of design, this exploratory inquiry was best suited to the survey research method which is an established procedure for collecting data in the field of education (Creswell, 2002).

Survey research involves asking a large number of people questions about the same topic. The survey research design can be of two types: cross-sectional which involves collecting data at one point in time from a sample that represents a larger population and longitudinal survey which involves collecting data from the same sample at different points in time. The survey presented in this thesis represents the cross-sectional type and aims to collect information from three different samples: students, teachers and designers. The survey research design was chosen for the following reasons:

- The aim of this part of the study was to examine ideas of design held by students, teachers and designers. As ideas are not observable, there was a need to seek the information from the sample by utilization of the tools commonly used in surveys, that is questionnaire and interviews;
- The survey research design enables mixed methods of data collections and analysis. For example, questionnaires with descriptive, pictorial and drawing tasks, open-ended and close-ended questions as well as the interviews ensured participants' expressions of their ideas through different means.
- This study involved cross-sectional survey design which enabled collection of ideas from a large sample at one point in time.
- The survey research design facilitated comparison not only within but also across the samples.
- Last, but not the least the purpose of survey research is to make generalizations from a sample to a population such that inference can be made about the characteristics, attitude or behaviour of that population. Though the study does not claim to make any generalizations about either of the samples' ideas of design, it is assumed that a number of such surveys in different parts of the country would help in forming a generalized pattern or trend in Indian students' and teachers' ideas of design.

Students, teachers and designers were surveyed separately at different occasions. However, the selection of the sample and the development of the survey questionnaire were done in an integrated manner. The survey involved selecting the sample, strategy to draw the sample, development of the questionnaire for each sample, its administration and analysis of the responses. Four different questionnaires were developed, one each for:

- Elementary class students (Classes 5 and 6) (*Appendix B*)
- Middle school students (Classes 7-9) (*Appendix C*)
- Teachers (*Appendix D*)
- Designers (Post Doctoral design students) (*Appendix E*)

The methods for collecting the data were slightly different in each of the cases, hence each of the methodologies are discussed separately under specific headings in the following sections, along with the description of the questionnaire used to collect data. Permissions were sought from the Principals of the school for conducting both the pilot and the final surveys. *Appendix F* provides a format of the letter that was given to the Principals of the schools where the surveys were conducted.

3.5 Sample for the survey

The participants for the survey were students, teachers and designers. The following sections give details about three samples.

3.5.1 Student sample for the pilot survey

The survey with students was conducted in two phases: pilot and final. Both the phases of the survey were conducted with students from schools in Mumbai. The pilot test of the questionnaire was done with students who were drawn from a school located in the vicinity of the researcher's institution in Mumbai. The student sample for the pilot consisted of 25 students (7 girls and 18 boys) from Class 7 (11-13 years of age). Students' willingness to participate in the study, their proximity to the researchers' institution and the researchers' rapport with the school management influenced the selection of the school and the sample. These students (like most Indian students) did not have D&T education in their curriculum. Their linguistic background was varied, with most students reporting different Indian languages spoken at home while the medium of instruction in the school was English. The language used by the researcher was also English.

3.5.1.1 Rationale for the choice of student sample for the pilot survey

Students in Class 7 were selected for the pilot phase of the survey for a number of reasons. Students of Class 7 are about the age of 11-13 years. They are able to articulate their thoughts and ideas in writing as well as understand written comprehensions, while students of younger age may not. According to Rennie and Jarvis (1995), students below the age of 10 years find it difficult to respond to long questionnaire especially when they are required to respond to descriptive questions.

The aim of the pilot study was to test the questionnaire prior to the larger study, in order to improve the quality and efficiency of the final questionnaire. Thus by administering the questionnaire on Class 7 students the researcher aimed to ensure that the instructions given in the questionnaire were comprehensible.

Based on the results from the pilot study, changes were made in the questionnaires for all students (classes 5-9). The questionnaire for classes 5-6 was made simpler and had less questions than the questionnaire used with classes 7-9.

3.5.1.2 Limitation in the choice of student sample in the pilot survey

The sample selected for the pilot was not a representative sample. It had several limitations. Firstly the sample represented students of only the urban school with English as their primary mode of instruction in their school. However, this sample was selected because of researcher’s limitation in being familiar with the common language spoken in the State of Maharashtra, namely Marathi.

Secondly the pilot sample was drawn from a single school. However, students’ willing to participate in the study came from different classrooms/sections of Class 7.

The third limitation was in unequal distribution of the number of boys and girls in the sample (7 girls and 18 boys). However, this was the result of the study being based on voluntary participation.

3.5.2 *Student sample for the final survey*

The sample for the final survey consisted of 511 students drawn from another urban school (different from the school used in the pilot study) located in Mumbai, in the vicinity of the researchers' institution. This sample consisted of students from Classes 5, 6, 7, 8 and 9 and ranged in ages from 9 to 15 years. This school was co-educational consisting of almost equal number of boys and girls in each class. The students' linguistic background was varied, with most students reporting different Indian languages spoken at home while the medium of instruction in the school was English. The instructions given by the researcher were also in English.

As mentioned earlier, Rennie and Jarvis (1995) have suggested that one avoid long questionnaire including descriptive questions with students below the age of 10 years, since they find it difficult to comprehend. A visit by the researcher to the school before the final survey revealed that there were many 10 year olds students and a few 9 year olds students in Class 6. Thus a different questionnaire was developed for classes 5 and 6 students than class 7-9 students.

Another sample of 22 students (Classes 7, 8 and 9) was interviewed using the final questionnaire. This sample was drawn from the same school as the pilot sample but was different from the pilot sample. The aim of these interview-based sessions with students was to probe their responses in the questionnaire, in detail.

For the sake of brevity, elementary school students (classes 5 and 6) henceforth would be referred to with the initials ESS while the middle school students (classes 7-9) would be referred to as MSS.

3.5.2.1 *Rationale for the choice of student sample in the final survey*

The aim of the study was to study elementary and middle school students' ideas about design and designers. The choice of sample was thus justified. Students younger than 9 years (Class 5) were not selected since it involved developing an entirely different set of questionnaire for them, due to their limited comprehensive abilities. Students older than 14 years (Class 9) were not easily accessible since they were busy preparing for their school leaving examinations.

3.5.2.2 Limitation in the choice of the student sample in the final survey

The sample for the final survey was controlled for the variables which were missing in the pilot sample. However, there still existed several limitations in the choice of the sample. For example, the criterion of keeping the number of boys and girls equal was met and the sample represented almost equal number of boys and girls in the final study. However, the sample was drawn from a single school which limits its generalizability to an extent beyond the selected group of students.

The final sample also included students from an English-medium school, that is, students whose language of instruction was English in school. This limitation was unavoidable since the researcher was not familiar with the Marathi language, which is the language of the State of Maharashtra and usually spoken in Marathi-medium schools. The details of the student sample for the final survey are given in Table 3.1.

Table 3.1: Student sample distribution in the final study

Mode of data collection	*Classes*	*Average age (yrs.)*	*No. of boys*	*No. of girls*	*Total*
Final questionnaire	ESS (classes 5-6)	10	92	101	193
Final questionnaire	MSS (classes 7,8 9)	12.3	160	158	318
Final questionnaire + Interview	MSS (classes 7,8 9)	11.9	12	10	22
	Total		264	269	533

3.5.3 Teacher sample

The teachers sample was drawn from a College of Education in Mumbai, during a workshop conducted with them. The workshop was not related to the research study reported in this thesis. Of the 34 teacher participants, 27 were females while 7 of them were males. The description of the teacher sample is given below in Table 3.2. As evident from the table, 24 teachers were pre-service teachers pursuing either, Masters, Bachelors or Diploma in education while 10 teachers were already established as in-service teachers. The pre-service teachers however, had experiences of teaching during their courses. Most of these teachers taught the subjects of English, Mathematics and Science to middle school students of Classes 6, 7, 8 and 9 (22 of them), while 4 of them were higher secondary teachers of Classes 11 and 12.

Table 3.2: Characteristics of the teacher sample

Teacher sample description		***No. (%)***
Gender	Male	7 (21)
	Female	27 (79)
Type	Pre-service	24 (71)
	In-service	10 (29)
Classes they teach in	Not mentioned	7 (21)
	Elementary (Class 5)	1 (3)
	Secondary (Classes 6-10)	22 (65)
	Higher secondary (Classes 11-12)	4 (12)
Subjects they teach	Not mentioned	4 (12)
	English / History /Arts	17 (50)
	Science / Mathematics	13 (38)

3.5.3.1 Limitation in the choice of the teacher sample

Although the teacher sample was varied and heterogeneous in terms of age, experience and academic qualifications, it was quite small in comparison to the student sample. The sample also, mostly included pre-service teachers. It is difficult to get many practicing teachers at the same place and to respond to a lengthy questionnaire due to their varying and hectic time schedules in schools. Another limitation identified in the teacher sample was the unequal distribution of male and female teachers. However, since gender was not a variable in the analysis of teachers' responses, it was considered irrelevant in case of teachers.

3.5.4 Designer sample

The sample of designers included post doctoral design students from a design school in Mumbai. Of the 5 designers (3 males and 2 females) participating in the survey, 4 of them were pursuing PhD in design, while one of them (a female designer) had done masters in animation design. Of the 4 designers pursuing PhD, one of them was a product designer (female), one was an architect (male), user experience designer (male) while the fourth one was a visual communication designer (male).

3.5.4.1 Limitation in the choice of the designer sample

The designer sample was limited since it included post doctoral and masters design students rather than practicing design professionals. The designer sample was chosen due to its easy accessibility. Moreover, the aim of the study was to contexualise students’ and teachers’ ideas of design with respect to the ideas from the design fields. The PhD design students served the purpose hence they were selected for the study.

Another limitation of the designer sample was its small size. This however, was done purposefully. A large scale quantitative survey of designer was neither feasible nor desirable. It was unlikely that a large scale survey with designers would give insights into designers’ understanding of design. A detailed qualitative study of a few designers’ ideas seemed more fruitful for pursuing the objectives laid down in this study.

3.6 Tools used for the survey

In the literature researchers have used a number of tools to probe students’ ideas of technology. These tools included questionnaires, drawing tasks, pictorial questions and interviews (Ratt and de Vries, 1986; de Klerk Wolters, 1989; Jarvis and Rennie, 1998; Rennie and Jarvis, 1995; Khunyakari et al., 2009, Mehrotra et al., 2007). In the present study, various tools were used to gather data from students, teachers and designers. In this survey too, questionnaires, drawing task, pictorial elements and interviews were used with the different samples.

3.6.1 Questionnaire format and content

Designing the questionnaires and interview schedules for students, teachers and designers was a challenge to the researcher, due to the diversity of the sample and the lack of available materials on the same topic in literature. The multiple meanings associated with design and the lack of D&T in the Indian school curriculum contributed to the problem.

The studies by Welch et al. (2006) and by Newstetter and McCracken (2001) informed the researcher’s construction of the questionnaire. A few items in the questionnaire were also informed by the studies done with Indian middle school students’ perceptions of technology by Khunyakari (2008) and Mehrotra (2008).

While developing the questionnaire several aspects were highlighted as themes and concepts related to design, interests of the participants and the artefacts, activities, knowledge and skills associated with design. Based on the literature and our own understanding of design, a scheme was developed that guided the development of the questionnaire.

3.6.2 Pilot questionnaire

The pilot questionnaire consisted of 36 items, of which 2 were open-ended, 2 required sentence completion, 10 had dichotomous responses (agree/disagree, yes/no) and 22 of them were multiple response questions (*Appendix A*). The pilot questionnaire was content validated by two experts in the field of D&T education, on various aspects such as,

- appropriateness of language in terms of age, gender and context
- logical validity of the content

3.6.3 Pilot survey with students

The pilot survey was conducted with 25 students of Class 7 who were participating in a workshop. 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 by students. The results of the pilot survey have been published by the researcher and her colleagues in a peer reviewed International conference publication (Ara, Chunawala and Natarajan, 2009a). The presentation of the results from the pilot in a peer-reviewed conference provided feedback which not only enabled the researchers to establish the validity of the questionnaire but also incorporate several changes into the final questionnaire. For example,

- The language of the questionnaire was made simpler;
- A drawing task was included in the questionnaire, in order to probe the images of designers held by students;
- Several new questions and items were included in the questionnaire, such as school subjects related to design and design occupations suitable for a girl or a boy. A few questions were also dropped from the pilot survey questionnaire;
- A pictorial segment was included which consisted of 30 pictures of people

(men/women) performing some activities. Participants were required to mark the activities which they considered as designing or related to design.

3.6.4 Final questionnaire

The basic questionnaire for all the three samples had 3-4 sections (see *Appendix B, C, D and E*):

A. This section included a short introduction to the purpose of survey and was aimed at collecting demographic data of the individuals such as name, gender, date of birth/ age, etc.
B. This section was only for students. It required them to *'draw a designer at work'*. The drawing aimed at probing students' images of designers- the nature and settings of activities of designers, their gender etc.
C. This was the largest section and had questions pertaining to respondents' ideas about design. There were open-ended questions, sentence completion questions, rating scales, dichotomous questions etc.
D. The last section consisted of several pictures showing certain activities performed by individuals. All participants were asked to mark the activities which they considered were designing activities.

To maintain gender parity, Section D had 2 versions- one in which the pictures depicted all the activities done by males while the other depicted all the activities done by females. Participants were provided with any one version of Section D (Figure 3.1, Figure 3.2). The two versions of this section were randomly distributed to participants.

Figure 3.1: 'Making a new dish' Male version of Section D

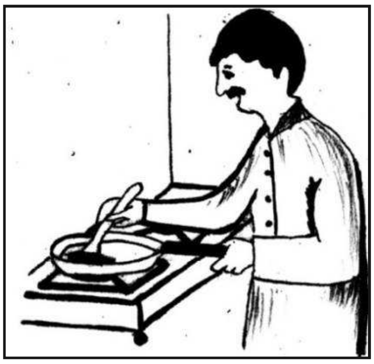


Figure 3.2: 'Making a new dish' Female version of Section D

Section A which collected demographic information, was modified for teachers and designers to seek different information from them. Section B or the drawing task was adapted from the questionnaire on engineers and scientists by Fralick, Kearn, Thompson, & Lyons (2009). In the survey questionnaire, this task featured an enclosed area where the students were asked to 'Draw a designer at work'. The task also included written responses in addition to the drawings. This section was dropped for the designers and teachers. Section C, which was the largest section including several open-ended and closed ended questions, had 4 separate versions: one each for (i) ESS (ii) MSS (iii) teachers and (iv) designers. Section D was common to all the participants.

In order to avoid repetition, the researcher reports the findings, only from the final survey in this chapter. Findings from the pilot survey are freely available in a peer reviewed International conference publication (Ara, Chunawala and Natarajan, 2009a).

3.6.5 Establishing validity and reliability of the final questionnaire

The validity of the final questionnaire was again 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

For the final survey, the questionnaires were again validated by the same two experts in the field of D&T education who validated during the pilot survey. The questionnaires were also scrutinized and validated a designer educator from a design school in Mumbai. Their critical comments and suggestions were incorporated into the final questionnaires.

In order to establish the reliability of the final questionnaire, *test-retest* method was employed. 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. However, Section B (i.e. ‘Draw a designer at work’) and descriptive questions were omitted from the retest version of the final questionnaire. Students were only tested for the close-ended questions in Section C and Section D. The results of the reliability analysis for the tested items are listed below in Table 3.3.

Table 3.3: Results of reliability analysis for the close ended questions

Question no.	***Nature of question***	***Correlation coefficients***
Section C IX	Subjects related to design	0.740
Section C X	Choose an occupation	0.866
Section C XI	Attitude towards design	0.785
Section C XII	Concept of design	0.871
Section C XII	Skills of a designer	0.782
Section C XIV	Qualities of a designer	0.905
Section D	Design activities (pictures of activities)	0.955

Table 3.3 indicates that the reliability analysis for the 7 questions yielded high correlation coefficients ranging from 0.74 – 0.96.

3.7 Procedure and Data collection

Procedure for data collection varied for students, teachers and designer. All the three samples were investigated at three different occasions. Besides, for the student sample, an additional twenty two students volunteered to participate in an interview-based sessions where they were probed on their ideas of design using the same questionnaire as in the final survey. These twenty two students did not belong to the student sample in the final survey. They were a fresh batch of students from classes 7, 8 and 9 from the same school as the pilot survey.

Table 3.4: Mode of data collection for the three samples

Sample	***Students***	***Teachers***	***Designers***
Mode of data collection	Questionnaire (n=511) Interview (n=22)	Questionnaire (n=34)	Interview (n=5)

3.7.1 *For students (Final survey)*

3.7.1.1 *Questionnaire*

The final survey was done with 511 students in their classrooms. Each class was given the questionnaire at a time. Researcher and two persons assisting the researcher handed out the questionnaire to the students. Data collection for the students involved distribution of only Section A, B and C initially. The instruction and guidelines were read aloud by the researcher or the person assisting her. In each of the classes, students were first asked to fill out Section A (demographic information) and then attempt Section B (the drawing task). After the completion of these tasks students were asked to complete Section C. On an average, ESS took about 40 minutes while MSS took about 60 minutes to complete Sections A, B and C of the questionnaire. Lastly Section D (Pictorial activities) was handed to the students which took about 5-7 minutes for completion by both ESS and MSS.

3.7.1.2 *Interview*

The interview sessions were conducted with middle school students from classes 7-9 from a different school. This was the same school as in the pilot survey; however, the students were different from the pilot study. The interviews were aimed at detailed exploration of their ideas about design and designers. The same survey questionnaire, without Section B (the drawing task), was used in the interviews. The interview session with each student lasted for about 70 minutes. Their interviews were audio recorded and transcribed verbatim.

3.7.2 *For teachers*

The procedure of administering the questionnaire to the teachers was the same as that for students. The teachers' questionnaire did not include Section B (the drawing task). Some of the questions in Section C of the questionnaire had been modified to seek teachers' justifications for their responses and this took more time. For example, teachers were required to justify with reasons whether their profession of teaching was related to design or not. Teachers took about 80 minutes to complete Sections A, C and D of the questionnaire.

3.7.3 *For designers*

The 5 designers were interviewed on separate occasions respectively. The interview schedule for the designers was very similar to the teachers' questionnaire except for some variations in the instruction. This schedule for designers also did not consist of Section B (the drawing task). The interview with each designer lasted for about 1 hour and 20 minutes. Their interviews were audio recorded and transcribed verbatim.

3.8 *Analysis*

The survey described in this thesis is complex as it involves different samples of different sizes and varied age groups. It also involves varied tools of data collection: questionnaire and interviews, with the questionnaire involving varied items: close-ended and open ended questions, drawing tasks and pictorial tasks. It was thus deemed necessary to develop a framework for analyzing the data collected from students, teachers and designers.

Since the three samples were not comparable in terms of their sizes, ages and expertise or experience in design, it was not appropriate to compare the three samples using quantitative methods. Rather different methods were used to analyse the three samples: quantitative and qualitative approaches were used to compare students' responses within the student sample, while a qualitative approach suited the analysis of teachers' and designers' responses.

3.8.1 *Framework for analysis of students' responses*

Firstly, the written responses of students were analysed 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). Two researchers (the researcher and her supervisor) coded the data. Firstly the researcher coded a student's response and then discussed it with the supervisor. Confirmation on a code was done through mutual discussion and agreement with each other. Students' ideas were interpreted on a gender basis wherein responses from boys and girls were compared irrespective of their classes. Next the responses were analysed on a grade level wherein elementary students' responses were compared with the middle school students, irrespective of their gender. Although the interview responses have been integrated in the final survey, the responses from the interviews are used for the qualitative analysis of students' ideas on the various aspects of design. The interview responses serve to triangulate students' responses in the written questionnaire survey.

Secondly, the drawings of students were analysed using codes that emerged from the data itself and those from the literature. These codes were analysed using descriptive analysis of SPSS across gender and grade. Date collected from multiple sources allowed for the triangulation of data within the student sample.

3.8.2 Framework for analysis of teachers' responses

Teachers provided only written responses to the questionnaire. There was no drawing task for the teachers nor were there interviews. Analysis of teachers' responses involved coding both the close-ended and open-ended data. For items in the questionnaire, which were common between students and teachers, the same codes were used for both the samples. For example, in case of the items such as, *'What comes to your mind when you hear the word 'design'?* or *'Can animals design?'*, which were common between students and teachers, the researcher made use of the same codes. However, in cases when the students' codes were not sufficient to analyse a particular response, new codes were generated for teachers' responses to those items.

Frequency of teachers' responses was computed and their qualitative responses were compared with the responses from students and designers. There was no attempt to analyse teachers' responses based on their gender or their experience because of the small sub-samples. There was also no attempt to compare students', teachers' and designers ideas of design using quantitative means.

3.8.3 Framework for analysis of designers' responses

The interview schedule of the designers and the questionnaire of the teachers were similar. The size of designers' sample was too small; only five, and the data was collected through an interview with each designer for about an hour and twenty minutes. The interview data was transcribed verbatim for analysis. Hence the qualitative approach of data analysis best suited this sample. The interview with each designer probed in detail on most of the items from the questionnaire. An attempt was made to categorise those responses based on some emergent theme and compare them with those of students and teachers.

The next section presents the results from the survey study.

3.9 Results

The results for each of the sample: students, teachers and designers have been discussed separately under each item of the questionnaire item. There is an attempt to compare the ideas across the three samples at the end of each section. In order to maintain uniformity and completeness in the analysis and to facilitate comparison across different samples, the entire Section C is presented first, then Section D (the pictorial task) and lastly Section B (the drawing task which was given only to the students).

3.9.1 Section C: Students', teachers and designers' ideas of design

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

A. Students' responses

In response to the above question, all the students came up with a number of spontaneous ideas related to design. Of the 533 students, 511 students responded to this question. The total number of ideas related to design suggested by students was 871 and this was more than the number of students responding to this question since some respondents provided more than one idea in their responses. The mean number of total ideas was around 2 (1.70). However, the mean for MSS and ESS differed. While the mean number of ideas by the MSS was around 2 (2.11), it was low for the ESS with one idea per student (1.31). The ideas suggested by students indicated the spontaneous associations that they made with the term design. Students' ideas were coded and categorized to find a general trend. Table 3.5 indicates the different spontaneous ideas of students for the word 'design'. The largest number of ideas was related to the meaning of the word, in terms of art, drawing, plan, modelling/making, invention, new idea, shapes of things or keeping things in order. Fifty one percent of ideas were closely related to the meaning of the word 'design'.

Table 3.5: Students' spontaneous ideas of 'design'

Students' ideas of design	***ESS No. (%)***	***MSS No. (%)***	***Boys No. (%)***	***Girls No. (%)***	***Total No. (%)***
Ideas related to the meaning of Design (51%)					
Art (painting/ decoration/ patterns)	**76 (34)**	**162 (25)**	**102 (25)**	**146 (29)**	**238 (27)**
Drawing (drawing/ scientific drawing)	21 (9)	45 (7)	35 (9)	31 (7)	66 (8)
Making/ repairing things	16 (7)	25 (4)	**32 (8)***	**9 (2)***	41 (5)
Plan/drawing to show how something is made	3 (1)	31 (5)	11 (3)	23 (5)	34 (4)
Invention/creation	10 (4)	22 (3)	21 (5)	11 (2)	32 (4)
Coming up with new idea	1(< 1)	19 (3)	11 (3)	9 (2)	20 (2)
Shapes of things	1 (< 1)	9 (1)	6 (1)	4 (1)	10 (1)
Keeping things in order	0	2 (< 1)	0	2 (< 1)	2 (< 1)
Subtotal	128 (57)	315 (49)	218 (54)	225 (49)	***443 (51)***
Other ideas associated with Design (49%)					
Examples (Egs.) of artefacts designed	33 (15)	131 (20)	86 (21)	78 (17)	164 (19)
Egs. of design professions	7 (3)	49 (8)	12 (3)	44 (9)	56 (6)
Attitude towards design/ design learning	28 (13)	46 (7)	41 (10)	33 (7)	74 (8)
Skills of designers	5 (2)	35 (5)	12 (3)	28 (6)	40 (5)
Egs. of design professionals	14 (6)	37 (6)	21 (5)	30 (6)	51 (6)
Attitude towards designed products (*attractive*)	0	20 (3)	8 (2)	12 (3)	20 (2)
Design is for a purpose	1 (.4)	9 (2)	4 (1)	6 (1)	10 (1)
Presence of design	0	5 (< 1)	1 (< 1)	4 (1)	5 (< 1)
Designer's workplace (*office, home,*)	8 (5)	0	4 (1)	4 (1)	8 (1)
Subtotal	96 (43)	332 (51)	189 (46)	239 (52)	***428 (49)***
Total	***224 (26)***	***647 (74)***	***407 (47)***	***464 (53)***	***871 (100)***

(* indicate significant difference)

The rest of the ideas (49%) were related to other aspects of design such as examples of the products of design, design professions and professionals, skills associated with designer, attitude towards design and designed products etc.

Majority of the ideas were related to design as *art* such as painting, decoration or pattern making (27%), while 8% indicated design as some kind of drawing. However, only 4% of the ideas suggested design as a *drawing to show how something can be made* or a *plan*. Few ideas were related to design as *making* (5%) and *inventing/creating* (5%). According to Balaram (2005), design in India has many meanings with past and present associations. He argues that while things such floral patterns, intricate decoration or a piece of jewellery might be considered designs, an innovative new chair might not be considered design by Indian people. This he, believes is due to the past association of design with arts and crafts of India. The sample in this study also expresses more ideas of design as related to art.

Other ideas most frequently associated with design were examples of designed artefacts (19%), such as, clothes, structures (building/bridges), art work, vehicles, jewellery, furniture, software and even people. Students who wrote that people could be designed usually considered dressing up as being designed. For example one female student wrote, *'an ordinary girl is designed and then she is beautiful'*. The various professionals in design (6%) were from fashion designing, architecture, engineering, interior designing, pottery, etc. About 5% of the ideas were related to the skills associated with design namely, creativity, imagination and hard work. Other ideas associated with design and expressed in some students' responses were attitude towards design (e.g. *'design is interesting'*, *'design is liked by girls'* etc.), design learning (*'all can design'*, *'I cannot learn to design'* etc.) and designed products *('...are attractive'*, *'modern'* or *'comfortable'*).

a) Gender

As evident from Table 3.5, girls in general produced more ideas than boys (407 or 47% by boys, 464 or 53% by girls). However, this difference was not found to be significant. Cross tabulation analysis to determine any differences in responses of boys and girls, revealed that girls produced more ideas of design as related to art such as decoration and painting. This difference was also not significant. There was however, a significant difference noted between boys' and girls' responses about considering *design as making* [χ^2 (1) = 14.776, p = .000]. More ideas from boys (8%) than from girls (2%) were related to design as *making, modelling, transforming, repairing or giving shapes to things*.

However since the responses of both boys and girls to this category was low, the statistical significance is not of much relevance.

b) Grade level

As shown in Table 3.5 and mentioned earlier, the grade-level distinctions indicated that more ideas were generated by MSS (647, 74%) than by ESS (224, 26%). The ideas of MSS varied both in quantity and quality. ESS came up with ideas associated to design as art (34%) more than the MSS (25%). More of younger students' ideas were also associated with design as *drawing* and *making*. Younger students also seemed to have simpler ideas of design such as design as mostly painting, making and drawing. This can be attributed to their age, wherein older students have begun to develop some understanding of the complexity involved in design. For example as evident from Table 3.5, more of older students' ideas pertained to design as 'planning', 'coming up with new ideas', 'inventing' etc. Interestingly, more ideas from ESS demonstrated expressions which were indicative of attitude towards design. For example, ESS wrote statements such as *'I like design very much'* or *'I become happy when I design.'*

c) Students' Interview Responses

The interviews revealed interesting aspects of students' understanding about design. Students' responses varied from those who strongly associated design with art and even craft in schools or at home to those few who considered design as associated to technology. For example, in response to the above question, a girl student (SG1) replied:

'Design is like an art, it means whatever an artist thinks he can make it. Art is natural for them; whatever comes to their mind, they just draw it. They don't have to think much about it. They can easily get it. It comes easily in their minds.'

This student reflected a strong association of design with art. Not only that, she seemed to suggest an inherent ability possessed by designer artists, for whom design or art is natural. She revealed in the interview that design is something that did not require much thought but was mostly intuitive. Another girl student (SG2), who had a school craft-oriented approach to design, said:

'Design is making up things with our own ideas that comes into our minds at that time; like, when we are thinking something and ideas come into our head spontaneously, we

can try it out…this has happened with me. When I watch some craft programs on TV [television] I like to design it in my own way with different materials, or when I do embroidery, I do it in my own way.'

This is interesting since although SG2 speaks of associating craft-like activities with design, she emphasizes on *her own way* of doing things or creating her own method for carrying out things as essential while she is designing.

Some students in the interview reflected an association of design with technology. However, it was soon revealed that their technological understanding of design seemed to be concealing their essential artistic notion of design. The following is a transcript of the conversation between the researcher (R) and a boy student (SB1) who considered technology to be associated to complex things while design functions as an artistic rendering process of making that complex thing look beautiful.

SB1: *Design is making something in an extraordinary way, which has complexity and it is beautiful.*
R: *Why should that thing have complexity?*
SB1: *Because many complex things are better.*
R: *How are complex things better?*
SB1: *Yes, because in complex things more technology are* [is] *required and it is more working* [works better].
R: *Why should it be beautiful, then?*
SB1: *It should be beautiful because when we see any beautiful design our minds gets* [get] *soothed*.

Reflecting an understanding of 'design as improvement', a boy student (SB2) responded in the following manner. The artistic rendering process as the function of design is reflected in his response too,

SB2: *Design means to make any simple object into looking good and attractive and makes* [make] *it better.*
R: *How does design make simple objects look good and better?*
SB2: *Because a simple object only can be made into attractive looking and comfortable.*
R: *What about complex objects? Can't they be made better?*
SB2: *A complex object cannot be further improved. They become better from simple[r] objects.*

Design as 'planning in general' and 'planning before making' were also evident in students' responses. For example, considering design as a plan in general a boy student (SB3) suggested:

‘*We also design for example, during exam time, like if it is an English exam paper, I’ll do the writing part first because in the morning time, our minds are fresh, so we can write it properly and the literature part we memorise only so we can write it at any time.’*

Although a few students in the interview suggested designing as planning before making something, but they were not very certain about what that ‘planning' entailed. For example one girl student (SG3) reflected an understanding of design as a planning required before making. She however, faced difficulty in articulating her thoughts about this. For example she suggested: *‘I feel everything here is a design because when a carpenter is making a sofa he designs; he takes a pen and a tape and he measures. He is designing ‘something’ to make a sofa.’*

Students in the interview also suggested various examples of design professions especially fashion designing, architecture and interior designing. They also suggested various designed products from embroidery to cars.

B. Teachers’ responses

All the 34 teachers came up with a variety of spontaneous ideas about design. In sum, teachers produced 75 ideas with a mean of 2 (2.21), similar to the MSS. Table 3.6 indicates teachers’ spontaneous ideas associated with design.

The responses by teachers were elaborate and descriptive. Like students, majority of teachers’ ideas (19%) were related to art or artistic expressions, mostly paintings and decorations. The responses of teachers indicate that they also associated design with ‘planning’ (12%). However, by planning, these teachers suggested a more general planning process rather than a plan intended before making an artefact. Interestingly, unlike students, none of the teachers mentioned *‘planning before making’* or *‘drawing to make something’* as design. Two teachers mentioned drawing as design without elaborating on what they meant by these drawings. Thus, teachers’ ideas seemed to align more with design of intangibles and planning in general. They considered planning to be useful in all walks of life. This may be due to teachers having a wider range of experiences than the students.

Table 3.6: Teachers' spontaneous ideas of 'design'

Ideas related to the meaning of Design (57%)	***Teachers Nos. (%)***
Art (art, painting, decoration, patterns)	14 (19)
Planning	9 (12)
Making/repairing things	5 (7)
Design is a method/process	5 (7)
Coming up with new idea	3 (4)
Shapes of things	3 (4)
Drawing (drawing or scientific drawing)	2 (3)
Invention/creating new things	2 (3)
Subtotal	***43 (57)***
Other ideas associated with Design (43%)	
Examples of artefacts designed (lessons/curriculum)	13 (17)
Skills associated with design/designers	9 (12)
Design is for a purpose	7 (9)
Examples of design professionals	2 (3)
Examples of design professions	1 (1)
Subtotal	***32 (43)***
Total	***75 (100)***

Teachers, like students gave examples of designed artefacts. However, their examples were strikingly similar to each other and were restricted to the design of curriculum, lesson plans and for a few, dresses.

Interestingly 5 teachers gave examples of design from their own profession of teaching. For example while discussing the purpose of design, two of them suggested that teachers design lesson plans for effective teaching while 3 of them suggested that school/teachers or the curriculum *design or mould the character, fate and mind of students* so that they become the *best* [good] *citizens* of their country. One of these teachers even used the metaphor of a flower wherein she implied that '*a child was like a bud and he needs to blossom…imparting values, knowledge and other education in the child is like designing the child*.'

Another aspect of teachers' ideas of design was their understanding of design as a method or a process, unlike any of the students. Teachers suggested that design 'as a process' could be utilized in schools by teachers to organize materials and plan lessons for students.

C. Designers' responses

On first hearing the question, all the designers came up with a few single words associated with design. Designers' associated words varied from *simplicity* and *common sense* to *invention* and *creation.* These words seemed to be linked either to the product or the skills required in designing. Table 3.7 indicates designers' generation of words on being asked to indicate what came to their mind on hearing the word 'design'.

Table 3.7: Designers' spontaneous ideas of 'design'

Designers	*Spontaneous words generated by designers*
Product designer	Creativity, simplicity and common sense
Animation designer	Invention, creation
Visual communication (VC) designer	Improvement
User experience (UX) designer	Communication, invention and conscious decision
Architect	Building designs, drawings, site where building is halfway through, conflicts (between the client and the architect)

In contrast to students and teachers, none of the designers associated design with art. Their ideas mostly pertained to design as a process of either creating something new, improving a current state of condition or making life simpler and comfortable for people. All the designers emphasized that design involved a conscious decision-making process in the service of some predetermined goal or a purpose. Students and teachers on the other hand, produced very few ideas related to the purpose of designing.

Although a few designers equated design with invention, Mitcham (1994) differentiates the nature of *designing* and *invention* by suggesting,

'As opposed to designing, inventing appears as an action that proceeds by non-rational, unconscious, intuitive, or even accidental means. Designing implies intentionally planning' (p.217).

When asked to elaborate on his idea about design, the user experience designer said,

'My understanding of design is that it's a holistic approach to look at things. When I use the word Design and I say design an activity or let's say design an environment or design

an interface or a park or a product or anything…design to me means that even before the act of creating tangibles I probably look at all different aspects of that tangibles, not only in terms of what it could be but also in terms of what effect it would have on the environment or what sort of positions would it entail in the entire spectrum of artefacts that we have. For me it is more like an holistic approach of looking at things…like you try to place things in a system and say that here pull is happening and here push is happening; it is more like managing forces.'

User experience design emphasizes all aspects of a person's with the system (namely, interface, graphics, industrial design, physical interaction) and the application of user-centred design practices to generate desirable designs based on holistic understanding of user's experience (UXDesign, 2010). Thus coming from a field which emphasizes looking at sub-systems and processes within a system and evaluating how users feel about that system, the UX designer, demonstrated a holistic understanding of design and seemed to capture its essence. He seems to consider artefacts and products that need to be designed not in isolation but as a part of the system that needs to be taken account of while designing. According to him, it is the responsibility of a designer to consider not only how his/her design will function but also, how it might influence the environment. He appeared to lay more emphasis on increasing the holistic experience of the user than the functionality of the products.

Coming from a product design background, the product designer, however, emphasised the simplicity of products in their use and looks. While being more concerned with the product functionality and use, she argued,

'Designing means simplifying things; making life simple… So things are obvious to you when they are difficult to use. When something is very natural, it becomes a part of the background. It becomes invisible. So good design is being invisible...As a designer we should be able to make thing so simple that they are invisible. They just become a part of you- intuitive; it just blends with your inherent being. That's what designing is.'

Considering design as an improvement, the visual communication designer suggested,

'Any current situation lacks something and the lack is felt in the form of some discomfort with what is existing and that is the trigger to design something new.... many people feel discomfort but they don't take any actions towards it. So the person who takes action, who feels the discomfort and decide to do something about it is the person who begins to design.'

This idea of design by the VC designer seems to be aligned more with what Simon says about design, '*Everyone designs who devises courses of action aimed at changing* *existing situations into preferred ones'*- (Simon, 1996: 111).

3.9.1.2 'Designers are people, who...'

A. Students' responses

When asked to complete the above sentence, 461 students responded. The total number of ideas on designers, generated by students was around 1000 (Table 3.8). Students were found to produce more number of ideas in relation to this question on designers (1000) than the previous question on design (871; see Table 3.5). The mean number of total ideas was however, around 2 (2.17). More than half the ideas (52%) were associated with the work that designers do while 48% of the ideas were associated with other aspects of designers' work, such as examples of things they design, skills associated with them, etc. About 30% of the ideas on designer's work were tautological since students just wrote '*design'*.

About 10% of students' ideas were associated with designers as engaging in *artistic work* (such as, painting, decorating, making beautiful patterns), 6% as *making or improving* while only 2% as *drawing to construct or planning*. Students' responses to this question on designers conformed to the last question on design. In response to this question, students again cited several examples (21%), mostly dresses/clothes that designers design. Some also cited examples of buildings, automobiles and handicraft like embroideries, baskets and pots. For example, students wrote, '*…designs things like baskets, clothes'* or *'…he designs the dress perfectly.'*

Table 3.8: Students' spontaneous ideas of 'designers'

Students' ideas of designers	***ESS No. (%)***	***MSS No. (%)***	***Boys No. (%)***	***Girls No. (%)***	***Total No. (%)***
Ideas related to the work of designers (52%)					
Designs	**116 (42)***	**185 (25)***	148 (31)	153 (29)	301 (30)
Makes art (paints/ decorates)	23 (8)	73 (10)	48 (10)	48 (9)	96 (10)
Makes (a thing / model / improve / shapes things)	23 (8)	33 (5)	30 (6)	26 (5)	56 (6)
Draws	6 (2)	18 (2)	15 (3)	9 (2)	24 (2)
Invents	2 (1)	18 (2)	12 (3)	8 (2)	20 (2)
Plans/makes drawing to construct	2 (1)	17 (2)	9 (2)	10 (2)	19 (2)
Others (comes up with ideas/operates)	0	5 (1)	4(1)	1(< 1)	5 (1)
Subtotal	172 (63)	349 (48)	266 (55)	255 (49)	***521 (52)***
Other ideas associated with designers (48%)					
E.gs of designed things	77 (28)	135 (19)	96 (20)	116 (22)	212 (21)
Skills of designers	**11 (4)***	**136 (19)***	60 (13)	87 (17)	147 (15)
Designs for a purpose	2 (1)	30 (4)	18 (4)	14 (3)	32 (3)
E.gs of design professions	0	25 (3)	13 (3)	12 (2)	25 (3)
Attitude towards design and design learning	0	17 (2)	6 (1)	11 (2)	17 (2)
Attitude towards designed products	0	17 (2)	8 (2)	9 (2)	17 (2)
E.gs of design professionals	9 (3)	11 (1)	8 (2)	12 (2)	20 (2)
Designer's workplace	3 (1)	6 (1)	5 (1)	4 (1)	9 (1)
Subtotal	102 (37)	377 (52)	214 (45)	265 (51)	***479 (48)***
Total	***274 (27)***	***726 (73)***	***480 (48)***	***520 (52)***	***1000 (100)***

(* indicate significant difference)

Students' responses could also be categorised as skills as possessed or required by designers (15%), such as creativity, having ideas, imagination, talent, intelligence, specific knowledge, expertise in the field and drawing skill. However, students did not come up with any specific knowledge that is required in design. Other skills very infrequently associated with designers were 'being artistic', 'hardworking', 'patient', 'technical' and 'having a presence of mind'.

Only about 3% of the ideas were related to the purpose of design. However these purposes were mostly identified in relation to one specific profession- dress or fashion designing. A few students pointed out that designers design for other people especially people such as actors and models, and events like fashion shows. A few students also considered that designers design for fun and entertainment. That designers design under constraints and for specific needs (besides the aesthetic ones), was present in very few responses only. Students' attitude towards design and designers could be seen in limited responses through such expressions as, '*designers are hardworking people'*, '*designers like to design things'* or '*I want to be a designer'* etc.

a) Gender

Although girls produced more ideas (520, 52%) than boys (480, 48%), no significant statistical differences were noted between the responses of boys and girls for each of the aspect described above.

b) Grade

Class-wise cross tabulation analysis revealed that as in the case of the previous question on 'design', here too middle school students (MSS) generated more ideas about designers (73%) than elementary school students (ESS) (27%). The mean number of ideas produced by MSS was around 3 (2.5) while that of ESS was around 2 (1.6). It was also found observed that ESS produced more tautological responses (42%) than MSS (25%). Most ideas of ESS (28%) were also associated with examples of products and things designed. Thus most of the responses to this question by ESS reflected a tautology with an example, such as *'…design dresses'*, *'…designs buildings,'* or *'…likes to design a dress.'* Significant differences were noted for aspects, such as ideas about the skills of designers which were provided more by MSS (19%) than by ESS (4%).

c) Students' Interview Responses

The interview responses were analysed to reveal students' reasoning behind their responses. As in the case of the first questions, here too, the responses of students demonstrated that the work of designers varied from self expression and doing artistic work like painting or decorating to making complex technological products. For example, SG1 replied to the question, ‘Designers are people, who...’ by saying, *‘…like making something decorative or creating something new.’*

When probed what this ‘something new’ could be, SG1 provided examples which suggested her strong association of visual graphics with designing. For example she mentioned examples of different cartoon characters that she had seen on the television, floral patterns on clothes and wall papers and different logos for cars.

A girl student (SG4) understood design as akin to self-expression and artistic rendering suggests that a designer is a person who *‘...tries to draw or tell his thoughts or message to others with the help of his drawing skills.’*

Students also demonstrated an understanding of different skills that designers have or need not have. SB3 for example, seems to suggest that the work of designer is not just limited to drawing on paper but also includes implementing the same. However, his idea of implementation or doing the ‘practical things’ mostly involved beautifying the place. His initial response was that a designer is one who *‘…designs on a paper and then does practical things.’*

When probed what the designer makes on paper and what are the ‘practical things’ that he does, SB3 replied, *‘He draws things or a room on paper and then he tries to make that thing look attractive or a room more attractive. He designs things which he feel will best suit that thing.’*

In contrast to making drawings before designing, SG3 who had a more ‘craft-like’ approach to design suggested that designers need not rely on drawings for designing. They may plan it in the head and make or fix things without drawing. This is what she suggests about a designer,

‘…he knows the art of planning. If he feels like he should draw, he may draw it on a paper. But he need not design it on a paper or draw something. He can also plan it in his mind while making some machine. He can just fix the parts in the machine. He doesn’t need to draw it.’

Design was considered by students as a vehicle for self-expression which is common in art but not in design. According to Butler (2012) art is a vehicle for self-expression as it first serves the artist and then serves the others just by existing or by inspiring. Design, on the other hand, never first serves the designer. Rather it should first serve the client and the process of serving the client serves the designer. Thus design is never primarily a vehicle for self-expression.

When drawings were mentioned by students, they considered it as a tool used by designers to communicate with themselves rather than with the others in the design process such as the clients or the makers. Most of these responses revealed the authority of the designers in the decision-making process wherein the designers made decisions at their own discretions. There was very less mention of the user/customer for whom designers design. This view is related to an understanding of design as an artistic process where the artist is at her own discretion without caring for others.

Owen (2005) suggests that the perceived similarity between a designer and an artist stems from their common use of the visual media to communicate ideas. However, their fundamental methods, results and goals are quite different.

B. Teachers' responses

In response to the above question, all the total number of ideas generated by teachers was around 61. The mean number of ideas produced by teachers for this question was around 2 (1.8). Table 3.9 gives the detail of the variety of ideas produced by teachers.

As indicated in Table 3.9, teachers mostly considered that designers come up with many ideas (13%) and that they plan (11%). This is consistent with the sample of graduate student in Newstetter el al.'s study (2001) where graduate students primarily suggested ideating as an important phase in designing.

Table 3.9: Teachers' spontaneous ideas of 'designers'

Teachers' spontaneous ideas of 'designers'	*Total ideas Nos. (%)*
Ideas related to the work of designers (51%)	
Comes up with ideas	8 (13)
Plans	7 (12)
Designs	5 (8)
Invents	5 (8)
Makes art (paints, decorates, makes things fashionable)	3 (5)
Communicates	2 (3)
Makes (a thing / model / improve / shapes things)	1 (2)
Subtotal	***31 (51)***
Other ideas associated with designers (49%)	
Skills of designers (*creativity, imagination*)	22 (36)
Examples of things designers design (lessons, curriculum)	4 (6.5)
Designs for a purpose (to build the character of a child)	4 (6.5)
Subtotal	***30 (49)***
Total	***61 (100)***

Like students in the present study, a few teachers also produced tautological responses for this question by just writing *'design'*. This perhaps stems from two plausible reasons. Firstly, in the English language, the word 'designer' is an extension of the word 'design'. It is a proper English if one says that 'a designer designs', just as one might say that 'a teacher teaches'. Thus even teachers did not find it inappropriate to give a tautological response. Another reason could be students' and teachers' limited understanding of the activity of designing.

Teachers' tautological responses to this question correspond to what they said in the previous question. Their responses were found to be more homogenous with regard to the skills associated with designers. They associated only two skills very strongly with designers, creativity and imagination. No other skills were mentioned by teachers besides these two. Even the examples cited by teachers as things that are designed were similar to what they revealed in the previous question, that is, lesson plan and curriculum. A few also mentioned dresses as product of design.

The interesting feature about teachers' responses was the remarkable similarity evident in their responses. Almost all of them associated design very much with their own profession of teaching and gave examples of designed things pertaining to their own profession, such as lesson plan and curriculum. This is not surprising since teachers indeed need to plan their lessons for effective learning. The responses also revealed that most of them laid great emphasis on the ideation phase of designing. They believed that designers come up with many ideas. However, none of them mentioned how those ideas could be realized and evaluated or tested.

C. Designers' responses

In response to the above question, designers came up with elaborate descriptions about designers. All of them tended to give the skills and knowledge that a designer has or needs to have. For example, the product designer emphasized the skills of observation and of being open to different sources of ideas for inspirations and influences,

'A designer is open to impressions; open to observations…A designer has to be like a sponge, has to absorb all influences. It's not like you need to know only these, but you have to know everything because you are designing for humans and humans are all kinds. So you have to absorb from all types, every surfaces. 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.'*

Using the analogy of bees and cross pollination, this designer considers the diversity of influences and inspirations from other fields (design or non-design) as of utmost importance for designers. The idea of influences and integration of disciplines in designing is well known. Several theorists such as Buchanan (1992), Owen (1991), Friedman (2003) have emphasised the integrative nature of design discipline and suggest that designers need to be able to reach across different disciplines, bring in information, extract ideas and think critically from the viewpoints of many.

For the user experience designer, however, the skills of visualization and intuition were most important. According to him, a designer is one *'...who could visualize and could possibly apply intuition with care.'*

For the architect too, a designer is one who is human-centric and optimistic while designing. He stated that a designer is one who,

'…intentionally reorganizes, alters, changes, rearranges with the concern for future. There is always a certain hopefulness in design. It is very structural. For example you cannot make a building design for people to be sad. There is always a certain positive aspect associated with building design. So it is very hopeful.'

This designer's view was essentially different from what the others suggested. He considered all designing as redesigning, improving or restructuring and argued that invention or 'creating something new' was actually a myth in design. Designers, according to him, are always improving the conditions or the present state through new combinations of solutions that already exist. This view is quite common in the design research literature (Goel and Craw, 2006). Michl (2002), for example argues that no design can start from a scratch; designers always start off where other designers (or they themselves) have left off and that design is always about improving earlier products.

3.9.1.3 Can animals design?

In this sub-section of the questionnaire, respondents were asked the questions, 'Can animals design?' and they had to justify their stance.

A. Students' responses

Of the 471 (88%) students who responded to this question, a majority (65%) denied that animals can design while 35% stated that animals do design. Students' denial could be attributed more to the responses from the ESS, where only 17% stated that animals can design as opposed to MSS where around 50% stated that animals could design. This difference was significant at [χ^2 (1) = 43.994, p = .000]. There was not much difference between boys' and girls' responses to this question.

i. Supporting design by animals

When asked to justify their stance, only 264 students (50%) provided adequate justifications for their respective stance. On the whole, 329 justifications were provided by all the students; 171 in support of animal designing and 158 against animal designing. The number of reasons provided in support of animals designing is more compared to those against animal designing although more students disagreed with animal designing. This is so since the number of ideas per student in support of animal designing is more than that against animal designing. The justifications in support of animal designing (171, 55%) were as follows.

Table 3.10: Students' justifications for why animals can design

Reasons for design by animals	***ESS No. (%)***	***MSS No. (%)***	***Boys No. (%)***	***Girls No. (%)***	***Total No. (%)***
Make their own shelters	6 (29)	64 (43)	34 (42)	36 (40)	70 (41)
Make patterns with paws/footprints	7 (33)*	23 (15)*	16 (20)	14 (16)	30 (18)
Have creativity/ imagination/ can work with materials	0	19 (13)	7 (9)	12 (13)	19 (11)
Have patterns on bodies	5 (24)*	10 (7)*	7 (9)	8 (9)	15 (9)
Design but people are not observant/ design to an extent	0	9(6)	4 (5)	5 (6)	9 (5)
Have brains/ common sense/ intelligence	1 (5)	8 (5)	4 (5)	5 (6)	9 (5)
Design indirectly since people get ideas from them	2 (10)	6 (4)	4 (5)	4 (4)	8 (5)
Plan for a living/ hunt/defend	0	6 (4)	2 (2)	4 (4)	6 (4)
Humans have evolved from apes, so design is evolutionary	0	3 (2)	2 (2)	1 (1)	3 (2)
Nature itself is a designer	0	2 (1)	1 (1)	1 (1)	2 (1)
Total	***21 (12)***	***150 (88)***	***81 (47)***	***90 (53)***	***171 (100)***

Thus, as seen from Table 3.10, the justifications provided most often in support of animal designing was based on the shelters that animals make for themselves (41%). Birds were most often cited by students to support their idea followed by other animals like rodents, ants, spiders and termites.

About 18% of the justifications were based on the fact that animals make footprints marks on the ground which students considered as design. A few students stated that by leaving footprints on the ground, animals design albeit unconsciously.

Few students also ascribed creativity, imaginative skills and feelings and emotions to animals. These they considered were required for designing. About 9% of the justifications were based on the different patterns found on the bodies of animals like cheetah, tiger and zebra.

Students acknowledged that animals had brains (5%) and thus they could design to some extent. A few students also reported that although animals might be designing in their own world, humans might not be aware of or observant enough to notice this.

A few students assigned designing abilities to animals on the basis of continuity of evolution. They believed that since humans have evolved from apes and ancient humans designed, so animals too have designing abilities or might develop this ability in the near future. In this context, Cross (2006) in his attempt to justify design as a form of intelligence argues that just as other forms of intelligences, design too has developed through evolutionary antecedents, which is evident in the home-building activities of and tool use by animals.

a) Gender

Girls in general produced more justifications (53%) than boys (47%). There were slight differences in their nature of reasoning. While boys produced slightly more number of justifications based on the animals' home building and pattern making capacities, girls provided more examples of skills associated with animals which help them in designing.

d) Grade

A cross-tabulation of younger and older students revealed major differences in their quantity as well as quality of justifications. While ESS produced only 21 ideas (12%), MSS produced 150 ideas (88%) in support of animal designing. The lack of responses from ESS is perhaps sign of their difficulties in expressing their ideas or thoughts. Interestingly, however, it was found that younger students (33%) more than the older ones (15%), considered that animals could design on the basis of their ability to make patterns with their paws. This difference was found to be significant [χ^2 (1) = 10.041, p = .000]. More ESS (24%) than MSS (7%) also ascribed designing abilities to animals on the basis of patterns of marks present on their bodies. This difference was also found to be significant [χ^2 (1) = 13.087, p = .000]. These differences in the reasoning patterns of ESS and MSS reflect younger students' lack of understanding about the nature of design and their strong association of design with pattern making and decoration.

e) Students' Interview Responses

In the interview also most students cited home building activities and pattern making with paws as evidences of designing abilities among animals. Those students who considered design as drawings in the earlier responses were asked why they chose animal home-building activities as designing. One of the students, SG4 revealed further, her ideas about design,

'Design is not only drawing but also creating something new. So animals are creating something new only. For them it is design.'

Students were also questioned about 'newness' in animal designing. For example, when students who supported animal designing, was presented with the examples of weaver birds' nests which look the same for all the weaver birds, a few of these students said,

'...but they design in their own way', or *'...it can be same and made with the same kind of twigs, still it is design'* or *'a bird might think that her nest is not as good as the other birds' nests but it still is new for her.'*

In the interview as well as in the survey, students did not seem to consider originality of design as an important element in animal designing. That all animals of the same species make similar kinds of homes was not considered relevant for animals.

Those who supported animal designing were also asked whether animal designing was different from human designing. Students said that human designing was more advanced than animal designing and one boy student (SB4) said,

'The shelters built by animals are small, temporary and not long lasting while the shelters by humans are very strong and can survive for a longer period of time'.

A few students also asserted that animals used limited materials available in nature while humans used a variety of materials to make their homes. One student revealed his thoughts about the triviality of design in human life as opposed to its significance in animals.

'Animals design to satisfy their basic needs whereas humans design to satisfy their luxurious desire'.

While supporting design from the evolutionary perspective, one student argued,

'… In future animals can design because man has also evolved from them and they can

design, so animals can also evolve and design things.'

ii. Not supporting design by animals

Overall, 158 ideas were provided by all the students who did not support animal designing. The characterization of the responses further exposed students' ideas of design and designers in general. Students provided a number of justifications for not considering that animals can design.

Table 3.11: Students' justifications for why animals cannot design

Reasons for why animals cannot design	***ESS No. (%)***	***MSS No. (%)***	***Boys No. (%)***	***Girls No. (%)***	***Total No. (%)***
Have no thinking ability/common sense	0	36 (23)	23 (26)	13 (18)	36 (23)
Have no knowledge/ capability of design	0	32 (20)	17 (20)	15 (21)	32 (20)
Have no hands/have four legs/cannot hold a tool	0	30 (19)	16 (18)	14 (20)	30 (19)
Have no creativity /imagination/drawing skills	0	24 (15)	13 (15)	11 (15)	24 (15)
Have small brains/no brains	0	19 (12)	10 (11)	9 (13)	19 (12)
Do not use objects/have no materials/technology	0	11 (7)	6 (7)	5 (7)	11 (7)
Not hardworking/no patience	0	4 (3)	1 (1)	3 (4)	4 (3)
Cannot communicate	0	2 (1)	1 (1)	1 (1)	2 (1)
Total	***0***	***158 (100)***	***87 (55)***	***71 (45)***	***158 (100)***

The most dominant reason provided by students for not supporting animal design was the lack of thinking ability or common sense in animals (23%). This suggests that these students considered design as an intellectual activity requiring reasoning and common sense. The next second most frequent justification by students was the lack of knowledge of design or the capability to design in animals (20%), which they considered was indispensable for designing. These students seem to consider design as dependent on knowledge and capability which can be developed through training or education.

Students also noted that animals either have four legs (like dogs) or only two legs (such as birds) but no hands and this limited their ability to design (19%). Students suggested that the lack of hands limited animals from manipulating and holding tools like humans do. It also limited them from developing drawing and writing skills. This suggests that students did not consider design solely as a minds-on activity but acknowledged the importance of hands-on manipulation as an important aspect in design.

Other skills which students considered missing among animals were creativity, imagination or *'having many ideas'* (15%) and the small size of animal brains (12%). Though some students acknowledged the presence of brains in animals, they suggested that *'big brains'* like humans were lacking in animals and this constrained them from designing. Some ideas also pertained to the lack of technology or limited availability of materials to animals as inhibiting them to design (7%).

a) Gender

Although boys in general provided more justifications (87, 55%) than the girls (71, 45%), no significant statistical difference was found. However, more boys than girls considered the lack of thinking ability among animals while more girls regarded lack of hands in animals as limiting them to design.

b) Grade

None of the ESS strived to explain why animals could not design while a variety of reasons were provided by MSS. This can be attributed to either their lack of an understanding of design or their limited ability in expressing their thoughts on paper.

c) Students' Interview Responses

During the interviews a few students exposed their understanding of the nature of design as being god-gifted. For example, a girl student (SG5) said:

'They have not got that blessing of God. They have four feet, I mean, two hands but they can't design something new….they don't have hands and they can't express themselves like us.'

SG5 emphasized the lack of hands for manipulation, as a reason which limited animals from designing.

All the students who stated that animals do not design were presented with examples of animals that make their shelters, like birds. All of them tried to justify their responses by suggesting that

'…they don't have materials like us; they make their nests from the wastes such as twigs and sticks' or *'…their nests are not so perfect like our houses. The nest might fall in the wind.'*

Only 1 girl student (SG6) attempted to justify her stance on the basis of the actual practice of design among design professionals.

'They (birds) make their nests for themselves but human designers design for others and they get paid for designing that thing. Animals do not design for others. It is an occupation for us.'

A few students (2) also demonstrated a tendency to change their responses from 'Yes' to 'No', after being presented with the examples of home-building activities of birds. However, a few others (2) resorted to a mid way approach by still maintaining that animals did not design but included exceptions in their justifications, such as *'some animals design but not all.'*

B. Teachers' responses

While responding to the question on animal design, 23 teachers (68%) agreed that animals design while 11 teachers disagreed that animals could design. All the teachers came up with some justifications (Table 3.12).

Table 3.12: Teachers' justifications for why animals can / cannot design

Justifications for design by animals (70%)	***Total ideas Nos. (%)***
Make their own shelters	17 (46)
Make patterns with paws/footprints	5 (13)
Plan for a living/ hunt/defend/learn to fly	4 (11)
Justifications for why animals cannot design (30%)	
Have no thinking ability/common sense	8 (21)
Have no knowledge of design/no capability of design	1 (3)
Do not use objects/have no materials/technology	1 (3)
Cannot communicate	1 (3)
Total	***37 (100)***

About 70% of the reasons given by teachers were in favour of animals designing while, 30% reasons were against designing by animals. Unlike students who had come up with several reasons, teachers gave only a few reasons justifying their stance which again indicates the homogeneity in their responses.

As seen from Table 3.12, most justifications given by teachers were similar to the reasons provided by students and pertained to the examples of home-building activities of animals as suggestive of their designing abilities. A little less than half of the reasons (46%) were related to this stance. Surprisingly, like students, even teachers came up with explanations of artistic expressions shown by animals with their paw or limb prints. At least 19% of the ideas were based on this. The fact that footprints or limb marks were left unintentionally by animals and which can even be created inadvertently by humans were somehow missed or ignored by both students and teachers. However, a few teachers justified their stance by suggesting that animals might design but they may not be consciously aware of their own capacities. Lastly a few teachers thought of animal designing in terms of their hunting and defending strategies.

About 30% (11) of reasons were given by teachers for why animals do not design and the most dominant one was the lack of basic common sense and thinking faculty in animals. A few teachers also acknowledged the lack of knowledge of design in animals, their inability to use materials and communicate.

C. Designers' responses

Two of the designers (animation designer and visual communication designer) suggested that animals do not design while 3 of them said that animals could design. The latter mostly justified their responses 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.

The designers differed from students and teachers in that none of them considered paw prints or patterns on grounds as design. Unlike students, none of the teachers or designers considered designing by animals by ascribing any designing skills (such as creativity, imagination) to them. However, unlike designers, some students and teachers considered hunting and defending by animals as designing or planning strategies.

The Product Designer's argument in favour of animal design was as follows:

'Yes. In some sense, because the monkey also uses a twig to bring out ants and eat then that is observation and application of that knowledge for something so...Yes animals can design; not in our classical definition of design like hold a sketch book and come up with multiple ideas and iterations but maybe their design is different because unless you apply your mind to something; a conscious decision to act you are not evolving. For the higher organisms; creatures who have some hands or appendages by which they can manipulate objects around them, they are probably able to manifest design in a better way like a monkey can do that a fish you know cannot do that…For any creature if it is able to come up with some solution for its survival, is designing, is behaving creative. So in essence it is design somewhere. But there are non-overlapping spaces also. They are many overlaps. What animals do is also design but it is not completely design in our definition. But, yes they do design to some extent.'

When counter-argued by the researcher that animals were programmed to behave in similar ways and their work of design displayed no variations and creativity, the product designer broadened her notion of design as a problem-solving process and included the problem-solving behaviours shown by animals as design.

'They are doing design by some definition of ours like by adapting to the environment. Trying to improvise on what they have…There is a difference [between animal and human designing]. They are doing problem-solving. We, as designers, are doing creative problem-solving. 'How about this' and 'how about that' do not happen in them. If they get one solution, it's ok for them. They will probably not try multiple solutions just to come up with the best thing. It will be more linear. Like if I do something and if it is not working then I'll try to improve on that something. For designers we spread; we look for multiple ideas. It is not necessarily one way. That's why it takes time. Animals do not have so many tools and such a knowledge base... We don't have to start from reinventing the wheel, but don't know about them; how much knowledge is passed down to the next generation. And if that knowledge base is already sound, then naturally they'll progress.'

Similarly when the architect was counter argued that animals do not show any variations in their design, he suggested that animals might have certain signatures or individual styles which perhaps humans are unaware of.

'...at least from the outside this (individual variation) is not visible. You can make out a weaver's bird's nest from other birds' nests, but you cannot find out if there are individual signatures on each of the weaver bird's nests. When a female birds comes to the nest she is able to make out what is a good nest and what is a bad nest. So probably within them they might be having signs which they exchange and all.'

This idea also gets reflected in some of the students' justifications provided in support of animal designing.

On the other hand, the VC designer who denied designing by animals argued in the following manner:

'Animals are hard wired to adapt themselves to an environment. They are not given sufficient faculties by nature to affect their environment with some free will which only humans can do; faculties that is lacking is will for making variation, for option and making choices. For example, they cannot imagine that the same function can be done by another object. Gorillas have been known to use sticks to take out ants from hills, but they have not improved the design of the sticks; they are still in the process of using the sticks, which again has been given to them through evolutionary process. It is not that the generations of gorillas have changed or will change the process of using the sticks.'

The animation designer was reluctant to take any stance on animal designing. However, when pushed by the researcher, she denied that animals could design. Just as the VC designer, she also believed that animals were programmed to make homes/shelters. According to her, animals do not think before making homes; they do not *consciously decide* upon the different materials and *be sensitive* to their environments while building homes.

It is interesting to observe that students' and teachers' responses of home building activities get reflected in designers' responses as well. Also, while designers considered a very holistic view of design for any creation by human beings, they attributed designing ability to animals on the basis of mere tool use and their capacity to 'make' something.

The subsequent questions are not applicable to the ESS students since these were not included in their questionnaire.

3.9.1.4 Design in different Indian languages

According to Balaram (2006) an attempt to define 'design' in Indian languages is an awesome task since the word 'design' has many meanings and past and present associations in India. The task is huge not just because of the numerous Indian languages but the manifestation of design in more than one area of Indian living and production. Thus the intricate floral patterns made outside home as auspicious welcome signs are traditionally considered as designs; an intricate decorative border of a sari is design; a piece of jewellery is design.

This section presents the meanings of the word design in various Indian languages as provided by the participants. Although the analysis has been presented separately for the three samples, the subsequent table presents the equivalent words for design produced by all of them.

Table 3.13: Indian words for 'design' by students, teachers and designers

Indian words for 'Design'	*Students*	*Teachers*	*Designers*
Work of art/ art (*kala*-Hindi, Marathi, Bengali, Gujarati, Oriya etc, *kalai*- Telugu)	417 (77)	22 (51)	0
Paintings/ drawings (*chitra, chitrakari, chitrakudu, aakriti*)	42 (8)	2 (5)	0
Creativity/ skill/ talent/ interest (*hunar, kaushalya, guun, lagan*)	24 (4)	9 (21)	0
Pattern (*rangoli, alpan*)	16 (3)	1 (2)	0
Beautiful/ beauty/ attractive/ decoration (*sundar, sundarta, aakarshik, khoobsurat, sajawat*)	15 (3)	0	0
Plan/ framework/ frame (*namuna, naksha, nakshika, nakshi, abhikalpana*)	7 (1)	6 (14)	3 (60)
Making/ make (*banana, banawat*)	6 (1)	0	0
Creation/create (*aavishkaar, nayi khoj, shristi*)	5 (1)	2 (5)	0
Designer/ artist (*kalaka*r)	6 (1)	0	0
Fashion	2 (.4)	0	0
Architecture (*vastushastra*)	2 (.4)	0	2 (40)
New idea (*nayi vichar*)	0	1 (2)	0
Total	***542***	***43***	***5***

A. Students' responses

When asked to give as many words for the word design as they could think of in different Indian languages, 253 (74%) students wrote different Indian words for the word 'design'. The total number of meaningful words produced by these students was 542 with an average of about 2 per student. Most words were in Hindi, the Indian National language and Marathi, the language of the State of Maharashtra.

As seen from Table 3.13, 77% of the words generated by students were 'art'/artwork or its counterparts in different Indian languages such as the word *kala* and *kalakari*, *kalakriti* in Hindi, Marathi, Sanskrit, Bengali, Oriya, Malayalam, Telugu etc.

Other words produced by students for the word design were paintings/drawings and its counterparts in different Indian languages such as *chitra*, *chitrakari*, *chitrakudu*, *aakriti* (8%), creativity/skill/talent/interest and other equivalent words in Indian languages such as *hunar, kaushalya, guun, lagan* (4%).

As seen from Table 3.13, 1% of all the words were related to plan. About 3% of the ideas were related to the words like 'attractive' or 'beautiful' and its related counterparts in Indian languages like *sundar, sundarta*, *khoobsurat, aakarshik* or *sajawat* in Hindi.

As found in the previous questions, students mostly associated design with art or artistic work. A plausible explanation for the fact that most students came up with the word art or beautiful and their counterparts in Indian languages, could be that students lack the Indian vocabulary for the word design or are unfamiliar with the Indian equivalents of design. In India the word design is used colloquially as ‘dezine’ or ‘deejain’.

B. Teachers’ responses

Of all the teachers, 30 responded to this question. On the whole 43 words were generated. About 51% of the words were related to ‘art’ and its counterpart in Indian languages. Thus fewer of the words given by teachers as compared to students (77%) were related to art. About 21% of the words were also associated with skill/creativity and its synonyms in Indian languages like *hunar* and *kaushlaya,* while 14% of the words were related to the word plan such as *namuna, nakshika*. Teachers also came up with the word of *shristi* in Hindi which means ‘creation’.

C. Designers’ responses

Designers came up with only 5 words, one by each designer. However, interestingly only 2 words were generated by the designers: *abhikalpana* which means planning and *vastushastra* which is an Indian terminology for architecture. None of the designers suggested the words that were suggested by either students or teachers. Thus words suggested by designers in comparison to lay people were more technical and limited.

3.9.1.5 Design in school subjects

A list of 20 co-curricular school subjects was provided to the respondents in the questionnaire. Students were asked to list the first three subjects that they would *prefer to* *learn* while teachers were asked to list the three subjects that they would prefer *to teach*. The question aimed at probing students' and teachers' interests in learning/ teaching these co-curricular subjects. Respondents were then required to indicate the subjects that they considered were related to design or which involved designing. The same list was also provided to the designers who were only asked to indicate through a tick mark the *subjects which they thought were related to design* or *involved designing*.

A. Student's and teachers' responses

The responses of students and teachers have been presented together. However, there is no intention to compare the two samples through statistical means since they were not comparable.

i. Subjects: Students' and teachers' preferences to learn / teach

Students chose the three co-curricular subjects which they wanted to learn. Table 3.14 indicates that computer education was the subject that most students (24%) wanted to learn. The other subjects besides computer education, which students opted for, were photography, drawing, music, painting, flower decoration, cooking handicraft, pottery and drama. Library management, block printing, book binding needlework, knitting and tailoring were the subjects selected by students least.

Teachers showed some similarity to students in the subjects they would prefer to teach. These were flower decoration, computer education, photography, music, painting, drawing, cooking, handicraft, drama and candle making. Table 3.14 depicts a comparison of the top ten subjects selected by both the samples. As evident from the table, their preferences show striking similarities and except the two subjects, pottery (selected by students) and candle making (selected by teachers), the eight other subjects have a priority in each of the sample's top ten lists. The only difference, however, lies in their order of preferences. Thus while most teachers prefer to teach flower decoration (which is sixth in students' list), most students prefer to learn computer education, which is second, in the teacher's list.

Table 3.14: Students' and teachers' preferences to learn/ teach co-curricular subjects

Top 10 subjects students prefer to learn (%)	***Top 10 subjects teachers prefer to teach (%)***
Computer education (24)	Flower decoration (32)
Photography (23)	Computer education (27)
Drawing (22)	Photography (27)
Music (15)	Music (27)
Painting (15)	Painting (27)
Flower decoration (14)	Drawing (24)
Cooking (13)	Cooking (24)
Handicraft (13)	Handicraft (24)
Pottery (11)	Drama (24)
Drama (10)	Candle making (21)

These similarities of interests have important implications for teaching and learning. What can be the best when teachers prefer to teach most of those subjects, which students prefer to learn the most.

a) Gender

When boys and girls were compared for their preferences through gender wise cross tabulation, significant differences were observed for subjects like *basket weaving* [χ^2 (1) = 9.778, p = .002 at 5% significance level], *candle making* [χ^2 (1) = 9.441, p = .002 at 5% significance level], *flower decoration* [χ^2 (1) = 15.143, p = .000]. More girls than boys preferred to learn these subjects. However in case of computer education, the number of boys preferring to learn this was significantly higher than the number of girls [χ^2 (1) = 30.896, p = .000]. This finding on boys' preferring to learn computers more than girls is rather a global phenomenon. Light and Littleton (1999) for example, have reported the findings from various research studies suggesting that more girls than boys have negative attitude towards computers right across the school age range. An international comparison by Reinen and Plomp (1994) also suggests that consistently across all countires, girls were found to report '*having more difficulty in understanding and using programs*' and enjoyed using the computers less than males.

ii. Subjects: Students' and teachers' association of subjects with design

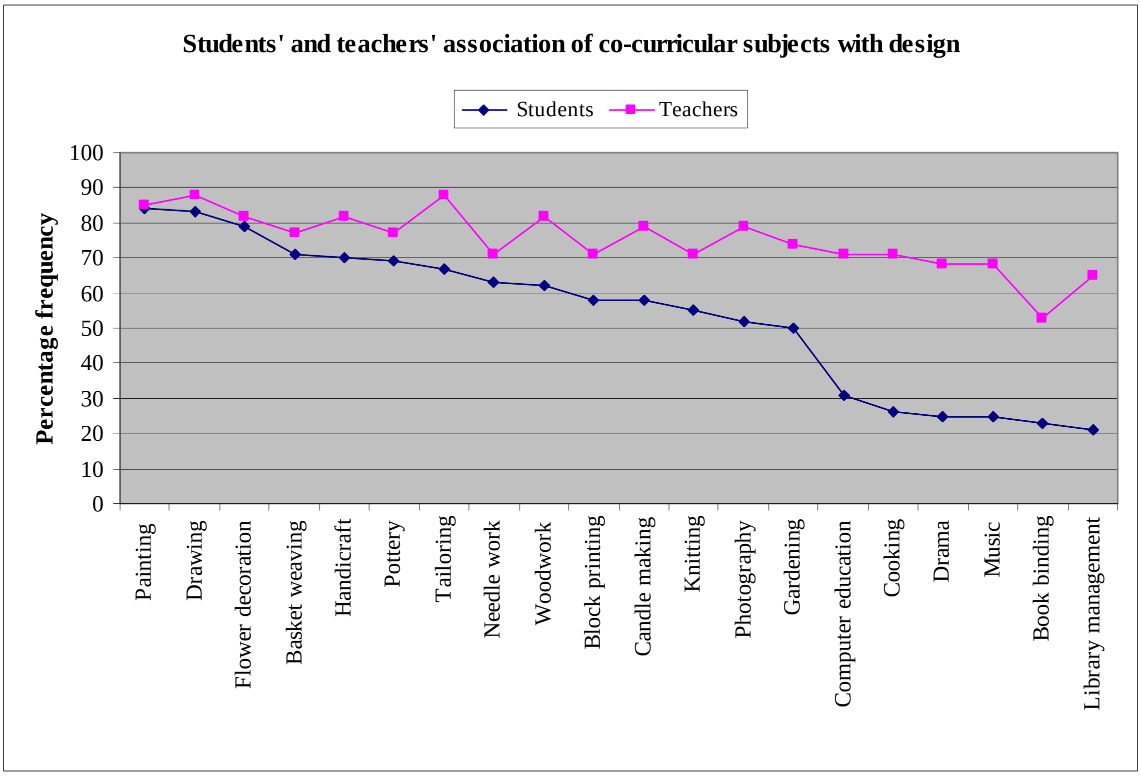
Students were then asked to indicate those subjects which they considered were related to design. Students showed varying level of associations of these subjects to design and they rated some subjects as designerly more often than other subjects. The top five subjects that were most frequently associated 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.

The researcher would like to clarify her stance regarding the 'designerly' nature of these subjects. As pointed out by Thomas and Carroll (1984), design problem is not a *type of problem* but it is *a way of looking at a problem*. In that sense, any activity can be looked at as a design activity. In contrast any typical design activity can also be viewed as non-design if say, the designer has a fixed sets of rules which she applies to the problem. Thus there is nothing inherently designerly about each of these subjects. Providing an authentic problem-solving context to each of these activities can facilitate designerly behaviours among students while they are engaged in these activities. In contrast removing the context from each of these activities can make them recipe-based, repeatable and mindless subjects. The researcher believes all these subjects have the potential to foster design thinking among students if set within an appropriate problem-solving context.

The aim of the question was to explore the criteria that students employ while categorising these subjects as designerly or non-designerly. This would in turn, facilitate a deeper insight into their thinking about design.

As seen from Graph 3.1, both students and teachers considered some subjects as more often related to design than the other subjects. The top 5 subjects which were rated as designerly by students were painting, drawing, flower decoration, basket weaving and handicraft, while the bottom 5 subjects were cooking, drama, music, book binding and library management.

Graph 3.1: Students' and teachers' association of co-curricular subjects with design



The interesting differences between the top 5 and bottom 5 subjects are 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 endeavour. In 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 or organization (drama, music, library management) and require a more ‘design as a planning’ approach to characterise them as designerly activities. The top 5 subjects, on the other hand, have tangible products resulting from hands-on activities and students perhaps applied a ‘design as making’ approach to them while responding to these items. These students who seemed to have a more ‘design as making’ approach to design (as evident in the earlier responses) categorised the bottom 5 subjects as less designerly. The analysis of students’ interviews provided a glimpse of the nature of their thinking.

a) Gender

Gender wise cross tabulations analysis revealed that for almost all these subjects, boys and girls showed similar associations. No significant differences were found to exist between male and female students' responses in associating different subjects with design.

b) Students' Interview Responses

During the interview, students were probed for their reasons of why they considered particular subjects as related to design and others as not related to design. A number of justifications were provided by the students. As mentioned earlier, some of the subjects were considered designerly more often by students. For example, subjects such as painting, drawing, flower decoration, basket weaving, handicraft, pottery, tailoring, needlework were considered more designerly while subjects such as library management, book binding, music, drama, cooking, computer education, gardening and photography were considered less designerly. Analysis of students' responses in the interview revealed that they had characterized the subjects based on some characteristics such as whether the subject or the activities involved with it (a) requires sketching or drawing (b) results in a tangible product, (c) requires moulding of shapes, (d) requires skills to undertake them, (e) requires making patterns, (f) has aesthetic appeal and (g) needs planning to undertake them. For example, the extra-curricular activity of basket weaving was categorized as designerly by many students because it involved either (b) making a tangible product, like basket, (c) giving shapes and sizes to the basket, (d) requiring specific skills, such as cutting thin strips from bamboos, (e) making different patterns with strips or colours, on the prepared basket (f) rendering aesthetic appeal to it, and (g) requiring thinking or planning before making them. These are the overall categories generated by students in the interviews.

Not all the students used all the categories in their reasons. Each student generated either one or more than one of these criteria to categorise a few or all of the subjects. For example, SB2 considered painting and drawing designerly because they both involved either sketching/painting (a). Basket weaving, candle making, handicraft, pottery, tailoring and woodwork were related to design because they all involved making tangible things (b) or moulding into different shapes and sizes (c). Flower decoration and gardening was related to design by him because they both involved giving shapes to the flowers and plants by cutting them (c) and making them look attractive (f). Furthermore, he considered block printing and needlework as designing activities since they both involved making patterns on them (e). The analysis thus revealed that students kept modifying their criteria as the subjects changed. Only one student had one fixed criteria of ‘thinking or planning’ before making or executing which she applied to all the given subjects.

When probed for why students had not selected certain subjects as related to design, interesting ideas about design came to light. For example, SB1, when asked why he did not consider ‘cooking’ as designing, he responded in the following manner,

‘It has variation, but it does not involve design. We can make different types of food but they are not related to design because we are going to eat it only, we are not going to showcase that item anywhere.’

SB2, when probed for not selecting library management and music responded in the following way,

‘No. They are not related to design. Because they are just to entertain people. We don’t design in that.’

Subjects such as drama, library management, music, cooking or gardening which involve planning were usually regarded by students as non-designerly. For cooking and gardening, except for a few students, all the students who perceived them as designerly considered their end products of design and not the process of cooking or gardening. This means that most of them considered these subjects as designerly only to the extent that they involved ‘garnishing the food’ or ‘cutting the plants to give them beautiful shapes’ respectively. Only 2 students thought they were designing activities because they involved planning and experimentation.

B. Teachers’ responses

Teachers on the whole associated most of the subjects with designing. They did not show any specific association of any subjects with design. As indicated in Graph 3.1, only a few subjects such as book binding and library management were considered less designerly than the others. Teachers’ selection of most subjects as related to design could perhaps be due to their more ‘planning’ approach to design, as evident in their responses to the first two questions in the questionnaire. This could also be due to their more and varied experiences which instigate designing or planning approaches to solve the problems in real world.

C. Designers' responses

Designers' responses to this question were also homogenous as were those of teachers'. However, unlike students, all the designers considered the nature of approach to each of the subjects as very important for considering them designerly. All stated that any of the given subjects that required a conscious thought and planning could be related to design. For example, the product designer gave importance to the problem-solving approach to each of the subjects and suggested that each of the subjects could become designerly if there was problem-solving happening in these. She acknowledged that if students have to go by any rule while doing the activities in each of the subjects, they would no longer be designerly.

Laying emphasis to the context, the architect highlighted its importance in the following way:

'I think, the challenge in design would come in when the context is new. And each time the context becomes new, you can't repeat the same thing. So even if you pick up a skill, the context demands that you always rethink your skills. So if you pick up basket weaving skills, you will keep weaving the same baskets. But if a context is provided in an activity, all of these will fall into design…Every subject has the potential for design, except that the way it is done, it becomes a kind of rote learning. So I think any of the subjects, including even English literature can have design learning potential if it is taught in that way. All of these are skills, but the moment you put it in a context, design will start happening.'

3.9.1.6 Design occupation and gender suitability

A list of 18 design related occupations were provided and respondents were required to suggest whether each of these occupations were suitable for females, males or both. While the analyses of students' and teachers' responses have been presented separately, their quantitative responses have been presented together in Table 3.15.

A. Students' responses

As seen from Table 3.15, there were some occupations which were considered by students as suitable for both, some which were suitable only for girls and some suitable only for boys. Occupations such as computer engineering, painting, architecture, product designing, civil engineering, electronics engineering, teaching and graphic designing were considered suitable for both, by most of the students. However, occupations like cooking, fashion designing and jewellery designing were considered suitable for girls by more students.

This finding is consistent with findings in the literature where fashion designing was associated mostly with females by students (Knipe, Leith, Gray, McKeown and Carlisle, 2002; Michelson, 1989). Similarly, Razumnikova (in Calvanese, 2007) have also reported that occupation of a cook is considered to be associated mostly with females.

Table 3.15: Students'/ teachers' responses to gender suitability for design occupations

Occupations	***Suitable for girls (%)***		***Suitable for boys (%)***		***Suitable for both (%)***	
	Students	***Teachers***	***Students***	***Teachers***	***Students***	***Teachers***
Computer engineering	5	0	12	0	**83**	**100**
Painting	19	0	6	3	**75**	**97**
Architecture	3	0	28	9	**69**	**91**
Product designing	18	3	18	6	**64**	**91**
Civil engineering	**0**	**0**	38	38	**62**	**62**
Electronics engineering	4	0	36	27	**60**	**73**
Teaching	**40**	18	1	0	**59**	**82**
Graphic designing	21	6	20	6	**59**	**88**
Textile designing	19	3	30	15	**51**	**82**
Tailoring	**35**	6	19	0	46	**94**
Mechanical engineering	2	0	**50**	**50**	48	**50**
Interior designing	**41**	21	16	0	43	**79**
Automobile designing	7	0	**47**	**56**	46	44
Pottery	10	9	**48**	18	42	**73**
Cooking	**65**	21	1	0	34	**79**
Fashion designing	**66**	24	1	0	33	**76**
Jewellery designing	**67**	29	8	6	25	**65**
Carpentry	1	0	**91**	**82**	8	18

An interesting thing to note is that while in India, it is women who usually cook at home, outside it is mostly men who are found to be cooks/chefs in restaurants and eateries. In the interview a few students gave explanations regarding this anomaly by suggesting that although men pick up the profession of cooking outside home, as an acitivity cooking is more suitable for women because they are '*better cooks*'.

There were also some occupations which were considered more suitable for boys by many students namely, carpentry (91%), mechanical engineering (50%) and automobile designing (47%). This finding is also consistent with findings in various studies where students have been found to associate engineering and carpentry mostly with males (Michelson, 1989; Khunyakari, 2008) and engineering with males (Knight and Cunningham, 2004; Fralick, Kearn, Thompson and Lyons, 2009; Karatas et al., 2010; Capobianco, Diefes-Dux, Mena and Weller, 2011). Perception of careers as being suitable for only one gender starts early in life and is evident at all age levels (Kuhn, Nash and Bracken, 1978). Previous studies in engineering education have found that engineering is among the most strongly gender-stereotyped of occupations (White and White, 2006).

Occupations such as teaching, tailoring and interior designing, although considered suitable for both, showed a tendency towards being more suitable for females since for each of these occupations, more than one-third of the student sample suggested that they were suitable only for girls. In India, the number of female teachers in urban schools is more than 50% in all the stages of education (DISE, 2008-09). Even in the school where the sample for this study was located, there were more number of female teachers than male teachers.

Again although many women do sew and stitch their clothes at home, tailoring as an occupation is moslty pursued by men. Thus there mixed responses where about 46% students think tailoring is suitable to both the genders while 35% believe that it is suitable to girls only.

Again, most parents of the students in this sample are provided accomodations in the residential complex. The layout of the rooms and interiors in these complexes are already set and built in and there are no scope of changing the interiors in the rooms. Thus it is assumed that students may not have interacted with or seen an interior designer. However, it seems that students perhaps know of interior designers from the media such as magazines, television, newspapers, or internet. Students showed a tendency to associate interior designing with women perhaps being influenced by the home-making activities of their mothers.

Furthermore, occupations such as civil engineering, electronics engineering and pottery which were considered suitable for both the genders reflected a tendency towards being suitable for males only since about one third of student sample suggested these to be suitable for boys only.

a) Gender

Gender wise cross tabulations among student sample revealed the existence of some stereotypes in students' responses. Most of the occupations were equally perceived by boys and girls as being suitable to a girl, to a boy or to both. However, significant differences were found to exist between boys' and girls' perceptions of 6 occupations such as architecture, computer engineering, graphic designing, mechanical engineering, interior designing and painting. For the first 4 occupations, more girls than boys tended to consider these as suitable for both the genders while more boys considered them as suitable for boys only. However, for interior designing and painting, surprisingly enough, more girls perceived it to be the feminine occupations while more boys considered them suitable for both.

b) Students' Interview Responses

Analysis of students' interviews revealed at least four reasons on the basis of which students considered a profession as suitable to boys, to girls or both. Firstly they considered that boys in general are better than girls in professions that involve 'complex tasks' such as taking measurements, performing calculations, taking decisions etc., while girls are better than boys in professions which involve 'simple tasks' such as beautifying things.

Research studies on occupational stereotypes suggest that occupations are described on several dimensions such as personality attributes, interpersonal interaction styles associated with each occupation (O'Dowd and Beardslee in Shinar, 1975). Students' reasoning matches with what Shinar (1975) suggests, that those occupations which are stereotypically associated with high levels of competence, rationality and assertion were perceived as masculine occupations, while those occupations which were stereotypically associated with dependency, passivity, nurturance and interpersonal warmth are considered as feminine occupations.

Both boys and girls provided this rationale for suggesting why occupations, such as architecture, civil engineering, mechanical engineering and electronics engineering are more suitable for boys; while occupations such as fashion designing, jewellery designing and interior designing were more suitable for girls.

Secondly, students provided the rationale that some occupations are more suitable to either a boy or a girl because of their growing interests in those occupations since their childhood. Thus they believed that boys like to play with cars and different mechanical toys since childhood and this leads to a development of interest in professions such as automobile designing and mechanical engineering respectively. Similarly girls play with dolls and houses; hence they develop an interest in fashion designing and interior designing respectively.

In this connection Rheingold and Cook (1975) reported that boys were found to have such toys like vehicles, toy animals, military toys, educational-art materials, sports equipment, and spatial-temporal objects. On the other hand, they reported that girls were found to have more dolls, doll houses, and domestic objects. Martin, Eisenbud and Rose (1995) reported that children often get communicated of the cultural stereotypes by explicit labelling of objects such as toys and activities (e.g. ‘boys like to play with cars’) though television, books, peers and adults and these labelling of toys as being for girls or for boys influences their behaviours such that it matches with the stereotypic expectations.

Thirdly, both boys and girls categorized the profession of carpentry as suitable to boys on the basis of the strength required in working with wood. Even researchers have found that physical strength has been used by people to stereotype occupations as suitable for either men or women (Shinar, 1975).

Fourthly, they considered some professions as suitable to either boys or girls since society reflected these occupational stereotypes. Thus they considered professions such as teaching and cooking more suitable to girls because they find more women as teachers and cooks (as housewives) in the society, while they see more men in engineering and carpentry. O'Dowd and Beardslee (in Shinar, 1975) suggest that one of the most common basis for defining an occupation as feminine or masculine is by assessing the relative proportion of men and women in that occupation. This is also reflected in students' reasoning for occupations such as engineering or carpentry etc. Indian society does reflect less women engineers and less enrollement of women in engineering in colleges (Velkoff, 1998; Parikh and Sukhatme, 2004). This trend has also been reported to be global (Nguyen, 2000).

B. Teachers' responses

As indicated in Table 3.15, teachers showed less stereotyping of occupations as compared to students, with teachers indicating many occupations as suitable for both the genders. However even teachers' responses were not completely free from stereotypes that were reflected in students' responses. For occupations such as carpentry, automobile designing and mechanical engineering, teachers like students, believed that these were more suitable to men than women. For carpentry and mechanical engineering, teachers like students, perhaps assumed these occupation to be more suitable to males on the basis of the requirement of physical strength needed to perform in them.

For other engineering occupations such as civil and electronics engineering, some teachers showed a tendency towards considering these as more suitable to males than females. On the other hand, for occupations such as jewellery designing, fashion designing, cooking and interior designing, some teachers a tendency to perceive these as feminine occupations.

An interesting point that was observed was that although most teachers (82%) regarded teaching as suitable to both the genders, there were about 18% teachers who perceived it as more suitable to females while none mentioned it was exclusively suitable for males, indicating teachers' own tendency to consider teaching as associated with women. Similarly for occupations such as cooking and fashion designing while about 20% teachers believed it to be suitable more to females, none mentioned that these were suitable exclusively to males, indicating again their tendencies to consider these professions with females. It is to be noted that most teachers in the teacher sample were females indicating that women actually considered these occupations as feminine.

C. Designers' responses

All the designers were reluctant to respond to the question on design occupations and gender suitability. They all agreed that occupations could not be segregated into feminine or masculine professions. Coming from the actual design fields and being strikingly homogenous in their responses, all of them agreed that each of the occupation was suitable to both men and women.

3.9.1.7 Students' occupational choices

Do students aspire a career in design? In the students' questionnaire, students were asked to indicate their future occupation or what they would like to become when they grow up. As seen from Table 3.16, about 9% of students did not respond to this question, while about 7% students provided more than one career options.

Table 3.16: Students' occupational preferences

Careers	*Total % (n=533)*	*Boys % (n=264)*	*Girls % (n=269)*	*ESS % (n=193)*	*MSS % (n=340)*
Engineer	23	**30**	17	14	**29**
Doctor	17	12	**23**	**21**	15
Scientist	9	**13**	6	**11**	8
Astronaut	8	**9**	7	**11**	6
Fashion designer/Model/Films	7	3	**12**	8	6
Multiple ambition	7	5	9	6	7
Pursue higher education	4	4	4	1	6
Officer/IAS officer/Manager	4	4	3	4	4
Teacher	3	0	5	6	1
Navy	3	4	1	2	3
Sports	3	5	0	3	3
Others (Businessman/ Artist/Lawyer)	3	3	3	3	3
Not mentioned	9	8	10	10	9

In the present sample, majority of the students wanted to become engineers (23%). This was followed by doctor (17%) and scientist (9%) and astronaut (8%). This finding on students' choice of engineering as their first career option is in contrast to the findings by Mehrotra (2008) where engineering was preferred by fewer students. This perhaps could be due to the fact that Mehrotra studied only younger students from Class 6 while this study comprised of both older and younger students. Even in this study more older than younger students aspired to become engineers.

A cross tabulation analysis of gender and career options revealed that more boys (30%) than girls (17%) wanted to pursue engineering, while more girls (23%) than boys (12%) wanted to pursue medicine. This finding is consistent with the findings by Mehrotra (2008) who also found that among Indian students, more boys than girls preferred a career in engineering (although both were less) while more girls preferred a career in medicine.

The other most favoured career options suggested by boys were scientist (13%), medicine (12%), astronaut (9) and sports (5%). Girls, on the other hand aspired to become engineer (17%), fashion designer/model (12%), astronaut (7%) and scientist (6%). Interestingly more girls (9%) than boys (5%) tended to prefer multiple career options.

While 5% of the boys preferred a career in sports, none of the girls considered so. The reverse was however true for the occupation of teaching wherein none of the boys aspired to become a teacher while 5% girls considered it as a career option. This reflects students' association of some careers more with males (such as sports) or with females (such as teaching). Interestingly, about 7% of total students expressed a desire to become fashion designers or models or work in films. This perhaps could be due to the influence of responding to a questionnaire on 'design', since for a similar question on career aspirations by other researcher (Mehrotra, 2008), students did not spontaneously suggest a career in fashion designing or modelling. Again from among the students opting a career in fashion or films, all the boys suggested they wanted to become film directors while none of the girls said so. Both girls and boys equally aspired to pursue higher education (4%).

A cross tabulation analysis across different classes revealed that more older students aspired to become engineers (29%) while more younger students (21%) expressed a desire to become doctors. Watson and McMahon (2005) cited several authors (such as Edwards, Nafziger and Holland, 1974; McCallion and Trew, 2000) who reported that children's knowledge about occupations become more detailed and comprehensive as they become older. In this study, the parents of most of these students were scientists and engineers. While younger students are familiar with what doctors do they might not be familiar with what an engineer does. Older students having a better understanding of engineering work as well as their parents' occupations, tended to prefer a career in engineering. This perhaps could also be true for occupations such as scientists and astronauts which were selected more often by younger students than the older ones.

More younger students suggested a career in teaching (6%). Since none of the boys had suggested becoming a teacher, it means most of these students were girls from the lower classes. Older students also wished to pursue higher education than younger students.

Students' suggestion of an occupation as stereotypically suitable to a girl or a boy in their responses to the earlier question also gets reflected in their career choices with more boys than girls choosing a career in engineering and science while more girls opting for a career in medicine, fashion designing and teaching. Looking at the range of career choices suggested by students, it becomes obvious that students have a very narrow choice of occupations.

3.9.1.8 Design and teaching occupation

A question was specifically designed for teachers to elicit their understanding of design in relation to their own profession of teaching. This question was not given to the students or designers. The question asked was, *'According to you, how much is the teaching profession related to design?'*

Teachers were required to indicate how much their profession was related to design ('very much', 'somewhat' and 'not at all'), and provide justifications for their chosen response. Of 34 teachers, 28 suggested their teaching profession was 'very much' related to design, while 6 of them suggested it was 'somewhat' related to design.

All the teachers provided justifications for their responses. These have been categorised and presented below in Table 3.17.

Table 3.17: Teachers' responses to why teaching is related to design

Justifications for why the profession of teaching is related to design		***Total (%)***
Very much	Teachers design lesson plans/activities	19 (56)
	Teachers mould children and their future	9 (26)
Sub Total		***28 (82)***
Somewhat	Teaching is creative	3 (9)
	Teachers teach art/craft	3 (9)
Sub Total		***6 (18)***
Total		***34 (100)***

As seen from the Table 3.17, all the teachers provided justification for why teaching profession involved designing. The dominant reason provided in support was teachers' roles as lesson planners and activity designers for students (56%). Indeed teachers need to develop effective strategies to ensure learning in the classrooms. For this teachers need to know students' past and present knowledge and achievement levels. Based on their knowledge, teachers then need to plan a road map of what students need to learn next and how they would accomplish that. They design appropriate learning activities and then devise strategies to evaluate students' learning. Not surprisingly, most teachers associated their profession strongly with design. Other rationales included teachers' role as builders of students' characters and futures. A few suggested teaching was creative without elaborating their ideas. A few considered only art or craft teachers' activities as related to design.

3.9.1.9 Design education in school

A question was exclusively designed for teachers and designers to find out whether they considered that design education should become a part of the school curriculum for students. Teachers were asked, '*Do you think design education should be a part of the school curriculum?* for which they were required to choose between the options of yes / no and provide justifications for their stance.

A. Teachers' responses

Of the 33 teachers who responded to this question, all of them agreed with the statement that design should be included in the curriculum. However, their reasons for including design education varied and are described below in Table 3.18.

Table 3.18: Teacher's justification for why design education should be in schools

Justifications for why design education should be a part of the curriculum?	***Total No. (%)***
It brings out the creativity/other aptitudes of children	9 (27)
It should be included for teachers to make teaching more effective	8 (24)
All around development of child	6 (18)
Learning will be fun and interesting	5 (15)
Students will get hands-on experience	3 (9)
Design process will help students in all fields later	2 (6)
Total	***33 (100)***

The main reason suggested by about one-third of the teachers (27%), for including design in the curriculum, was its specific role in facilitating the expression and development of aptitudes such as creativity and imagination. This is consistent with teachers' association of creativity and imagination with designers in their earlier responses on designers and indicates their understanding of design as essentially a creative endeavour.

Interestingly about 24% of the teachers suggested that design education should in fact be introduced in the teacher education programs for teachers who can learn to design their lessons and activities for students and thus make their own process of teaching more meaningful and worthwhile for students. About 18% believed that design education will help in the overall cognitive development of the child, while 5 (15%) teachers considered that learning would become fun and interesting for students with design in the curriculum. Three teachers suggested that design education would provide students with hands-on experience. However, they did not elaborate on how students would benefit through hands-on learning. Interestingly 2 teachers suggested that design process in general would help students develop the skills of planning which would be advantageous to them in all spheres of their lives.

The responses of teachers to this question thus reflect a positive attitude and a desire for the inclusion of design education in the school curriculum. This is significant because it is the teachers who have to actually implement the curriculum in the classrooms. As professionals with actual teaching experience, teachers are of the opinion that design education would make a creative contribution to the curriculum development for Indian students. Although views regarding the contribution that design education makes to the curriculum differed, all the teachers are all for design in general education. About 24% teachers' suggestion of including design education for teachers is also important and points to the significance that teachers were laying on planning and exploring possibilities of finding new ways of teaching and learning. As practicing professionals teachers acknowledged the importance of designing lessons, strategies activities for effective learning in classrooms. Workshops or short term courses on design can be incorporated in the professional development of teachers that would offer new dimension to their teaching practices, thereby facilitating a growth and development in their profession.

B. Designers' responses

Of the 5 designers, 4 designers agreed that design should be introduced as a part of the school curriculum for students. One of the designers (architect) disagreed with including design education in the curriculum. According to him, people have an intrinsic ability to design and solve problems. He argued that most professional fields such as art have also claimed that it is one of the fundamental abilities of human being and must be introduced in the curriculum. However, he believed that art should not be included in the curriculum since humans have the tendency to learn art even without practicing or training. He held the same rationale for introducing design in schools and believed that it would generate unnecessary burden on the students, who anyway have the ability to design, and do activities very similar to design like building and putting things together, by default. Holding a very specialist view on design, this designer suggested that design should be introduced in a professional sense at a later stage and to students who would opt to make a career in design.

The female animation designer narrated her own experience as a designer and said that her work as a designer is considered by many as a hobby and not as a career opportunity. People consider design as something which is *low* and *extra-curricular*. She suggested that design education should be introduced which would sensitise people and students to various aspects of design.

The visual communication designer suggested that design education would provide opportunity to students to do hands-on activities which would help in nurturing creativity in them. Two of the designers (product designer and user experience designer) 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. The product designer's response provides a clear account of what she meant by integrating design into the curriculum.

'Very much! For me design is not separate from common sense or the intrinsic nature of creating. I believe that creativity and common sense put together is design. Nothing more nothing less! The essence of being humans, that we are capable of designing, like simplifying things or like making efficient better use of things. If you are taught or being facilitated to think creatively, then I think, design is being taught. You don't have to put it as a separate subject but if you are encouraged to absorb the subject or anything through a means of inquiry, instead of just passively accepting but questioning, asking can it be better, what is it? How does it work? Why is it like that? Now once you start asking those questions you get into the design mode. So I believe it should be holistically be there in the curriculum as an intrinsic part.'

Unlike teachers all of whom considered design to be a part of the school curriculum, designers' points of view on imparting design to all were found opposing. While one of them disagreed with including design in the curriculum, the other four suggested that design should be taught in schools. The perception of design education as burdening the curriculum perhaps mirrors the perceptions of some people in India regarding design in general education. Design education is practiced-based and involves hand-on learning. Thus the burdening can only be reduced or mitigated if the aims of design education remain undistorted and untainted while implementing it in the classrooms.

The four designers' opinions on including design for all students have been echoed by other Indian designers too (Kasturi, 2005; Menon, 2005; Rajamanickam and Krishnan, 2005 and IDC, 2010). Two of the designers' opinions of integrating design in the curriculum, rather than introducing it as a separate subject reflects the policy document published by the Industrial Design Centre (IDC, 2010), which takes an inititave in incorporating a subject equivalent to D&T called, Design and Innovation in Indian schools (see Section 2.3.5.7 for description of the initiative).

Designers and teachers have recognized the importance of design education in general schools. The above finding provides insights into their perspectives on inclusion of design in Indian schools. Curriculum developers and policy makers may find this study relevant since it reflects Indian designers' and educators' standpoint and their rationale for integrating design in general education.

3.9.1.10 Attitude and interest towards design

A list of 10 statements was used to probe students' and teachers' general interest and attitude towards design. The analysis of their responses revealed several similarities in their responses on various items of this question. Hence it was considered reasonable to present both students' and teachers' responses together to facilitate comparison. Hence forth for all the structured questions, the analysis of responses from students and teachers would be presented together. Analysis of students' and designers' interview responses will also be presented together for all the subsequent structured questions.

A. Students' and teachers' responses

Overall both students and teachers exhibited positive attitude towards design. About 75% students and 97% teachers showed an interest in design ('*I am interested in design')* (Table 3.19). Similarly, about 74% students and 85% teachers showed an interest in taking up design as a learning/teaching school subject (*If design is introduced as an optional school subject, I will choose to study/teach it).* In order to validate students' and teachers' responses, negative statements were also included. So when asked whether design work was boring only about 21% students and none of the teachers agreed, suggesting that most of them would consider to learn/teach design. Almost 90% students and 91% teachers agreed that designing requires creativity. These responses suggest that students and teachers show a positive attitude towards design learning and teaching and they believed that design education has the potential to promote and boost creativity among the learners. Teachers' positive attitude is in consistent with their views expressed in their earlier responses towards design inclusion and its importance in schools (see Section 3.9.1.9). Interestingly, teachers who have never taught design or learnt it themselves, are found to be very positive about it. Students' positive attitude towards design is in consistent with Welch et al.'s study (2006) on elementary students' ideas about design, where most students also demonstrated a positive attitude towards design.

Table 3.19: Students' and teachers' attitude towards design and design learning

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

However, some stereotypes were also revealed regarding design field and design learning. To the statement, whether designing needs a lot of mathematics, only about a fourth of each sample (24% students and 29% 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 or is an art.

It was found that about a third of the student sample (33%) but only 18% of the teachers sample 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. However, it also reflects the attitude that designing is relatively easy so one need not go through design courses to learn it. This was confirmed in the interviews of students and has been discussed in the students' interview section.

It was also found that both students and teachers demonstrated some gender stereotypes in their response to design learning. A large proportion of both the samples (70% students and 68% teachers) considered that girls/women could be better designers than boys/men and more girls/women choose design professions (69% students and 79% teachers).

a) Gender

Both boys and girls displayed a positive attitude towards design. However, the proportion of girls exhibiting positive attitude to design and design learning was significantly more. For example significantly more girls agreed with the following statements *'I am interested in design'* (67% boys, 82% girls) [χ^2 (1) = 9.533, p = .002], *'I like to read magazines about design and designers'* (51% boys,72% girls) [χ^2 (1) = 13.867, p = .000] and *If design is introduced as an optional school subject, I will choose to study/teach it* (66% boys, 82% girls) [χ^2 (1) = 10.526, p = .001]. However, the analysis of the interview responses revealed that girls' interest towards design were more aligned with their understanding of design as art. The evidences have been provided and discussed in the students' interview section.

Girls also exhibited gender stereotypes in design more often than boys. For example, more girls (86%) than boys (54%) agreed with the statement, *'I think girls can be better designers than boys'*. This difference was found to be significant [χ^2 (1) = 40.347, p = .000].

Very few girls (18%), in comparison to boys (31%) agreed that mathematics was required in designing. This response reflects an important attitude of students (especially girls') towards designing. It suggests that if designing does not employ mathematics, it is relatively easy and hence mostly pursued by girls.

B. Students' and designers' interview responses

This section of the result presents the analysis of interviews of students and designers. During the interviews students and designers were probed for their reasons for agreeing or disagreeing with certain statements. The analyses of students and designers have been presented together because they were both probed for the same items of this question. Iinterestingly there was a great deal of similarity in the responses of students' and designers' interview though the nature of their reasoning was completely different.

Students and designers were asked to provide reasons for their responses to Statement 4, 5, 7, 8 and 9 from Table 3.19.

Students who agreed with Statement 4 (*I think girls can be better designers than boys),* revealed gender stereotypes in their responses. For example students said that girls could be better designers than boys *because they were more interested in the field* or *they were better at coordinating things like wearing accessories matched with their clothing,* or *keeping things in order***.** A few students also said that *most of the time fashion designers are girls so they must be better designers than boys*. When asked whether they were better in other design fields like architecture or car designing, these students agreed that they were better even in these fields since '*they were more creative'* or **'***had more ideas than boys*.' One student also said that *'girls were better in designing but boys were better in making things***.'** A few students considered girls as better designers because they thought *'girls were better in painting, needlework and tailoring.'*

Those who disagreed with Statement 4 still reflected elements of stereotypic thinking. For example is the response from SB3,

'No, I disagree because boys have good ideas in many professional fields such as mechanical engineering' or

'Girls can be better designers than boys only in one or two ways but not in all ways, like in stitching, embroidery, girls are better but not in others.'

Only a few students gave non-stereotypical responses such as suggested by SG3

'…Designing needs ideas and ideas don't have any difference, whether from a boy or a girl.'

All the five designers disagreed with the statements and suggested that there were no differences between men and women designers. However, the female product designer believed that in certain aspects of design, women prove to be much better than men, who, on the other hand, prove better in other domains.

'Women are more sensitive to the environment. They have the capacity to be more absorbent but then that can make them a very emotional designer. And it might not work always. Suppose there is an urgent need in some locality where there a lot of poor...maybe there is not enough food; then maybe all designer may feel more passionately to help them but in the process she might get so much involved that she might not think pragmatically. On the other hand she could also be sensitive to some aspect of that

localities; thing which a male would not notice. I have a gender bias that there is more patience with a woman; maybe she'll sit there and observe a little longer and ask a few more questions…asking and getting to know what could be the actual solution. It depends on the context. For such a case a women helps. She gets more insights for that particular case. Otherwise if go for a case where an industry wants a very quick and very good design; then maybe a man is also good because he is focused. There are differences between men and women and each of them behaves well in a certain context.'

For Statement 5 (*I think more girls than boys/men choose design*), most students said that more girls than boys choose design professions because *they were better in it* or because they found *more women in design than men*. Students' responses to Statements 4 and 5 reflect their belief that designing ability is present more among girls and that design professions are more suited to girls. Thus both in the interviews as well as in the questionnaire girls were found to hold more stereotypes than boys.

All the three male designers agreed that more women choose design profession. They suggested this response on the basis of the enrolment of women in design colleges and the percentage of women in different departments. In some sense, students' ideas overlapped with those of the designers'. However, while students' responses were based on assumptions, those from designers' were based on evidence.

For the Statement 7 (*We can design only after taking up courses in design*), most students in the interview agreed that people can design without taking up any courses in design since one needs to either have the '*talent*', '*interest*', '*good imagination*' or '*experience*' for designing. Some students, gave interesting responses to this statement, suggesting that design in everyday life can be intuitively learnt and transferred.

SG3: *'Even our parents had not taken up courses in design, but we come to know about design in our daily life, like cooking, stitching, cleaning.'*

SB5: *'Design needs creativity. We don't get creativity after getting courses in design.'*

All designers agreed and their responses matched students' responses. They suggested that individuals do not need any formal courses in design to participate in design activities in their everyday life. One has the inherent ability to design solutions without formal training. However, unlike students, all the designers asserted that one needs courses in design if one wishes to pursue a career or a profession in design.

A point of departure between students' and designers' understanding of design is the relative importance given to the process of design. While designers considered that even lay people engage in design in their everyday life through problem-solving and decision-making, students' examples seemed to suggest that they trivialised design to something that was intuitive and hence did not require any training.

When probed for statement 8 (*I feel designing needs a lot of mathematics*), some students suggested that the use of mathematics in design was only limited to recognizing shapes and sometimes measuring them. Most students disagreed with the statement and said that they believed that fields such as pottery, basket weaving did not use mathematics. Those who agreed with the statement revealed that *'measuring perfectly'* was indispensable in design since the *'angles of different shapes should be perfect and not tilted'* or *'if we are making a circumference, we need to know its radius and diameter, which are mathematics concepts'*. Hence the use of mathematics was necessary, they believed. When the researcher asked them whether professionals such as potters required mathematics, one of the students justified their stance by saying, *'for potters mathematics is not needed, but if you have to make the same size pots, then we will need mathematics.'*

This idea also gets reflected in two of the designers' responses who acknowledged that mathematics was necessary only when designers need to consider how their product will be mass-produced. All the designers argued that although basic mathematical skills was necessary during modelling of ideas, intuition and imagination were more essential during the conceptualization phase of designing.

Since Statement 9 (*Anyone who is not good at drawings should not take up design courses)* is complex and has a double negative, the researcher probed it further with the students in the interviews. All the students said that they understood the statement. Of those who disagreed with the statement, most suggested that drawing skill was not necessary for designing. For example one of the most typical responses justifying their stance was, *'they can do other jobs in designing which are different from drawings; for example they can do manual work'* (SB2). The *'other job'* suggested by students and which they thought did not require drawings were music, art, craft, cooking, software designing, pottery and weaving etc. When asked how designers would communicate their ideas to others most students suggested that they choose a design profession where drawing is not needed, or *'they can either make a rough sketch' ('but not* [necessarily] *be good in drawings'),* or *'describe it in words so that others might draw it'* for them.

Once again all the designers were homogenous in their responses and all of them disagreed that drawings were essential for designing. They argued that a rudimentary skill in design was enough to pursue design courses. Drawing skill could then be developed during the courses. The user experience designer suggested,

'Designing is not only about drawing. May be it was very essential 50 yrs ago. But now there are other ways. You can do 3D rendering; you can use software tools or you can prototype things. Now you get 3D printers available in the market. You just have to conceptualize. Do you think differently? That's the bigger question. Do you know drawing, is a secondary question. And if you want to express I have seen very great thinkers and very great architects with very dirty drawings. But they communicated with themselves how the drawing should be and then the technical drawings happened. It's a way of expression. Drawing helps you to communicate; it's a visual language. It is very necessary but it is not the end of the world. If you don't know, you can always pick up. You don't have to be a God in design. No great designer was always God in drawing. They pick up.'

An interesting point of difference between students' and designers' responses with respect to this item was that while designers argued for the use of alternative strategies (besides drawing) for modelling ideas, students suggested individuals, not good in drawings, to switch to different design professions having low requirement of drawing skills.

3.9.1.11 Nature of design

In order to probe respondents' ideas about the nature of design and designing activity, a set of 16 statements was designed. They had to indicate whether they *agreed, disagreed,* or were *unsure* about each of the statements. The 16 statements were categorised for analysis purpose. Once again analyses of students' and teachers' responses have been discussed together for the sake of brevity and convenience (Table 3.20).

Table 3.20: Students' and teachers' responses to statements on nature of design

Statements	***Agree (%)***		***Unsure (%)***		***Disagree (%)***	
	Students	Teachers	Students	Teachers	Students	Teachers
i. Design as activities						
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	30	29	70	31	0
Designing means to give shapes to things	60	85	28	9	13	6
ii. 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
iii. 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
iv. What designers do						
Designers solve real world problems	35	62	40	35	25	3
Designers get their ideas by observing people	66	62	21	3	13	35
v. 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
vi. 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
vii. Specific talent in design						
Design is an activity that we all do	56	85	22	9	22	6
People can learn to design	76	94	15	6	8	0

A. Students and teachers' responses

The responses to these structured questions have been presented based on the categories generated to analyse them.

i. Design as activities

As indicated in Table 3.20, large percentages of students (60%) and more teachers (85%) agreed that '*designing means to give shapes to things*'. To the statement, '*Design is about making patterns*', more teachers (62%) than students (46%) agreed. However, about one third of the student sample (33%) was unsure about this. Moreover, many students (54%) and teachers (62%) considered design as being '*...about appearance of things*', suggesting their emphasis on visual aesthetics while considering designed products. Many teachers (71%) expressed doubt regarding the statement '*to design means to draw*'. Only 29% teachers and 40% students agreed with this statement. For this particular item, teachers were required to provide justification for why they agreed, disagreed or were unsure about the statement. They were provided a space to write their justifications for their opted choice.

The following justifications were provided by 33 teachers for their responses to the statement '*To design means to draw*' (Table 3.21).

Table 3.21: Teachers' justifications for the statement, 'To design means to draw'

Justifications: To design means to draw		***Total No. (%)***
Agreed	Designing involves sketching	10 (30)
Unsure/ Disagreed	Drawing is just a part of design/ designers draws and then implements	8 (24)
	Many designs do not involve drawings	7 (21)
	Drawing can be done by anybody but not design/not all drawings are design	5 (15)
	Drawing can be imitative, design is creative	2 (6)
	Designing involves other creative abilities	1 (3)
Subtotal		***23 (70)***
Total		***33 (100)***

About one-third of the teacher sample agreed that most designing involved sketching or drawing and so drawing and designing were same. Most teachers (70%) disagreed or were unsure about the statement and the most common reason stated in support of their stance was the role of drawing in design. About 24% of teachers suggested that *drawing was just a part of designing.* Of these 24% only 2 teachers argued that *designers' implementation of the drawing is an essential part of designing.* Other teachers who disagreed with the statement provided examples of designs such as website designing which they believed did not involved drawing (21%). Some teachers also argued that not all drawings are designs but only those done by designers can be called as design (15%).

ii. Consequences of design

Most students (70%) and teachers (97%) agreed that '*designing improves things'* suggesting that they had a positive attitude towards design which was seen as something that improved the quality of people's life experiences. Almost equal percentages of students (58%) and teachers (59%) agreed that *'a well-designed product must look attractive'* again suggesting the value of aesthetics that they considered important in design of products.

iii. Knowledge and skills in design

While most teachers (77%) agreed that scientific knowledge was used in design, only 39% students agreed to this statement and about one third of the student sample in each case, either disagreed or were not sure about it. This reflects students' understanding of design as detached or distanced from science while teachers integrated science concepts into design. Teachers showed a somewhat homogenous understanding about the statement, '*in design one has little opportunity to work with one's hands,* where they disagreed with the statement suggesting that they all believed that designing involved working with hands. Students' responses varied for this item with about one third of the students either agreeing, disagreeing or not being sure about it. Perhaps students who agreed with the statement believed that designing was more of a mental activity while those who disagreed considered design to be involving hands-on activity. This was however probed in the interviews.

iv. What designers do?

Majority of the students (66%) and teachers (62%) agreed that '*Designers get their ideas by observing people'*. Students were probed for their responses in the interviews as to how designers got ideas on observing people. The interview responses revealed interesting ideas of students about designers which have been presented separately in the students' interview (Section 3.9.1.11 B).

To the statement, '*designers solve real world problems'*, only about a third of students (35%) and 62% of teachers indicated agreement. The low percentage of students' agreement with this statement suggests that they did not consider design as a problem-solving activity or as beneficial to the world. However, students' interview responses revealed that students considered real world problems only in terms of social or political problems which they thought designer do not solve. Teachers were probed for this response and asked to provide justifications. Of the 31 teachers who responded, about 62% teachers (18) agreed that designers solve real world problems. Their justifications are provided in Table 3.22.

Table 3.22: Teachers' justifications for 'Designers can solve real world problems'

<table>
<tr><th colspan="2">Justifications: Designers can solve real world problems</th><th>Total No. (%)</th></tr>
<tr><td rowspan="2">Agreed</td><td>Designers can plan, so they can solve any problem</td><td>11 (38)</td></tr>
<tr><td>Designers have solved problems by improving systems/ making products</td><td>7 (24)</td></tr>
<tr><td>Sub Total</td><td></td><td>18 (62)</td></tr>
<tr><td rowspan="2">Unsure/ Disagreed</td><td>Designers work is to design, they cannot solve natural/ social/political problems</td><td>10 (35)</td></tr>
<tr><td>Not necessary/ Don't know</td><td>1 (3)</td></tr>
<tr><td>Subtotal</td><td></td><td>11 (38)</td></tr>
<tr><td>Total</td><td></td><td>29 (100)</td></tr>
</table>

As evident in Table 3.22, about 62% of teachers agreed that designers can solve real world problems. The dominant reason provided by teachers in support of their stance was that designers were apt at planning and so can solve any problem through their planning strategies (38%). This justification by teachers is in consistent with their perception of design as a planning process revealed earlier in the analysis of their' spontaneous ideas on design and designers. About 17% indicated that designers mostly improve systems or make products which solve our day-today problems. Those who disagreed emphasized social and political problems as real world problems and denied that designers can solve those problems (35%).

v. Is design modern or ancient?

Most students (66%) and teachers (85%) believed that ancient people did design. To the contrary statement regarding design as a modern activity, 48% students and 29% teachers agreed, suggesting that they considered design more as a basic human ability than as a professional discipline.

vi. Design and other disciplines

Around half of each of the sample (52% students, 50% teachers) agreed that design and art were same. Only 17% students and 24% teachers thought that designing and engineering were same. This reflects students' and teachers' strong association of design with art and limited association with engineering. These responses concur with students' and teachers' spontaneous responses to the first questions on design and designers where most of their spontaneous ideas were related to artistic design and less with the technological one.

In this context, it is important to note that several studies on students' and teachers' understanding of technology points to the fact that most students and even teachers associate technology with computers and electronic appliances (Jarvis and Rennie, 1998; Khunyakari et al., 2009; Mehrotra et al., 2007; de Klerk Wolters, 1989). However in the present study, there were no mentions of 'technological' objects such as computers, electrical appliances or machines anywhere in either students' or teachers' spontaneous responses. This finding can thus be extended into the analysis that students and teachers in the present sample were not able to connect design with technology. A low percentage of students' and teachers' agreement of the link between design with engineering and their strong association of design with art further reflects their failure to relate design with technology and expose their narrow view of design as mainly artistic or aesthetic.

vii. Specific talent in design

About 76% students and 94% teachers agreed that *'people can learn to design'* which reflects their positive attitudes regarding design learning. The responses from teachers are consistent with their positive attitude towards design integration and design learning in schools. Teachers' perspective on design learning resembles a 'democratic' view which considers the presence of a talent in the many and not just a few, in contrast to the elitist view of talent which represents the view that talented people are few who can make contribution without any help or support.

However, these responses could also be analysed otherwise. Together with the negative response to the attitudinal question on design (Statement 7: *We can design only after taking up courses in design*), both these responses may reflect the attitude that design is relatively easy for people to learn on their own. About 56% students and 85% teachers agreed that all people engage with design in their daily activities. Students were probed for the kinds of design activities that people engage in their daily life. Interesting insights were revealed in students' responses in the interviews (Section 3.9.1.11 B).

Gender

Boys and girls presented similar perception for all the statements on the nature of design and there was no significant difference observed between their responses for each of the statements.

B. Students' and Designers' Interview Responses

The analysis of students' and designers' responses have been presented together to reveal interesting comparisons in their responses. In the interview, students' and designers' ideas were probed to expose why they preferred a certain option over the others. Students, who agreed with the first statement (*To design means to make patterns*), suggested that there were certain design fields like fashion designing or floral designing where making patterns were important but not all design fields required pattern making. Interestingly, for some students all the design fields were involved in making patterns to some extent. For example, one student suggested that an architect follows a certain pattern for all the floors in the building, while an air conditioner (AC) designer has to put the different elements of the AC in a certain pattern.

Students who agreed with statement (*Designing means to draw*) suggested that designing and drawing were the same things. For example one of the students argued,

SG1: '*I agree because when we draw then only it becomes a design'*

However, those who disagreed provided several explanations in support of their stance, some exactly in contrast to the one presented by SG1 and also emphasizing the modelling/making aspects of design. SG2: *'I disagree because to make drawing does not mean to design. All of the drawing that we make does not mean that it will be design. There is not only drawing that can make design. If we are creating anything, that is also a design.'*

Another student (SB5) following a similar line of thought, suggested, *'... it (designing) is also about modelling, giving it a 3D model'.*

A few students suggested that implementation of the drawing was more important than drawing, as noted here, *'it is not necessary to draw but it is necessary to make the final thing'.* Thus some students' understanding of the different modelling techniques besides drawing was revealed in this section of the interview. Students realized the importance of other ways of modelling ideas such as 3D rendering and modelling.

Designers were all homogenous with regard to their response to this statement. All of them disagreed with the statement. They all asserted that drawing was just an aspect in design. For example, one of them suggested,

'Drawing can also be seeing and drawing, mimicking, copying; can just be direct representation. But when one is doing design one is internalizing, putting in a thought, doing conscious processing and coming up with something that need not always exist... Drawing is like language. Language is not necessarily poetry. That's the difference between design and drawing. Drawing might not have that element of creative problem-solving.'

This view of designer reflects 2 of the teachers' view who also suggested that drawing can be imitative but design is creative. However, in case of teachers a creative drawing could also mean a creative painting.

When probed for the idea whether designed products should look attractive (*A well designed product must look attractive*), students who agreed with this statement mostly suggested that designed products should look attractive since people first look at the products before buying. For example, SG3 argued, *‘if a product is well designed and it looks attractive, then only buyers will feel like buying it’*. Interestingly, even Norman (2002) proposes that usability or the product functionality may not be the crucial factor when a user decides to purchase a product from an array of designs. Instead, a user may rely on her emotions which are affected by the aesthetic side of a design and that can become the overriding factor in the success of that product.

Those who disagreed with this statement usually cited examples of products which might work well but might not be attractive to look at. For example, SG5 said, *‘many machines might be very well designed and might be working fine but outside they would be rusty or might not have good shape.’*

All the designers disagreed that design was only about appearance. They suggested designing need a lot more than just appearance such as its functionality, ergonomics, sustainability etc. However, the product designer, emphasizing on the simplicity of products, suggested that, '*A well designed product by default is attractive.'*

For the statement, *In design one has little opportunity to work with one's hands*, half of the students agreed with the statement and suggested that ‘*in design we are mostly using our minds than our hands’* (SG1). The other half disagreed with the statement and mostly suggested that designing involved making sketches and making things with hands. Responses to this statement thus suggest students’ diverged notion about design as being a minds-on or a hands-on activity.

Designers, having an authentic experience in design, however agreed that both hands-on and minds-on activities were needed for designing in the professional domains.

When asked whether designers solved real world problems, students, who disagreed, usually thought of ‘real world problems’ as global, social or political problems (e.g. *‘national calamities’*, *‘poverty’* or *‘municipal’*) which they thought could only be resolved by government authorities or politicians and not designers. Very few in the interview agreed and they provided examples of modern technological artefacts like air conditioners, heaters, computers and bridges that solve our problems. These views were also shared by teachers as suggested earlier in the analysis.

Designers, all of whom conceived design as a problem-solving process, agreed that designers solved real world problems. Interestingly 2 of the designers argued that designers can also create problems with the products/systems that they design and therefore designers need to be more responsible. However, they did agree that designers *'intend'* to solve the problems.

When probed for their responses for the statement '*Designers get ideas by observing people,*' it was found that students understood 'observing people' as imitating others which was in opposition to their standard notion of designer who is essentially a creative individual. Thus those who disagreed with the statement said, *'designers are creative, they make things on their own'.* Another student replied, *'if designers observe people and then design, it means they are copying'.* Those who agreed with the statement usually gave examples from fashion design. A few suggested that fashion designers usually '*see the trend of what people like and then they design according to their needs and requirements*.' Only two students suggested that designers can look for problems of people and what they need and then design or improve things according to their needs.

All the designers agreed that designers get ideas by observing people. However, besides observing people, they also acknowledged getting inspired from nature and environment.

Students who agreed that ancient people had designed things suggested examples like the wheels, stone tools, cave paintings, architectures, sculptures, utensils and handicrafts from the past. A few students who agreed that design was both modern and ancient, argued that there are a variety of design professions today which were absent in ancient times, such as car designing or website designing.

All the designers agreed with both these statements and suggested that design was modern only in terms of its professions; however, design as a basic human ability has been there since pre-historic times.

While probing students for their responses to the statements '*Art is the same as design*' and '*Designing and engineering are the same'*, it was found that students associated design with art more than with engineering. None of the students in the interview realized that while design was utilitarian, art was not; that designers are required to serve the needs of their clients instead of presenting their own views, while artists present their own views to the world and do not necessarily serve the needs of others. A few students attempted to differentiate engineering and design by suggesting that engineering had many different branches which involved different kinds of engineering works while all fields of designing involved making things attractive. A few students also revealed that though design and engineering involved giving shape to things, engineering was more ‘*concentrated in science*’ while designing was more ‘*concentrated in our day-to-day activities’*. Two students held the idea that engineering *‘did not involve creativity’* but *‘making the same things again and again’* while *‘designing involved more creativity’*.

All the five designers agreed with these two statements but with certain conditions. For example, all the designers argued that design and art and design and engineering were not SAME but they could be considered SIMILAR. The UX designer suggested that both art and design, and engineering and design used the same *‘dictionary’*, such as tools, colours, shapes, proportions, but their intents were different. Similarly the product designer argued that while both art and design involve creativity and aesthetics, design was more pragmatic than art. Moreover, while design was functional and useful, art may not necessarily be useful. Considering design as a problem-solving process, the product designer provided an example, which suggests how a problem in art could be transformed into a design problem.

'If the user, say a king is adverse to the colour red and if the designer intelligently puts red in the painting in such a way that the king becomes ok with the colour and the phobia with the colour goes then it is solving some kind of a problem in some sense and improving his life; then he is designing; he is consciously putting a thought of how to communicate something but when you are doing a mimic and do exactly as it is, say making a portrait of a queen then that is not design. Design mostly serves a physical tangible purpose. If we make the definition of design thin, then a child doing art is also design. If we do that then everything is design. Then all the boundaries become blurred and there is no point in comparing. Art is an aspect of design. Design is an applied art. Design is not only art; it is more.'

According to Owen (2005), design is not art. It also is neither engineering nor science and a student must be made aware of the distinctions among them.

Most students in the interview agreed that people engage in design in their daily activities. When asked for exemplars, they suggested activities such as *‘drawing’*, *‘painting’*, *‘cooking’*, *‘garnishing food’*, *‘keeping things in order’*, *‘tailoring’*. These responses of students, matches with their earlier responses to the attitudinal question, *We* *can design only after taking up courses in design* (Statement 7), wherein many students in the interview suggested that design was intuitive and people can learn to design without any formal training or courses. The examples provided by students also suggested their association of design with visual aesthetics.

All designers also agreed that people engage in design in a non-professional manner in their day-to-day life. Even though designers agreed that lay people engage in design, their examples of everyday design implied a problem-solving situation in an everyday activity.

3.9.1.12 Skills of a designer

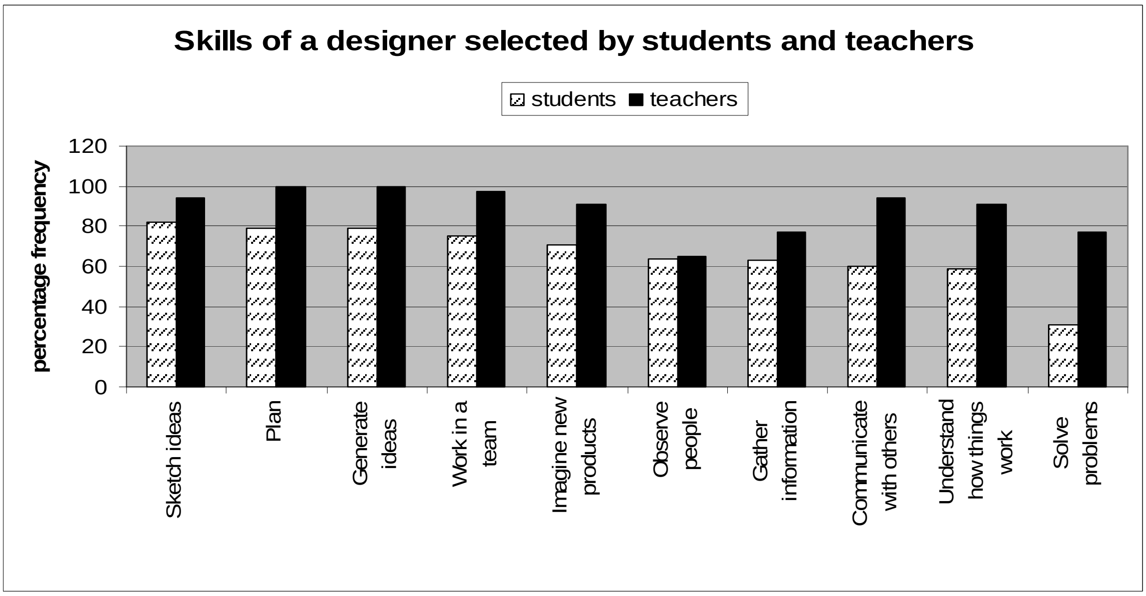
A list of 10 skills was provided and respondents were expected to indicate those which they felt were necessary skills of a designer.

A. Students' and teachers' responses

As seen from Graph 3.2, the top 5 skills that students and teachers most frequently associated with designers were *sketching*, *planning*, *generating ideas*, *working in a team* and *imagining new things*.

The bottom 5 skills associated with designers were *observing people*, *gathering information*, *communicating with others*, *understanding how things work and solving problems*. Thus both students and teachers showed an understanding of the skills that a designer might possess. This is similar to the findings by Welch et al. (2006) and Trebell (2009) who found that students in their sample had an understanding of the skills required by the designer. In the present study, however, a very important skill, solving problems was not considered important by students. Only 31% of the student sample marked this skill. In contrast, this skill was considered important by many students in Welch et al.'s sample. This perhaps is due to students' lack of understanding of the nature of design, in this study.

Graph 3.2: Students' and teachers' responses to the skill associated with designers



a) Gender

Boys and girls presented similar response for all the items in this question. No significant difference was observed between their responses, in any of the items for this question, suggesting that they perceived similar skills in a designer.

A. Students' and designers' Interview Responses

In the interview most students suggested that many design activities like cooking or website designing do not require sketching but designers in other fields need to know the basic in sketching. Almost all students in the interview suggested that working in a team was a needed skill among designers since working in a team would give them more ideas to work with.

When students were probed on why designers need to have a skill to observe people, students most frequently gave examples from the field of fashion design who might look for what people wear and then design clothes according to their requirements. Others who disagreed with designers having this skill, considered observing people as tantamount to imitating or copying ideas from others which is against their belief of designers being highly creative and imaginative.

Some of the students, who agreed that solving problem was a necessary skill among designers, suggested that designers solve problems of people by creating or improving artefacts. A few suggested that designers must know how to solve problems (or troubleshoot) in the course of their design work. In the interview those students who marked that designers need to have communication skills, argued that communication was an important skill needed in designing since designers needed to convey their product ideas to others for them to buy.

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'*.

3.9.1.13 Qualities of a designer

A list of 20 contrasting qualities was presented and respondents had to select one of each pair as a quality of designers. 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 (Table 3.23).

A. Students' and teachers' responses

It was observed that for all the personality traits, both students and teachers most frequently marked the positive qualities (Table 3.23). Thus designers were viewed as intelligent, hard-working, honest, interesting, kind, honest, modern, original and friendly. This finding is consistent with Welch et al.'s study where students were also found to associate positive qualities with designers. However, students reflected a somewhat polarized view for the trait humble/proud. About 43% students considered designers to be proud. This perhaps stems from their assumption that designers are proud of their ideas. This was probed further in the interview to reveal students' justifications for their responses.

Table 3.23: Students' and teachers' association of qualities with a designer

Qualities of a designer	***Ticked left (%)***		***Ticked right (%)***		***Ticked both (%)***	
	Students	***Teachers***	***Students***	***Teachers***	***Students***	***Teachers***
Personality traits						
Intelligent / Stupid	**96**	**97**	4	0	0	3
Kind / Cruel	**90**	53	7	3	3	44
Honest / Dishonest	**87**	68	10	3	3	29
Modern / Old-fashioned	**86**	56	8	6	6	38
Original / Imitative	**81**	**85**	15	6	4	9
Friendly / Hostile	**83**	53	14	15	3	32
Sensitive / Insensitive	**71**	**82**	27	6	2	12
Humble / Proud	52	62	43	15	5	23
Timid / Bold	17	0	**80**	68	3	32
Boring / Interesting	10	3	**87**	**94**	3	3
Lazy / Hardworking	4	0	**96**	**91**	0	9
Skill-based traits						
Organized / Unorganized	**87**	**82**	12	6	1	12
Practical worker / Abstract thinker	58	47	36	29	6	24
Unscientific / Scientific	22	6	73	53	5	41
Technical / Artistic	13	3	79	68	8	29
Interested in people / Interested in Ideas	12	6	**83**	**88**	5	6
Biological traits						
Female / Male	**51**	23	35	15	14	62
Old / Young	7	0	**83**	47	10	53
Social traits						
Popular / Unpopular	**70**	47	25	27	5	26
Poor / Rich	15	3	**76**	21	9	76

Teachers were not as positive as students and showed a tendency to select both the personality traits of the designers. Thus many teachers (44%) considered designers to be both kind or cruel, modern or old-fashioned (38%), friendly or hostile (32%), timid or bold (32%) etc. This perhaps stems from teachers' more and varied experiences of people with different personalities in various professions. However, for certain traits such as being original, sensitive, interesting and hardworking, even teachers marked the positive qualities, suggesting that they considered these qualities as important for designing.

Regarding the skill-based traits, it was observed that both students and teachers considered designers to be mostly organized, more interested in ideas than in people, artistic as well as scientific. There was some polarity observed in students' and teachers' responses for the skill-based traits of being a practical worker against abstract thinker. Around half the sample in each case, considered a designer to be a practical worker while the other half considered him/her as an abstract thinker. Majority of the students (79%) and teachers (68%) considered designers to be artistic. Interestingly majority of students (73%) and teachers (53%) considered designers to be scientific as well. This finding is interesting since most students and teachers considered designers to be both scientific and artistic, but less technical. Perhaps students were thinking about certain kinds of scientific knowledge that designers need to have. This was also probed further in the interviews.

While marking the biological traits, a large number of students (51%) suggested that designers were females while 35% stated that they were males. These responses indicate that they considered design as largely a feminine profession. This finding is in contrast to Welch et al.'s study (2006) on elementary students' ideas about design, where most students suggested that designers could be either male or female. Students did portray gender stereotypes regarding designers. However, this bias was absent from the teachers' responses, most of whom (62%) suggested that designers were both males and females. Most students (83%) suggested that designers were mostly young while teachers did not share this view with the students. They thought designers were both young and old (53%).

Students' suggestion of designers being young in this study is however, different from Welch et al.'s (2006) study where their sample did not associate any stereotype with respect to the age of designers. Welch et al.'s sample suggested that designers could be either young or old. Interestingly, studies done on Indian students' perception of scientists have revealed that while globally scientists are perceived as old (Chambers, 1983; Mead and Metraux, 1957; Finson, Beaver and Cramond, 1995; Turkmen, 2008), Indian students perceived them as young (Chunawala and Ladage, 1998).

While responding to the social traits, students mostly thought that designers were popular (70%) and rich (76%). This view of students perhaps stems from the wide popularity of fashion and interior designers in the media, which suggest design to be a lucrative enterprise. However, teachers mostly suggested that designers could either be popular or unpopular and rich or poor.

Overall in this question, teachers mostly differed from students in opting for both the qualities of the designers. Thus teachers most frequently marked both the options available. This suggests that teachers as adults responded to this question differently than students. They were more open in attributing both the contrasting qualities to a designer and thus displaying less stereotypes in their responses.

a) Gender

Cross tabulation analyses of boys' and girls' responses suggest significant differences for 2 qualities: *female/male* [χ^2 (2) = 47.508, p = .000] and *technical/artistic* [χ^2 (2) = 10.947, p = .004]. In case of *female/male,* most girls (69%) suggested that designers were females while 31% boys indicated that designers were females. This suggests a strong stereotype held by female students that most designers are females. More girls (87%) than boys (71%) also suggested that designers were artistic and less technical.

A. Students' and designers' Interview Responses

When probed for their responses in the interview, most students suggested similar reasons for why they considered certain option/s. They felt that designers were mostly intelligent since they come up with different ideas. They were hard-working since *they come up with different ideas and work hard to implement them*. They were honest and original since *'most designers work with their own ideas and do not steal from others'*. A few students, however, did suggest that designers sometimes imitate from others and are dishonest about acknowledging that. Most also thought that designers were bold because their professions demanded them to communicate their novel ideas to others and be bold about them. Most students in the interview suggested that designers were humble since they need people to buy their products. A few students, who considered otherwise, mostly thought designers were proud because of their innovative and creative ideas.

In the interview a few students suggested that designers are '*organized, because designing means keeping things in order, and designers are always organized and keep things in order'*. Another student observed that designers are *'interested in ideas, because if he is interested in people, he will not have a concentration on his work*'. Students who suggested that designers are interested in people argued, '*...because he learns new things from people and gets ideas from people.*' Students who marked both the options suggested, '*both- because first they must know what people want then they must also consider certain ideas so that they can create those ideas and according to people's needs they can implement it*.'

When probed for why designers were scientific, a few students noted that different designers were required to know about the materials that they were working with. The understanding of materials, students assumed, entailed a scientific understanding. While still retaining their artistic view of design, some students gave examples of painters who need to have a scientific understanding of the colours and canvases, of how different colours react with different canvases etc.

In the interview, almost all the students suggested that designers were young and modern. They argued that young people had a greater variety of creative ideas than older people and they can conceive modern products which older designers might not be able to.

Regarding the social traits, students who chose both the options (poor and rich) thought designers were both rich and poor and cited fashion designers as rich while potters and carpenters as poor.

All the designers marked both the options for all the qualities of the designers. According to them designers could not be ascribed with any specific qualities or personalities. Being in the field of design, designers had more knowledge than students or teachers and were therefore less likely to attribute singular or positive qualities to designers since they knew the range of people working in design.

3.9.2 Section D: Pictorial activities

Section D consisted of a question on activities. This part was common to the elementary (ESS) and middle school students (MSS), teachers and designers. It was pictorial in nature and this question was given to all the respondents at the end of all the questions in order to avoid any influences of this activity and the pictures on respondents' preliminary ideas of design and designers. This question consisted of 30 pictures with a phrase labelled underneath each picture, indicating the nature of activity occurring in each picture (in case the picture was unclear). Respondents were required to indicate which of the activities depicted they considered as related to design.

As mentioned earlier, Section D had 2 types. There was one set with all the activities performed by males and another set with the same activities performed by females. This was done to attain three objectives: (i) to maintain gender parity (ii) to observe gender preferences for the kind of activities considered as designing activity and (ii) to reduce the gender stereotypes of assigning a particular activity to a particular gender (for example, assigning cooking activity to a male or a female individual).

Participants had to respond to any one of the types of Section D. This section was randomly distributed to all the respondents. However, it was ensured that there were an equal number of males and females in each sample responding to the male and female questionnaire each.

The Table 3.24 displays the distribution of the questionnaire among all the students and teachers, indicating that about equal number of male and female pictures were provided to students and teachers.

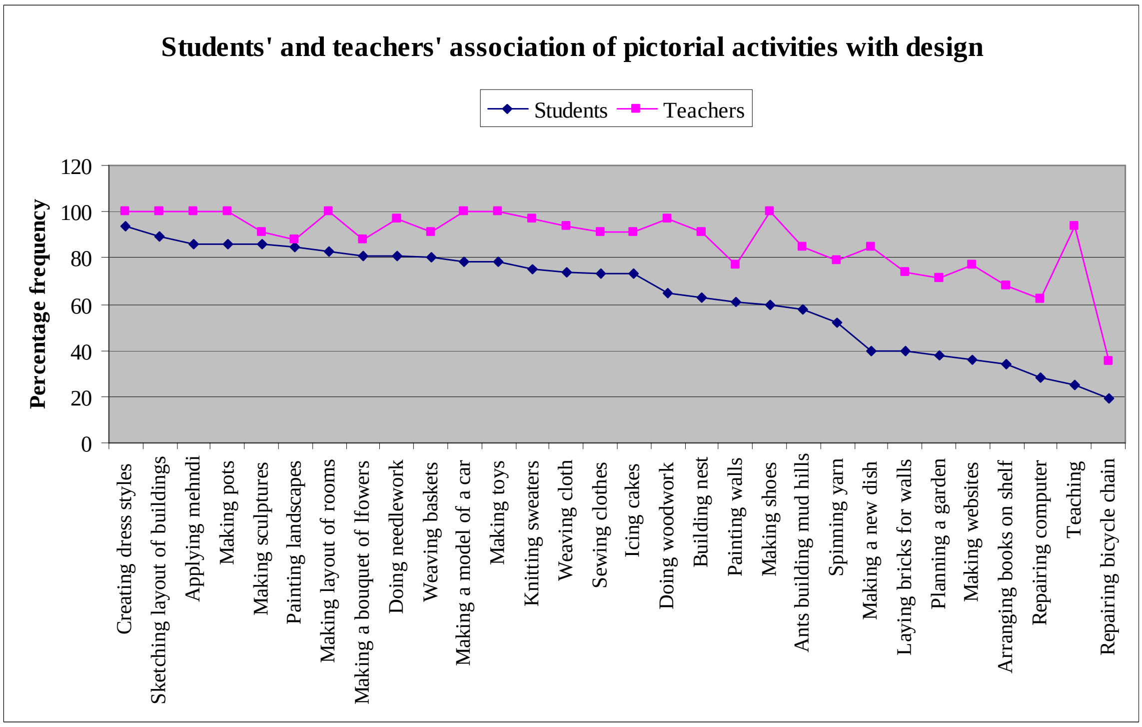
Table 3.24: Distribution of Section D to students and teachers

Sample	*Male pictures provided*	*Female pictures provided*	*Total*
ESS	82 (43)	109 (57)	191
MSS	178 (52)	162 (48)	340
Teachers	20 (59)	14 (41)	34
Total	280 (50)	285 (50)	565

A. Students' and Teachers' responses

Graph 3.3 displays the overall perception of the activities by students (ESS, MSS) and teachers. As in the case of the question on the co-curricular subjects related to design, each of the pictorial activities could be considered a design activity provided an authentic problem-solving context or situation is presented in each case.

Graph 3.3: Students' and teachers' perception of pictorial activities



However, the pictorial activity was different from the co-curricular subjects' related question since they were visible and each of them had a label beneath them which described the activity being performed in the picture. These labels could serve as a cue to decide where design was happening. From the analysis it can be argued that students did not look for cues within the labels, since some of the descriptions which could have suggested a designing activity was considered non-designerly by many students, while other labels of the pictures which suggested that design was not happening, were considered designerly by many students. As for example, 'planning a garden', 'making a new dish', were not considered a designing activity by many students while painting landscapes, making sculptures which suggest artistic enterprises were considered as design activities by most of the students.

As seen from Graph 3.3, students show a trend in associating the given activities with design. The top ten activities associated to design by students were: 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. This indicates that activities which involved any form of sketching, painting or pattern formation were rated as designing activities more often than other activities. Also activities which included the label ‘making’ (except for the activities of making a new dish and making websites) were associated with design by more than 60% of the student sample. This indicates their association of design with making.

The bottom 5 activities which were least frequently associated with design by students were making websites, arranging books on shelf, repairing computer, teaching and repairing bicycle chain.

As seen from Graph 3.3, teachers more frequently associated most of the activities with design than students. Interestingly activities which were not designing were also considered as designing activities by teachers, such as repairing computers or laying bricks for walls. However only some teachers marked repairing a bicycle chain as related to design.

a) Grade

Of the 30 activities given to students, significant differences were noted between the responses of elementary and middle school students for the following 14 activities and have been presented in Table 3.25. It was observed that MSS more frequently marked the activities as designing activities compared to the ESS.

Table 3.25: Significant differences between ESS and MSS for the pictorial activities

Activities	*ESS (%)*	*MSS (%)*	*Chi square values*
Planning a garden	23%	47%	χ^2 (1) = 31.202, p = .000
Making a model of a car	69%	82%	χ^2 (1) = 12.335, p = .000
Knitting sweaters	65%	81%	χ^2 (1) = 15.014, p = .000
Weaving basket	68%	87%	χ^2 (1) = 27.755, p = .000
Spinning yarn	42%	58%	χ^2 (1) = 11.829, p = .001
Icing cakes	64%	78%	χ^2 (1) = 11.687, p = .001
Making a bouquet of flowers	73%	86%	χ^2 (1) = 12.084, p = .001
Doing woodwork	53%	72%	χ^2 (1) = 19.816, p = .000
Doing needlework	74%	85%	χ^2 (1) = 10.530, p = .001
Making layout of room	75%	88%	χ^2 (1) = 15.803, p = .000
Sketching layout of a building	82%	93%	χ^2 (1) = 15.716, p = .000

This perhaps could be due to the limited understanding of design in ESS. For example, while planning a garden was related to design by 47% of MSS, only 23% ESS thought it to be related to design. This was also true for other activities which could be related to design such as making a model of a car, making layout of room or sketching layout of a building.

b) Gender

No difference was found to exist between the responses of boys and girls among the students for any of the activities indicating that both boys and girls perceived the activities similarly.

B. Students' and Designers' Interview Responses

Some activities such as creating dress styles, sketching layout of rooms, making layout of rooms, making a model of a car and painting landscapes were considered designing activities by almost all the students in the interviews. On the other hand, activities such as laying bricks for walls, arranging books on shelf, repairing computers, teaching and repairing bicycle chains were considered non-designerly by most students in the interviews. Students generated criteria to consider an activity designerly, very similar to the ones created to regard the co-curricular school subjects as designerly. Thus an activity was categorised as a designing activity by students if it involved either (i) making a tangible product, (ii) giving shapes to that product, (iii) skills to make it, (iv) making patterns, (v) giving aesthetic appeal to the product, (vi) 'complex thinking' or planning before executing and, (vii) arrangement of parts in more than one way.

The analysis of students' interview responses revealed that students characterized all the activities based on either one or more than one criteria. As in the analysis of the co-curricular subjects, in case of these activities also, students were not found to be consistent while generating these justifications. They kept modifying their justifications as the activities changed. For example creating dress styles, sketching layout of buildings and painting landscapes was regarded as designing activities since these involved sketching or painting (i), while planning a garden was considered designerly by many students on the basis of the second criteria (that is, cutting the plants to give them different shapes and sizes) and fifth criteria (that is, growing different flowers to make the garden look aesthetically pleasing).

Interestingly while repairing bicycle chain was considered as non-designerly by most students in the interview, many students considered repairing computers as designerly. On probing students justified through similar explanations, namely that the latter involves ‘complex thinking’ (vi) and rearranging of the parts in more than one way (vii), while the repairing of bicycle chain does not involve ‘complex thinking’ as there is only one way of fixing the chains. One of the students’ responses is suggestive of this kind of explanation,

SB1: ‘*Repairing a bicycle chain is not designing because it is very simple. We just need to fix the chain in only one way. We cannot design anything new here. But repairing a computer is designing because it involves complex thinking. It has so many parts and we have to place all the parts correctly otherwise it will not work properly. We can change the monitor from round to flat. We can design something new here.’*

This finding seems consistent with what de Klerk Wolters (1989) reported on students’ attitude towards technology, that students considered repairing a bike an inferior technological activity to working with a computer.

Interestingly while most teachers had strongly associated their own profession of teaching with designing (as evident in their responses to the question *'According to you, how much is the teaching profession related to design'* in Section 3.9.1.8 and Table 3.17) none of the students in the interviews, except only 2, considered teaching as involving design. Students again provided similar kind of explanations while suggesting why teaching was a non-designerly activity. For example one of the most typical responses was,

SB2: *‘Teachers know how things happen. They just describe those things to the children. They don’t apply their minds to create something new. What they know, they teach.’*

This response definitely underscores the creative aspects of teaching and might perhaps be due to the lack of information or awareness in students regarding the nature of teaching activity and perhaps stems from the traditional teacher-centric approach to learning and teaching in the classrooms.

Another interesting aspect exposed in the interview was that all the students in the interviews considered birds building nest and ants building mud hills as designing. Even students who denied designing by animals in the previous question in Section 3.9.1.3, selected the two pictorial activities as related to designing. On probing, these students justified that *'not all but only a few animals could design.'*

Once again all the designers considered contexts of the activities as significant for considering them as designerly. According to them, all the activities could be related to design. It depended on how one came about doing it. All of them emphasized that the process was very important. However, when asked to go by the labels provided underneath each picture, designers selected only a few activities as designerly, namely planning a garden, creating dress styles, sketching layout of buildings, making layout of rooms, making a model of a car, making a new dish, ants building mud hills and building nests. They were cautious in selecting the other activities since they thought that the labels were not suggestive whether design was happening in each of them or not.

3.9.2.1 Summary

This section summarises the main findings from the analysis of students', teachers' and designers' written and interviewed responses. The results of the findings indicate that although students and teachers in the present study did not have a formal education in design, they all had prior ideas about what design is and what designers do. Analysis of students' spontaneous ideas on design and designers indicate that they strongly associated design and the designer's work with art such as painting, decorating, making patterns and drawings. Other ideas infrequently associated with design were making things, planning inventing and ideating. Students suggested examples of designed products and design professionals mostly from two design domains- fashion/dress designing and architecture. While there were no marked difference in boys' and girls' responses to the spontaneous ideas of design and designers, younger students held simpler ideas of design mostly as painting, drawing and making. Teachers' ideas of design were also mostly related to art. Teachers also strongly associated design with their own profession of teaching and assumed design as a general planning process. Skills such as creativity and imagination were associated with designers by both students and teachers. Designers held a holistic and sophisticated understanding of design and considered design as a goal directed problem-solving activity. They mostly regarded the skills of observation, imagination, and visualisation as needed in designers.

Most older students and all teachers agreed that animals design. They emphasized on home-building activities especially that of birds. Interestingly, most younger students ascribed designing abilities to animals on the basis of their ability to make marks on the ground with their feet or paws indicating their strong association of design with pattern making and decoration. Surprisingly even a few teachers subscribed to this view.

The Indian words for design produced by both students and teachers also suggest their association of design with art. None of the designers generated words related to art. They instead came up with appropriate Indian words for design, perhaps learnt in their courses.

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 with design as planning and working with hands. Both students and teachers showed an awareness that designers need to depend on different knowledge and skills for designing and 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.

Overall students and teachers showed a positive attitude towards designers and design learning. An important finding is that both students and teachers showed interest in learning design. Most teachers expressed a desire to teach as well as learn design in schools. In the student sample, however, more girls than boys were found to be interested in learning design. The positive attitude of girls towards learning design, however, seems aligned more with their idea of design as an artistic rendering process than as a problem-solving one. Both students and teachers also reflected the attitude that girls/women could be better designers than boys/women. Designers did not reflect any gender stereotype in their attitudes towards individual's learning in design. Except one designer, the rest four designers expressed a democratic view of design ability and emphasized its inclusion in the general school education. The other designer who did not favour the inclusion of design in general education did carry a democratic view of design ability but mainly emphasized the burdening of the curriculum due to design education.

In response to the question on co-curricular school subjects and pictorial activities, students considered those subjects and activities as related to design which involved sketching (with or without planning), making of a tangible product, giving it different shapes, rendering aesthetic appeal to it, requiring specific skills to make it, arranging/rearranging its parts and requiring thinking or planning before executing. Subjects or activities which required a more planning approach to design were considered non-designerly by many students, while activities which involved sketching, painting, making patterns or decorating were considered designerly more often by students. Teachers considered most school subjects and pictorial activities as related to design. Designers laid emphasis on the context and the nature of approach to each of the school subjects and pictorial activities for considering them as designerly.

3.9.3 Section B: Students' images of designers

Section B or the drawing task was provided only to the elementary school and middle school students. This task featured an enclosed area on an A4 sheet paper where the students were asked to 'Draw a designer at work'. The task also included written responses in addition to the drawings. Below the drawing space the following questions were included:

- *What is the name of the designer you have drawn?*
- *The designer in your drawing is Male / Female (Circle any one)*
- *Where is the designer working?*
    - i. *Indoor / outdoor (Circle any one)*
    - ii. *Home / office / other ________ (Circle any one)*
    - iii. *Village / town / city (Circle any one)*
- *What is the designer in your drawing doing?*

As a first step in data analysis, the researcher went through the drawings of all the students and examined each of the drawings for the physical appearance of the designer, items depicted, work settings and actions portrayed. Then a checklist, as developed by Fralick et al. (2009) was modified for analysing the data. The checklist provided by Fralick et al. consisted of the following indicators such as (1) Appearance of Engineer/ Scientist, (2) Location, (3) Objects, and (4) Inferences of Actions. On account of a few extra elements being represented in the students' drawings quite often, Fralick et al.'s main checklist was modified by adding those elements to the checklist such as dresses and accessories worn by the designer, designer is seated or standing, different kinds of designers depicted. This modified checklist is presented below in Table 3.26

Table 3.26: Checklist for coding the drawings of designers

Characteristics	Human / Non human figure
Appearance	Number (number of human figure/s; designer/client/user- explicitly mentioned or portrayed)
	Gender (male or female human figure- explicitly mentioned or portrayed)
	Age (young/middle aged/old human figure- explicitly mentioned or portrayed)
	Other Attributes (dress/accessories worn by designer)
Location	Indoor / outdoor
	Home / office / other
	Village / town / city
Objects	Tools depicted (writing tools/ construction tools)
	Products of design depicted (plans/ model/ cars)
	Artefacts other than tools and products of design (furniture)
Inferences of actions	What the designer was doing- explicitly mentioned or portrayed
	Designer's professions- explicitly mentioned or portrayed

3.9.3.1 Appearance

A. Human or non human figure

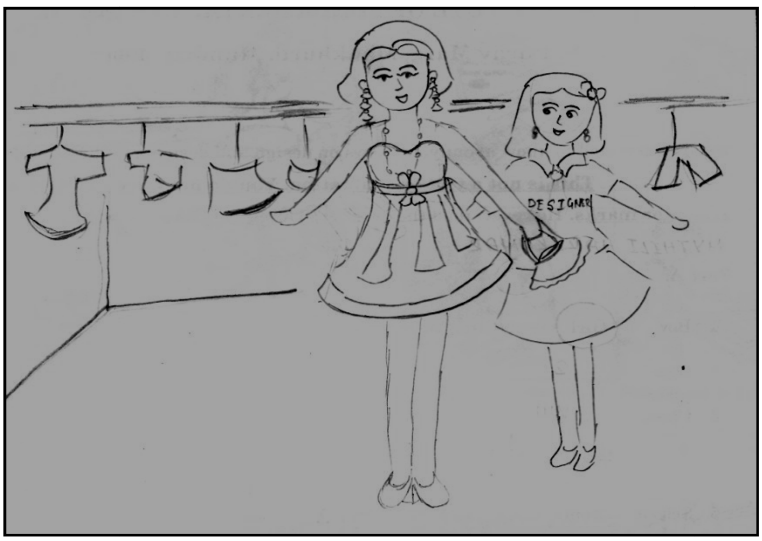
Each student's drawing was observed to check the kind/s of human figure/s depicted. Twenty nine (6%) students did not draw any designer in the space provided. They were excluded from the analysis. Of the remaining 482 drawings, most students portrayed a person (96%) while a few students (4%) drew non-human pictures in the space provided. The non-human drawings included drawings of flowers, patterns and artefacts like dresses, cars, airplanes, and robots. These perhaps indicated the products resulting from designing.

B. Number of human figure

The designer was often drawn as working alone (99% of those who depicted a human figure). Only 4 students drew more than 1 designer working together. However they did not portray these designers working in team but depicted one designer as a subordinate to the other (Figure 3.12). The subordinates were usually shown as labourers, example, painting walls while the main designers usually architects/interior designers were depicted as giving instructions to their subordinates (Figure 3.12). Interestingly all these 4 students were drawn by ESS. None of the older students drew more than a single designer. The large number of students drawing a solitary designer indicates that students considered designing activity as an individualistic activity and not a team work. This may be due to the difficulty arising from making a human figure. But it is important to note that it is not the inability to draw human figures that prevented students from drawing more than one designer. This can be supported by the fact that 41 students (9% of those who depicted only human figures) did draw other human figures in their drawings as customers, clients with whom the designers were working and usually models in case of dress/fashion designers (Figure 3.3). The analysis of students' writings revealed that of these 41 students only 13 referred to the extra human figure as a client or a customer in their writings. However, another 37 students did mention that their designers were designing for some user/customer (mostly celebrities and models) though they did not portray the users.

Except for the above 4 students (who depicted 2 designers working together), no attempt was made by any student to depict a maker for the intended designed product. The designers themselves were shown as designing and making the products.

Figure 3.3: A young female designer dressing up a female model, (MSS, girl)

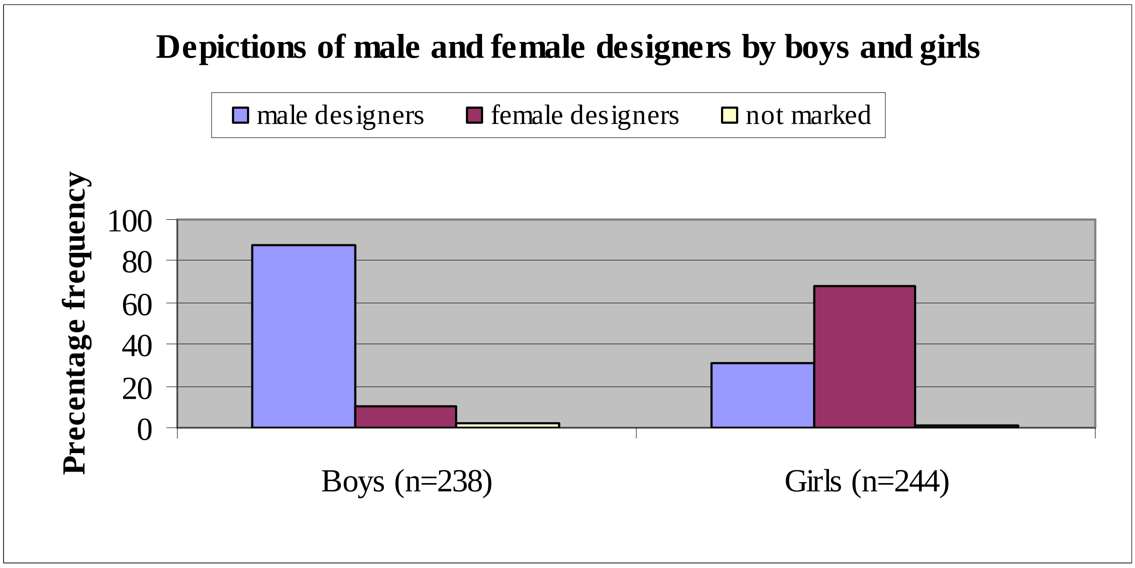


C. Gender of the designer

Students were asked to write whether their represented designer was a male or a female. The mentioned gender was noted for all the drawings whether human or non-human. When the gender of the designer was mentioned by the students (98%), it was found that 59% of the students indicated their designers were males and 40% indicated their designers were females, and about 1.5% (7 students) did not mention the gender of their designers. Attempts were made to ascertain the gender in these 7 drawings. However, it was found that in 2 of these cases, the gender of the designers could not be ascertained from the drawings while 5 of them drew non-human figures and hence did not mark the gender. Overall, the number of male designers depicted was significantly higher than the female designers [χ^2 (1) = 165.330, p = .000].

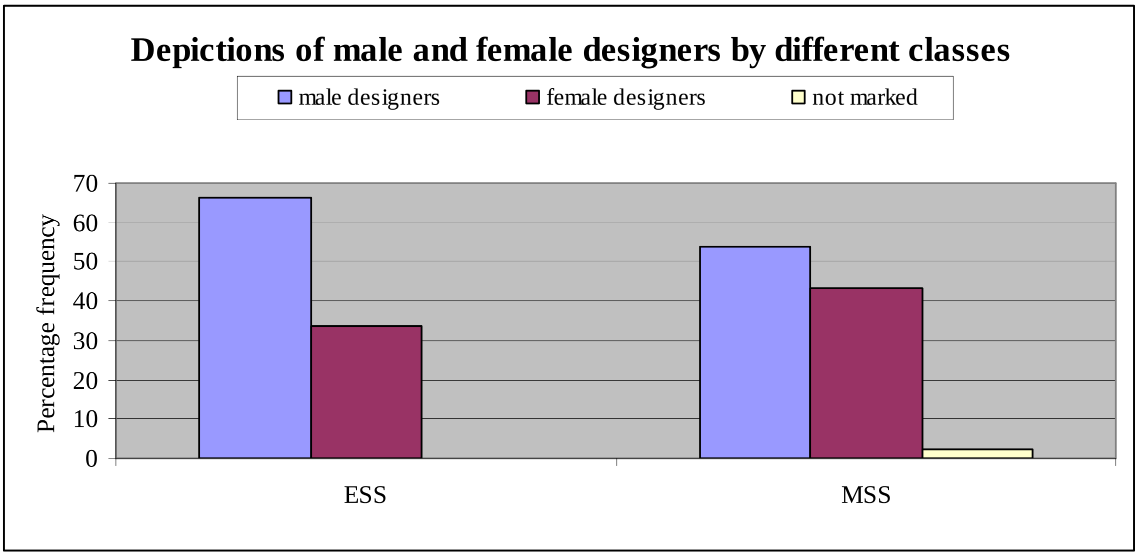
It can be seen from Graph 3.4 that more boys drew male designers while more girls drew female designers and the number of boys depicting male designers (87%) was significantly higher than the number of girls (68%) depicting female designers [χ^2 (2) = 166.678, *p* = .000]. This result is consistent with the findings in other drawing tasks where male figures are mostly drawn by boys while female figures are more often drawn by girls (Huber and Burton, 1995; Chambers, 1983; Chunawala and Ladage, 1998; Knight and Cunningham, 2004; Capobianco, Diefes-Dux, Mena and Weller, 2011).

Graph 3.4: Depictions of male and female designers, gender wise



However, a reasonable representation of female designers by students reveal that they did not associate the profession of designing predominantly with males unlike the findings on students' conceptions of scientists (Mead and Metraux, 1957; Chambers, 1983; Fralick et al., 2009; Finson et al., 1995; Chunawala and Ladage, 1998) and engineers (Knight and Cunningham, 2004; Fralick et al., 2009; Karatas, Micklos and Bodner, 2010; Capobianco et al., 2011) who are predominantly represented as males by students.

Graph 3.5: Depictions of male and female designers by their grades/classes

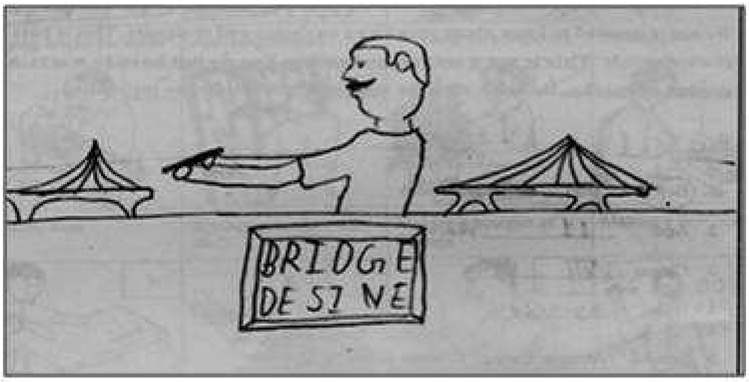


As indicated in Graph 3.5, the greatest percentage of students depicting male designers were ESS (67%), as compared to the MSS (54%). Thus the bias of representing more male designers is reduced in the higher classes. Older students depicted more female designers than male designers. An interesting thing to note is 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 and Newton, 1998). In the present sample, however, the finding was contrary. However most of these females depicted by older students were stereotypically shown as dress/ fashion designers.

D. Age of the designer

Judgment on the age of the depicted designers was subjective, based on the appearance of the designers, such as their physical appearance, presence of moustache or beard for male designers, dressing style etc. For the purpose of categorisation, the young aged people were considered to be below 30 years, middle-aged as between 30-60 years and old aged people as above 60 years. Around 78% of the students depicted designers as being less than 30 years (Figure 3.3, Figure 3.5, Figure 3.8, Figure 3.9, Figure 3.11, Figure 3.12, Figure 3.13 and Figure 3.14). About 8% of the students depicted the designers as middle aged with a moustache on male designers (Figure 3.4, Figure 3.7) and only 2 students depicted designers as old with beard and moustache and wrinkles.

Figure 3.4: Middle aged male designer working on a 3D model; (MSS, boy)



Middle aged female designers were usually depicted with Indian traditional dresses and hair tied in bun. Thus overall designers were depicted as young. Even students' writing in the earlier part of the questionnaire suggested so (see Section 3.9.1.12). This is different from the stereotypic image of an old scientist held by western students (Mead and Metraux, 1957; Chambers, 1983). Interestingly Indian students have also been reported to depict scientists as young (Chunawala and Ladage, 1998). This finding is also inconsistent with the findings from Welch et al.'s study (2006) where students did not show any stereotypes regarding the age of a designer. Designers were reported by Welch et al.'s sample to be either young or old. In this study, no significant differences were noted between the responses of boys and girls and students from different classes.

E. Other Attributes (dress/accessories worn by designer)

The clothing worn by the designers was noted to explore whether students associated any stereotype with designers' clothing and accessories. Many students (55%) depicted their designers in modern formal outfits, such as trousers and shirts for male designers (Figure 3.7, Figure 3.12, Figure 3.15) and skirts or frock for female designers (Figure 3.3, Figure 3.6, Figure 3.8). Around 9% depicted their designers in traditional Indian dresses such as dhoti or kurta for male designers and saree or salwar kameez with dupatta for female designers (Figure 3.11, Figure 3.13). About 27% of student's drawings were not clear enough to recognize the dress worn by their designers (Figure 3.4, Figure 3.10). Both boys and girls, attempted to depict trendy or stylish dresses especially if they depicted a fashion designers (Figure 3.3, Figure 3.5, Figure 3.6).

Regarding the overall appearance, students depicted designers in neat and tidy clothing. In fact most students were preoccupied with fashion and good appearance of the designers, especially girls. Girls seemed to take more effort in drawing the designer's dress in great detail. About 29% of the students (mostly girls) showed the designers wearing accessories such as earrings, necklaces and bangles for female designers (Figure 3.3, Figure 3.13) and eye glasses, helmet or turban for male designers (Figure 3.5, Figure 3.7).

Figure 3.5: A male dress designer, selecting a dress, (MSS, boy)

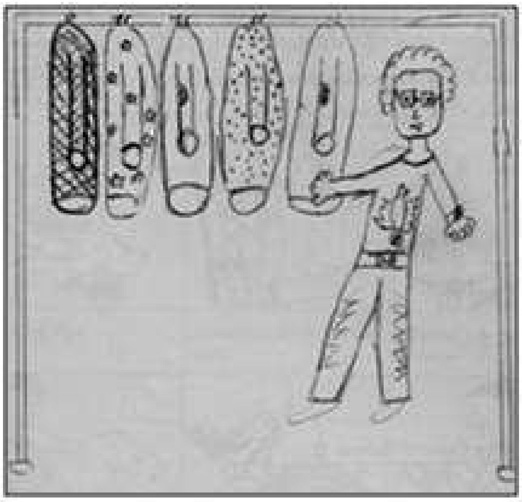
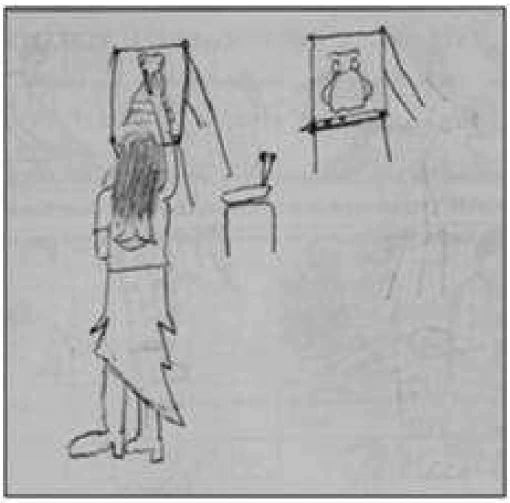


Figure 3.6: A female dress designer, sketching (MSS, girl)



In a study on public's attitude and perception towards engineers and engineering (Marshall, McClymont and Joyce, 2007) it was found that when the engineers were conceptualised as designers, people tended to perceive them as 'cool-looking'. This finding regarding the neat and tidy designer is also in conformity with the Indian students' depiction of scientists where Indian students depicted the scientists as tidy and neat persons (Chunawala and Ladage, 1998) in contrast to the western stereotype of a clumsy and untidily dressed scientist (Chambers, 1983; Mead and Metraux, 1957).

When asked to name the designer, 84% of students provided a name for their designer. About 7% of these students had named the designer with their own names while 3% stated the names of some famous personalities, such as Manish Malhotra (famous Indian dress designer), Michael Jackson (dancer and performer of international reputation), Dilip Chhabria (Indian customized car designer), M.F. Hussain (famous Indian painter) and Leonardo da Vinci (painter, sculptor and scientist). Many students (22 %) just used noun labels instead of names, such as carpenter, architect, painter, dress designer etc.

F. Summary: Appearance of designer

When asked to draw a designer at work, students mostly depicted designers as humans, working alone and sometimes in conjunction with clients (usually fashion models in case of fashion designers). Around 40% of the depicted designers were females (mostly depicted by female students) and this finding is not consistent with the findings in other studies on students' perception of scientists and engineers who are predominantly males. Most designers depicted by students were young and dressed in neat and tidy clothing, sometimes in stylish ones (in case of fashion/dress designers). Girls were found to be preoccupied with fashion and the overall appearance of the designer.

3.9.3.2 Location of the designer

A. Indoor/ outdoor

While reporting the location of where the designer was working, about 69% of students reported that their designers were working indoors while 31% reported outdoors as their designers' location. Even in the depictions, most of the backgrounds suggested an indoor location (43%). For example, students made use of vertical lines and perspective, or depicted furniture around to indicate the indoor location (Figure 3.3, Figure 3.8, Figure

3.10, Figure 3.12, Figure 3.13). This was also supported by their writings. For the outdoor location, students depicted natural objects like sun, trees or mountains (Figure 3.9). It is interesting to relate this study with studies on students' depictions of scientists and engineers. Fralick et al. (2009) found that engineers were depicted outdoors by students twice as often as indoors, whereas scientist were depicted twice as often indoors than outdoors. This could be due to the nature of the activities assigned to them. Scientists who were mostly shown as experimenting and analysing were depicted within laboratories while engineers 'building' and 'making' or repairing things were depicted outdoors. Designers who were shown as sketching, painting, decorating, making/modelling things, were depicted indoors more often than outdoors. Designers shown in indoor location were usually dress makers or fashion designers while those depicted in outdoor location were usually painters, architects and few engineers.

B. Home/ office/ other

Within the indoor location, about 38% of students reported that their designer was working in an office (Figure 3.3, Figure 3.4, Figure 3.5, Figure 3.10 and Figure 3.15) while 30% indicated their designer was working at home (Figure 3.6, Figure 3.8, Figure 3.11, Figure 3.12 and Figure 3.13). Around 26% of students indicated different locations such as factories, plants, ramps in fashion shows, etc. The designers working at home were usually females (Figure 3.6, Figure 3.8, Figure 3.11 and Figure 3.13).

Figure 3.7: A middle-aged male architect sketching (MSS, boy)

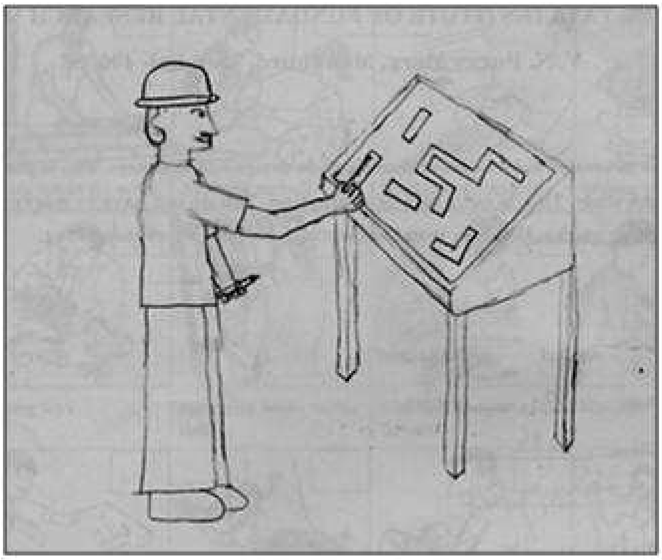
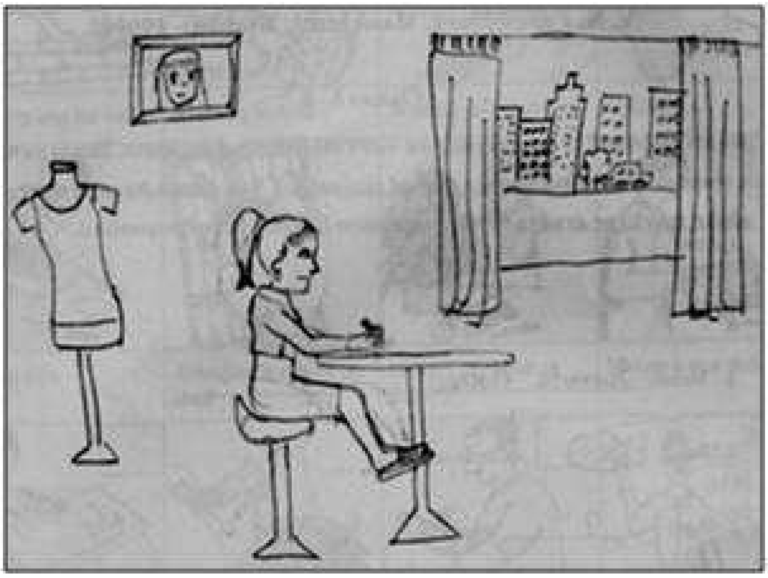


Figure 3.8: A female dress designer, sketching (ESS, girl)



C. Village/ town/ city

Majority of the students (72%) mentioned in their writing that their designer was working in a city (Figure 3.3, Figure 3.4, Figure 3.5, Figure 3.6, Figure 3.7, Figure 3.8, Figure 3.10, Figure 3.11, Figure 3.12, Figure 3.13, Figure 3.14 and Figure 3.15). About 14% mentioned their designers were working in towns while few students (6%) indicated their designers were working in villages (Figure 3.9). A large number of students depicting designers as working in city could perhaps be explained by the fact that these students were themselves from an urban locality.

The designers depicted in the cities belonged to a variety of professions such as fashion designing, architecture, interior designing, engineering, art etc. In contrast, those depicted as working in towns and villages were not just limited in number but also in variety of professions. Those depicted in villages or towns were usually artists (painting landscapes), engineers (working in factories) and a few potters.

A large percentage of students indicating that designers work in offices and at home, reflects students' understanding that designing was both a professional field as well as something that is done even at home, that is design is both a professional as well as a non-professional field.

Figure 3.9: A male designer painting in a village (MSS, boy)

However, the fact that most designing at home was done by female designers (drawn mostly by girls) usually designing clothes or painting, suggests that more girls than boys considered design as an everyday act and more close to an artistic rendering process than to a technological one. This data seem to support the findings from the written responses described in the earlier section of this chapter, where more girls than boys considered design as an artistic rendering process and showed a positive attitude and eagerness to learn design. It was contended that their interest in design seemed to be aligned with an understanding of design as an artistic process (Ara, Chunawala and Natarajan, 2011b).

D. Summary: Location of designer

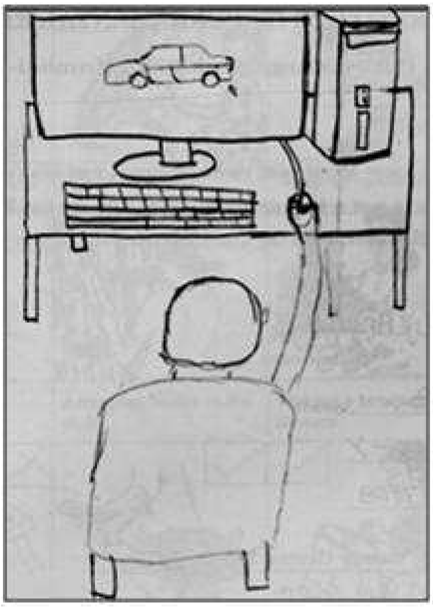
Students depicted designer mostly in a city probably influenced by their own urban location. The need to show the designer sketching at a desk influenced the students' choice of an indoor location for their designers. About equal proportion of students showed their designers working either in offices (38%) or at home (30%) indicating that they understood design both as a professional activity carried out in offices as well as an everyday activity that can be pursued even at home. However, designers depicted at home were more frequently depicted by girls and were often fashion/dress designers or artists doing artistic or decorative work. This indicates girls' association of designing more with artistic than with the technological design.

3.9.3.3 Objects

A. Tools

Tools are items that help us accomplish a task in hand. People often choose appropriate tools to perform the intended task. The choice of tool thus gives an indication to the task being performed. Each drawing was analyzed for the tools depicted by students. An artefact was categorized as a ‘tool’ in a drawing if the designer was found to be working with it as an extension of the hand (Figure 3.6, Figure 3.7, Figure 3.8, Figure 3.9, Figure 3.10, Figure 3.11).

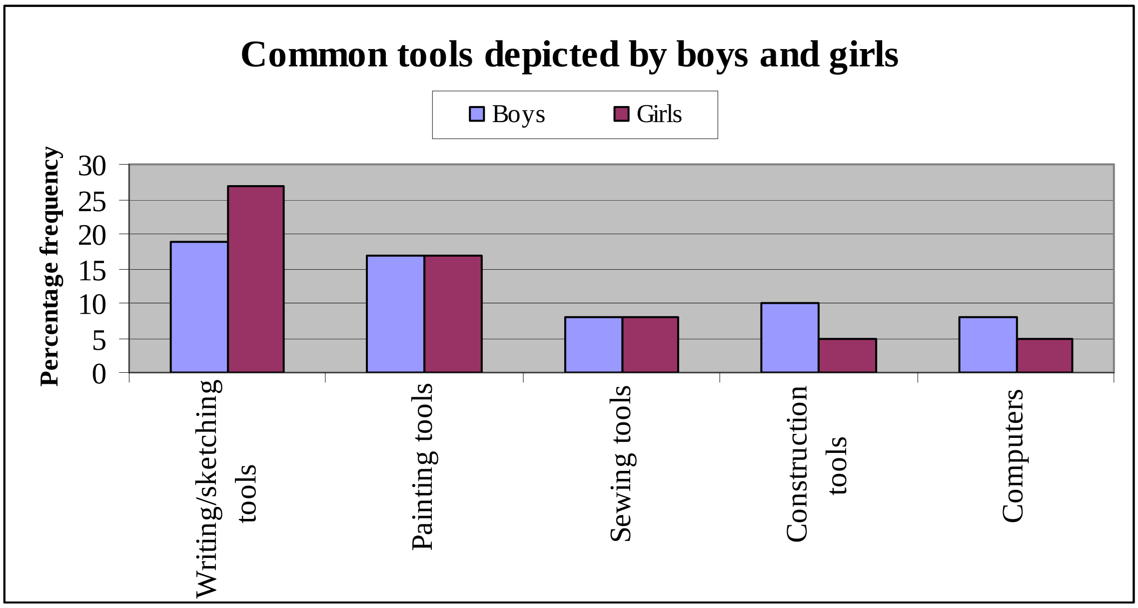
Figure 3.10: A male car designer designing on computer (MSS, boy)



The variety and frequency of tools depicted in students’ drawings are represented in the following graphs. The most frequently depicted tools included: writing tools, painting tools, sewing tools, construction tools and computers. Writing tools usually included pen, pencil or chalk while painting tools included paint brush, palette and canvas. Knight and Cunningham’s (2004) study of students’ depiction of engineers revealed that when students depicted their engineers as designing, they depicted tools such as pens/ pencils, plans/ blueprints, models and computers and artefacts such as desk.

Construction tools usually included hammer, saw and paint brushes and dispensers for painting walls. Ten students (2%) showed a mixed set of tools in their drawings indicating more than one step of the design process. For example, a combination of writing tools and sewing tools or writing tools and construction tools (Figure 3.12) suggest that the students have depicted their design process beyond the conceptualization phase. In Figure 3.12, the student shows the interior designer with the writing/sketching tool, instructing his subordinate designer who is shown to be painting the walls using the construction tools (wall painting brushes and wall paints).

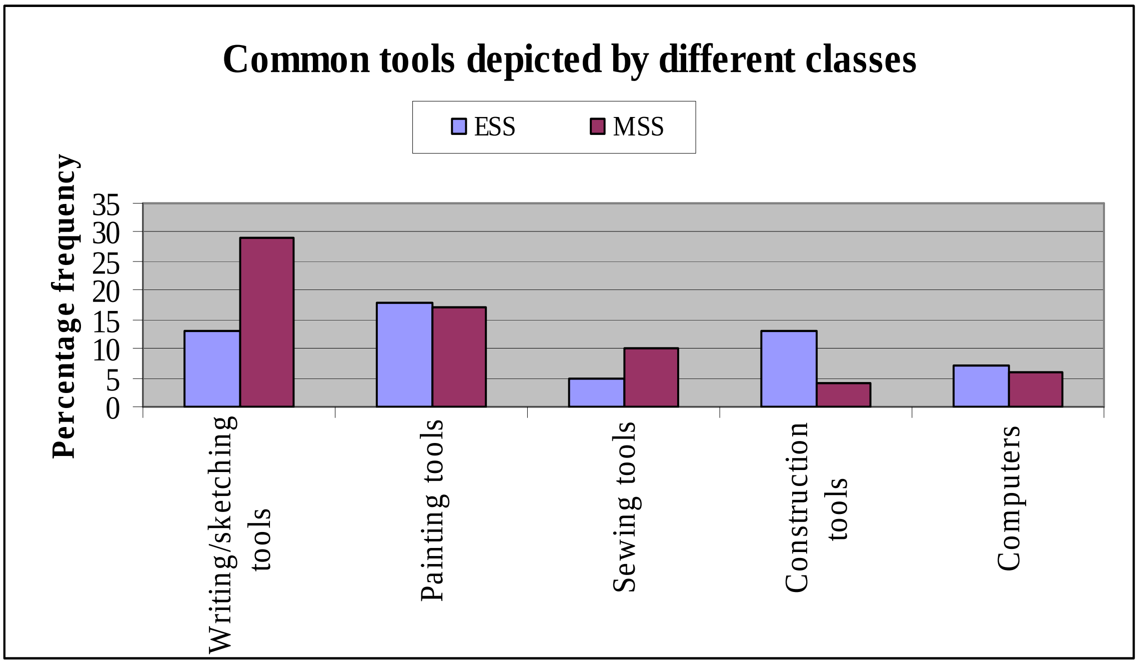
Graph 3.6: Common tools depicted by boys and girls



As seen from Graph 3.6, overall more girls than boys depicted writing/sketching tools. However more boys than girls were found to depict their designers as sketching. This apparent discrepancy could be explained by the observations that that although many girls depicted the writing/sketching tools in their drawings, indicating that writing/sketching has occurred, their designers, however, were shown to be engaged in different activities such as displaying their work (Figure 3.13), making something, or just handling things. About 8% students depicted construction tools usually a painting brush (for painting walls as in Figure 3.12) and a hammer. Only about 6% depicted computers as tools for designers (Figure 3.10). A computer was regarded as a tool only if the designer was shown to be working on it. If the computer was depicted as kept in the background, it was coded as furniture. This has implications in the analysis since a student depicting a designer working on a computer demonstrates an understanding that designing can be done with the aid of a computer. However, a computer just kept as furniture with no one working on it, does not demonstrate whether a student recognizes the importance of computers in designing.

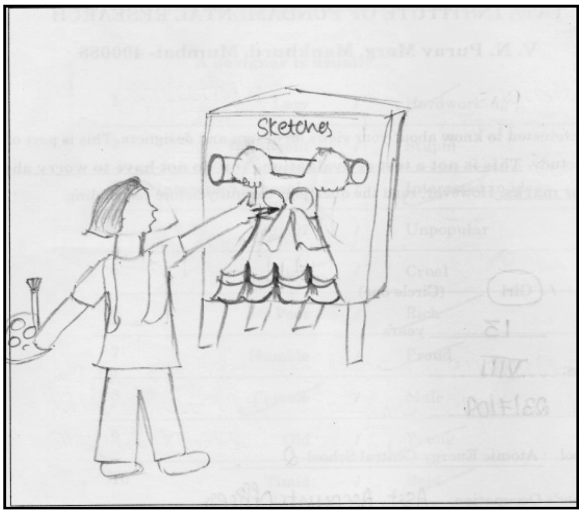
A greater proportion of students' depiction of writing tools in their drawings suggests that designing perhaps was perceived more as a 'white-collar' work represented by the activities of sketching/drawing using writing/ sketching tools and often carried out in an indoor location, than a 'blue-collar' work mostly represented by the repair-type of activities associated with engineers and pursued mostly outdoors (Fralick, et al., 2009; Karatas, et al., 2010).

Graph 3.7: Common tools depicted by students from different classes



A cross tabulation analysis across classes revealed that writing/sketching tools were depicted more often by MSS (29%) than by ESS (13%). This difference was found to be significant at [$\chi 2$ (1) = 16.872, p = .000]. As seen from Graph 3.7, it was also found that more number of ESS (13%) depicted construction tools than MSS (4%). This difference was also found to be significant at [$\chi 2$ (1) = 11.266, p = .000]. These data are supported from the findings that more MSS depicted their designers engaged in the activity of sketching while more number of ESS portrayed architects/construction workers in their drawings (discussed later).

Figure 3.11: A female designer using painting tools for designing a dress (MSS, girl)



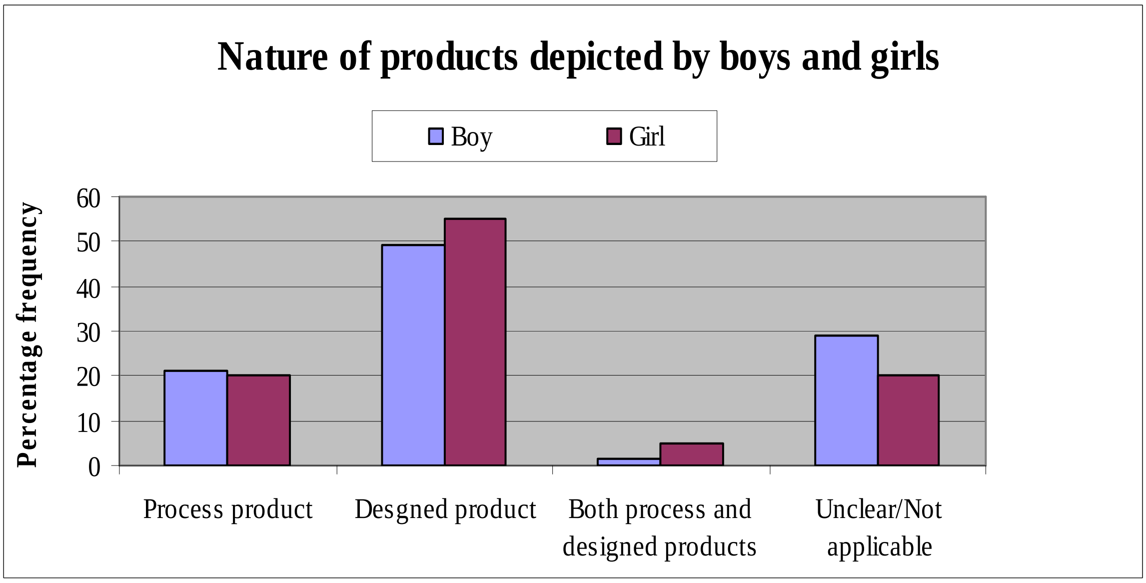
B. Products of design

Products of design include those artefacts which are created during the process of design (such as sketches, blueprints, models) and those which result from designing (finished products like dress, paintings, cars, buildings). The artefacts which were created in the process of design were coded as ‘process products’ and usually entailed a conceptualization phase of the design process. The artefacts which were created as the result of the design were coded as ‘designed products’ and can be said to entail the modelling or the making phase of design. Any attempt by the students to depict either of the artefacts were coded accordingly and matched with the writings of the students. If a student depicted an artefact such as a car without indicating anything in the writings, it was labelled as ‘unclear’. If the student mentioned that a designer has designed the car, it was coded as ‘designed product’ and if the student showed the designer working on a sketch of a car either on paper or on computer, it was labelled as ‘process product’. Students depicted the ‘designed products’ (either finished or incomplete) (Figure 3.3, Figure 3.5, Figure 3.8, Figure 3.9, Figure 3.13, Figure 3.14, Figure 3.15) more often (52%) than the process products (either complete or incomplete) (Figure 3.4, Figure 3.6, Figure 3.7, Figure 3.10, Figure 3.11, Figure 3.12) (21%). Very few students (3%) depicted both the type of products (Figure 3.8, Figure 3.13).

The kind of 'designed products' depicted were mostly dresses, paintings, buildings and few cars and robots. It should be noted that in studies on students' perception of engineers that when students depicted their engineers as designing, they mostly drew cars, buildings and electronic devices (Capobianco, et al., 2011). Engineers were also shown as making, fixing or repairing cars, trucks, trains, rockets, airplanes, machines or electronic devices, etc. (Knight et al., 2004; Cunningham et al., 2005; Fralick et al., 2009; Karatas et al., 2010). The only common 'designed' products depicted by students in this study and the 'engineered' products depicted in other studies mentioned above are buildings, very few cars and robots. Students in this sample instead, largely depicted dresses and paintings which indicates that they associated design less with engineering and more with art, decoration or styling. This is also consistent with their written reponses where they mostly suggested examples of dresses as designed products.

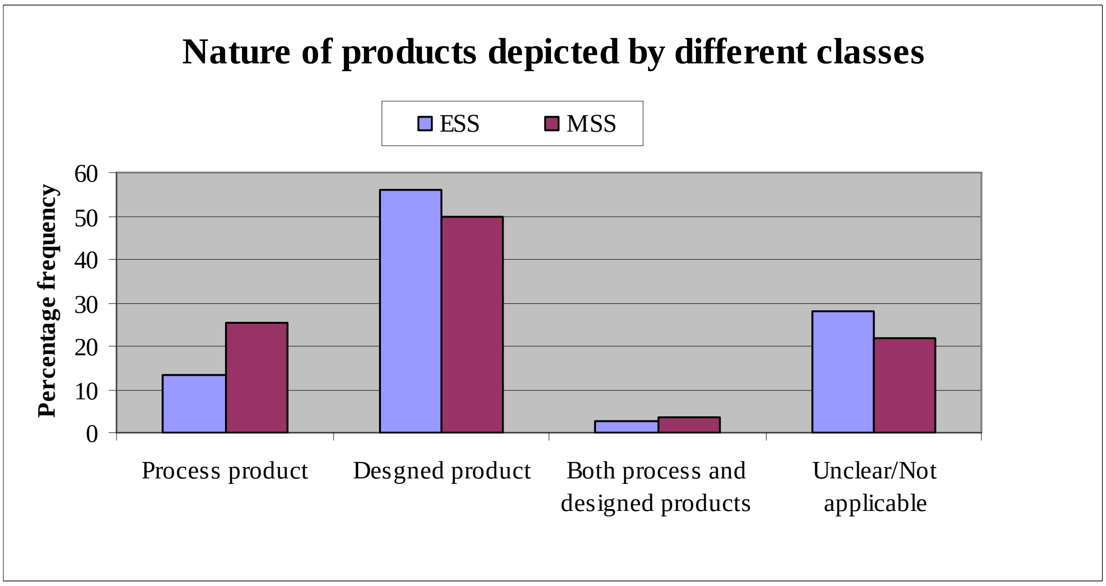
A cross tabulation across gender revealed that there was no significant difference found between boys and girls in depicting the products of design. However, girls depicted the 'designed products' slightly more often than the boys.

Graph 3.8: Nature of design products depicted by boys and girls



A cross tabulation analysis across classes revealed that the 'process products' were more often depicted by MSS than by ESS. Thus MSS were found to depict their designers in the conceptualization phase more often than the ESS. The reverse was true for 'designed products' with ESS depicting more of these products than the MSS. On the basis of these findings, one can extend the analysis by claiming that younger students in this sample considered designing as inclusive of making. This claim can be justified from the fact that ESS were found to depict their designers engaged in 'making' some things more often than those from the higher classes. This is also consistent with their responses in the written questionnaire where they produced ideas related to designer's work as 'making' more than MSS (Table 3.8).

Graph 3.9: Nature of design products depicted by students from different classes



This finding is also supported by students' spontaneous association of ideas with design where more ideas of ESS than MSS were reported to be associated with 'making'.

C. Artefacts other than tools and products of design

Students' drawings were also analysed for the artefacts other than the tools and products of design. Nearly half the students (45%) depicted furniture, mostly desks, chairs and easels. Mannequin/hangers were the next artefacts that were very common in about 14% of students' drawings. Girls, significantly more than boys, depicted mannequins/hangers [χ^2 (1) = 12.97, p = .000] (Figure 3.8, Figure 3.13). Girls were also found to depict fashion/dress designers more often than did boys and thus had the need to depict mannequin/hangers (shown in Graph 3.10 and discussed in a later section).

A cross tabulation of analysis across classes revealed that MSS students depicted mannequin/hangers more often than the ESS, and it was found that they also depicted fashion/dress designers more often than the ESS. Other artefacts depicted by a very few students were cars and buildings which were not indicated as products of design unless mentioned by students in their writings.

D. Summary: Objects

Choice of tools indicates the kinds of task being performed. The common tools that were frequently depicted by students were tools for writing, painting, sewing, constructing and lastly computers. Older students were found to depict sketching tools more often than younger students, indicating that they showed their designers engaged in sketching more often than the younger students. Younger students, in contrast depicted more construction tools suggesting they depicted their designer often engaged in making something. ‘Process products’ or those products created during the process of design (such as blueprints, plans or models) indicated the ideation or the conceptualization phase of designing and were more frequently depicted by the older students than younger ones indicating that the former had a better understanding of design. The ‘designed products’ included the finished products resulting from designing. Designed products in general were depicted more often than the ‘process products’ and mostly included artefacts such as dresses, paintings, buildings, very few cars and robots. Other objects depicted were furniture, mostly desks where the designer was shown to be working, and mannequins for hanging and displaying prepared clothes. Girls were found to be depicting more mannequins and this also matched with their depictions of more number of dress or fashion designers.

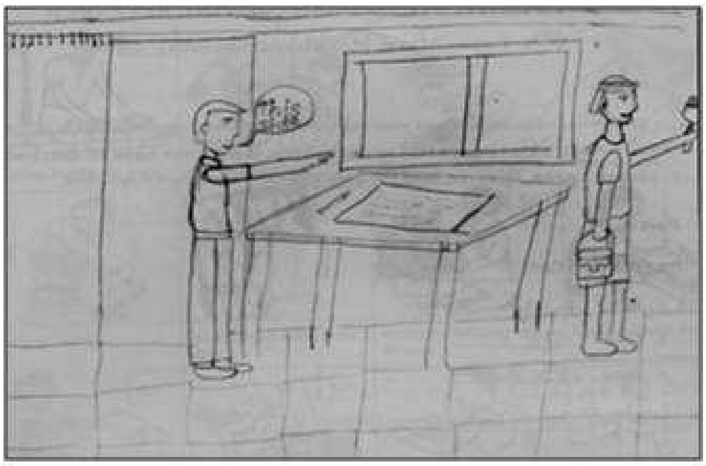
3.9.3.4 Inferences of actions

A. What the designer was doing

Attempts were made to infer the actions of designers depicted in students’ drawings. An action was coded as working when a student has attempted to show some activity through a moving hand/s, or holding a tool/artefact in hand, working with tool/artefact. The actions depicted in the drawings were then matched with the description given by the students.

However, in cases where the descriptions did not match the drawings, the actions were coded on the basis of what was shown in the drawings and not what the student wrote. For example if a student wrote, '*He is designing the interior of a house'*, and the drawing by the student suggested the designer to be giving instruction to somebody then it was coded as 'giving instruction' (Figure 3.12). Yet again for example if a student just wrote, ‘the designer is designing’, while actually the drawing represented a person painting walls, then the action was coded as ‘painting walls’. However, in cases of drawings with labels, ‘the designer is designing’, if a designer was shown as sketching something without students’ indicating what the designer was sketching, the action was coded as ‘designing/sketching’. Coding in this way allowed the researchers to list the kinds of activities that students considered as designing, or which they thought were subsumed in designing.

Figure 3.12: A male designer giving instruction to a sub-ordinate (ESS, boy)



Most students (90%), including about equal number of boys and girls showed their designers as working. Both boys and girls equally showed their designer working.

Table 3.27 represents the top ten depictions of designer’s actions based on gender and class. As seen from the table, the activity that was depicted by 20% students was sketching (on paper or on computer) (Figure 3.6, Figure 3.7, Figure 3.8, Figure 3.10; Figure 3.11). The other activities that were depicted by students as designer’s actions were doing artistic work (18%) (Figure 3.9), making/modelling (12%) (Figure 3.4), displaying (11%) (Figure 3.13), handling things (6%), reading/writing (5%), trying/testing (5%), doing personal work like cooking, playing (4%), doing labourers’ job such as cleaning, painting walls or constructing (4%) **(**Figure 3.12, Figure 3.14) and operating on something (3%).

Table 3.27: Designer's action depicted by boys and girls from different classes

Designer's action inferred	*Total %*	*Boys n=238*	*Girls n=244*	*ESS n=188*	*MSS n=294*
Designing (sketching)	20	21	20	13	25
Art work (painting/ decorating)	18	17	18	19	17
Making, modelling, repairing,	12	16	8	14	11
Displaying /advertising	11	7	14	9	12
Handling things	6	6	6	3	8
Trying, testing, evaluating	5	3	7	6	5
Personal work (playing, dancing)	5	5	5	6	4
Reading /writing/observing	4	4	5	4	4
Labour (painting walls, laying bricks)	4	5	4	9	1
Operating on, driving,	3	2	3	3	3

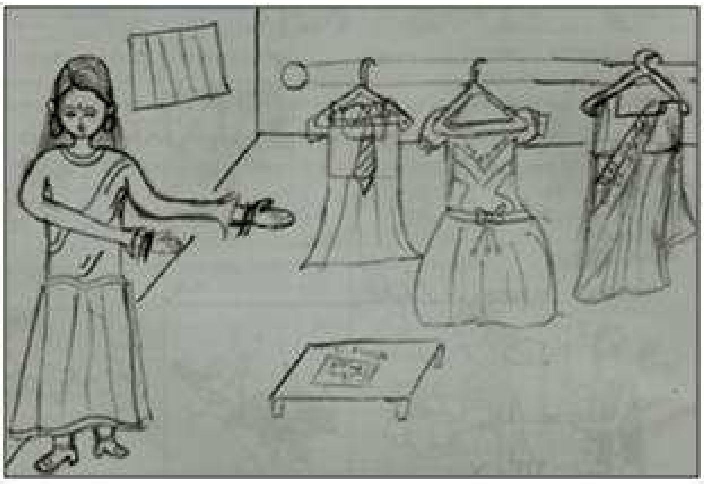
Many students, both boys and girls (18%) showed their designers engaged in some artistic work like painting, decorating, doing embroidery or making some patterns on clothes etc.

Significant differences noted between boys and girls in depicting the different actions of designers for the activities of 'making', 'displaying' and 'testing'.

More boys than girls depicted their designers as 'making' (Figure 3.14, Figure 3.15), modelling (Figure 3.4) or fixing some things. Designers were usually shown to make dresses and buildings. This finding is in conformity with students' responses to the spontaneous ideas associated with design where many students provided examples of mostly dresses and buildings as designed products.

About 26% of the designers, who were depicted as 'making' something, were engaged in doing some labour work such as laying brick (Figure 3.14), painting walls (Figure 3.12), cleaning rooms etc. A few boys also depicted their designers as making cars and robots (Figure 3.15). More girls (14%) than boys (7%) showed their designers as displaying their products either through literal display (Figure 3.13) or through modelling like walking on the ramp in designers' clothing.

Figure 3.13: A female dress designer displaying her work (ESS, girl)

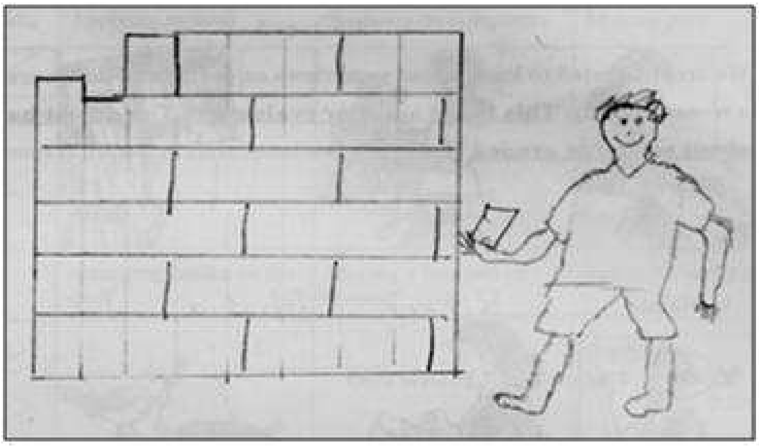


A display of products by designers represents the completion of the design process and thus represents students' emphasis on the final products of design.

Girls were also higher in number (7%) than boys (3%) in depicting their designers as testing or evaluating the products (mostly dresses). The testing or evaluation of products was mostly shown to be done by dress designers through trials of the dresses on models (Figure 3.3) or mannequins. The idea of testing the dresses perhaps stems from the customary practice of trying out an outfit once it is stitched by a tailor.

Class-wise cross tabulations revealed that older students depicted their designers as sketching more often (25%) than did the younger students (13%). This is in conformity with the data on writing/sketching tools and process products where older students were more often found to depict writing/sketching tools and process products than younger students. Although less than quarter of the students (20%) depicted their designers as sketching, this is important, given that design is not taught in schools, these students begin to see sketching as designing. However, most of these sketching by older students were related to the designing of dresses.

Figure 3.14: A male designer laying bricks on walls, ESS, boy



Both ESS (19%) and MSS (17%) equally showed their designers engaged in artistic work. However, while the younger students mostly depicted painting as designing, older students usually depicted their designers as decorating something mostly on cloth/clothes. These older students usually depicted a fashion/dress designer who was engaged in artistic work. The fact that many students depicted their designers engaged in artistic work represents their strong conflation of designers with artists or decorators. This finding confirms our findings in the written responses where students associated design mostly with art (Ara et al., 2011b).

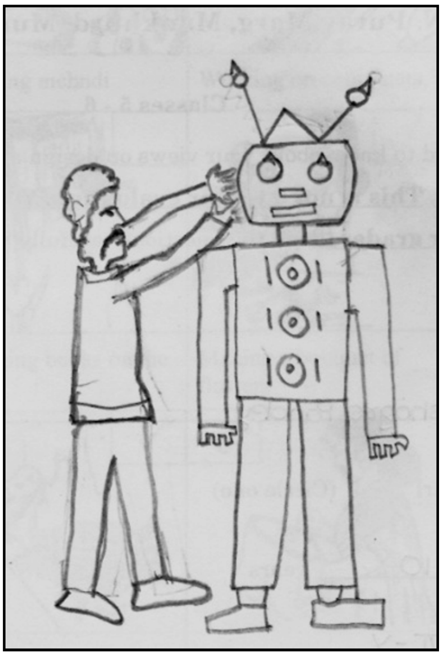
As seen from Table 3.27, MSS (11%) depicted their designers as making something more often than the ESS (4%). ESS also depicted their designers engaged in labourers' work like laying bricks (Figure 3.14), painting walls (Figure 3.12) and cleaning rooms, more often (9%) than the MSS (1%). These students seemed to have assumed that designing includes the making of artefacts. These findings indicate students' lack of understanding of the nature of design and their strong association of the activity of designers with making art or making something. That designing involves conceptualization and generation of specifications for an intended product and modelling (and not making) was missed by many students. Only 2% of all the students depicted their designers as making a 3D model (Figure 3.4).

A cross tabulation analysis between gender of designer and the activities assigned to them by students was done. Significant differences were noted for the activities of making and displaying where more male designers were shown to be 'making' more often than the female designer [χ^2 (1) = 13.842, p = .000] while more female designers were shown in a more passive role of ‘displaying their products [$\chi2$ (1) = 14.259, p = .000].

B. Designers’ professions

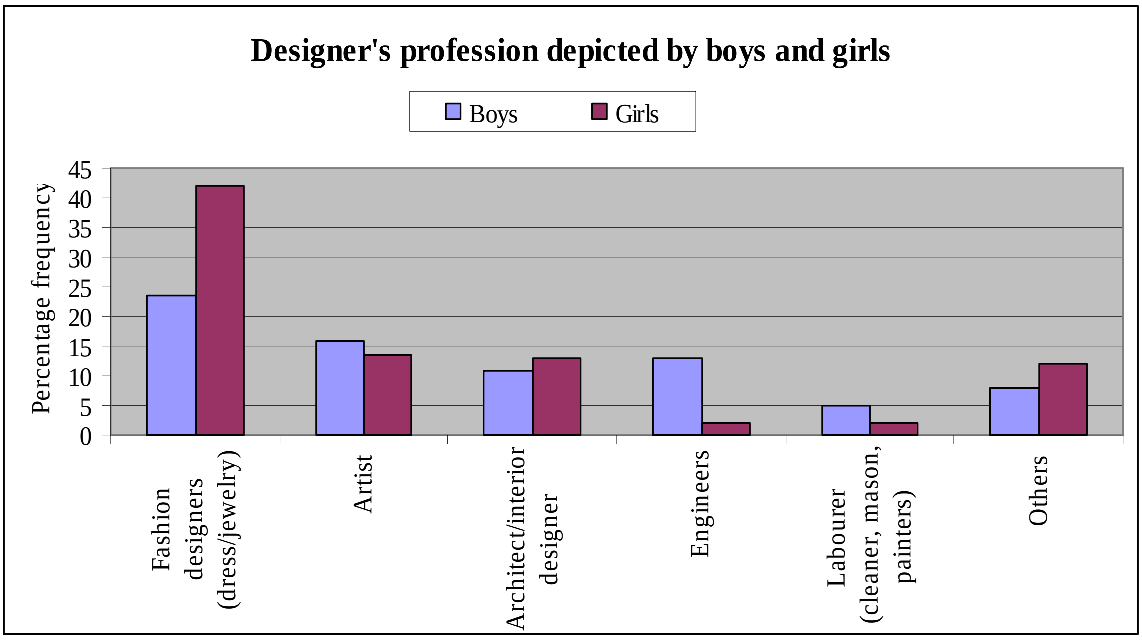
This section describes whether and how students differentiated designing as a profession. It describes the kinds of designers (dress designers, interior designer, etc.) that students depicted in their drawings. Graph 3.10 represents the characterization of designer’s professions as depicted by boys and girls. As seen from Graph 3.10, the design professional that was mostly portrayed by students was a dress/fashion designer (33%; Figure 3.3, Figure 3.5, Figure 3.6, Figure 3.8, Figure 3.11, Figure 3.13).

Figure 3.15: A male robot engineer making a robot (ESS, boy)



Both boys and girls seemed to have assigned a gender and professional stereotype to their drawings by depicting more female dress designers. This finding substantiates the findings in the first part of the survey where students spontaneously generated examples of fashion designers. Other professionals depicted were artist (15%; Figure 3.9), architect/interior designer (12%; Figure 3.4, Figure 3.7, Figure 3.12), car/robot engineers (7%; Figure 3.10, Figure 3.15), labourer (4%; Figure 3.12, Figure 3.14) and others such as a scientist, models, teachers, doctors etc (10%).

Graph 3.10: Designers' professions depicted by boys and girls



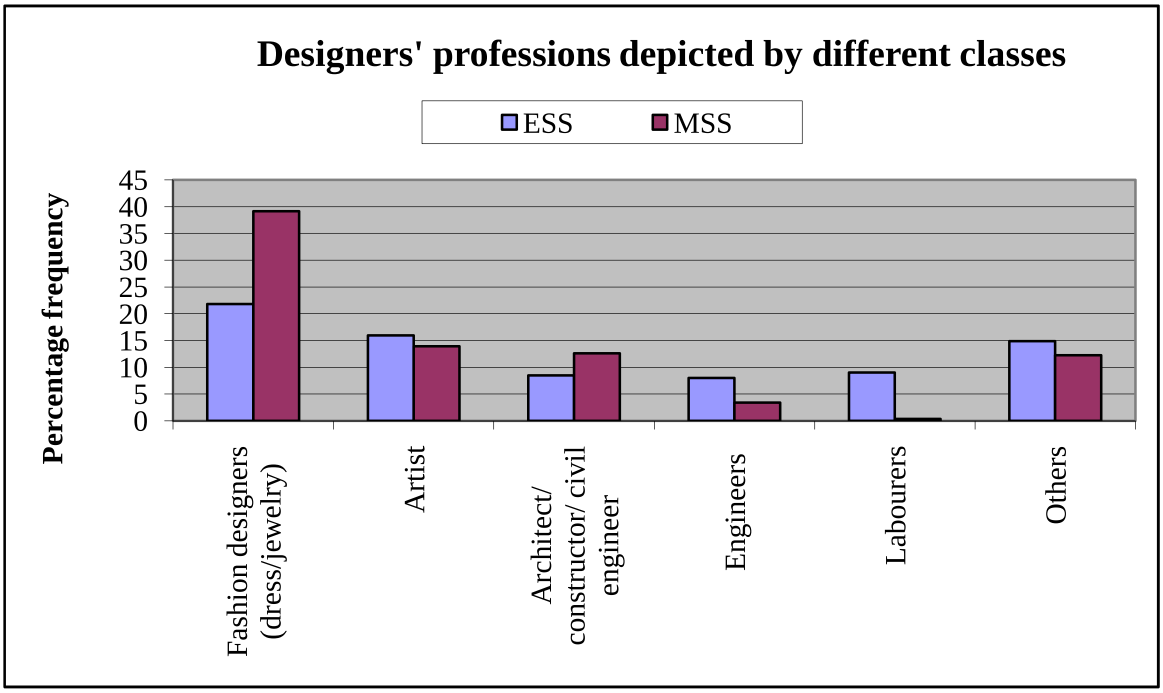
Gender-wise cross tabulation revealed that more girls (42%) than boys (24%) depicted dress designers. Also, except a few depictions, most of these dress designers were females. A cross tabulation analysis between gender of designer and the professions assigned to them were done. A significant difference was also noted in the depiction of more female fashion designers (17%) than male fashion designers (6%) [$\chi2$ (1) = 14.259, p = .001].

Even Owen (2005) suggests that there is confusion among the general public about the nature of design due to the extensive use of the word 'design' to mean fashion. While fashion designers are stylists mostly concerned with the aesthetics without much regard to functionality, performance or human factors, other design professionals do not deal with aesthetics exclusively. Perhaps this leads to the strong association of design with beautification or aesthetics among the general public.

More boys (13%) than girls (2%) depicted their designers as engineers, mostly related to software, car (Figure 3.10), civil and robot (Figure 3.15). This difference was found to be significant.

A grade wise cross tabulation analysis revealed that more MSS (39%) depicted dress designers in their drawings than ESS (22%). Artists (15%) mostly painters were the next professionals that were depicted by students. Characterization across grades also revealed that both ESS (16%) and MSS (14%) equally represented their designers as artists.

Graph 3.11: Designers' professions depicted by students from different classes



A cross tabulation analysis between gender of designer and the professions assigned to them revealed significant differences in the depictions of more male engineers than female engineers [χ^2 (11) = 8.363, p = .004].

Students' drawings showed considerable evidence of designers of mostly one profession: dress designing. These images were present through the products of designing like dress, clothes, and sketches. This is in agreement with our findings from the written responses wherein most students gave examples of dress/clothes as things that are designed and fashion designers were the most cited examples (Ara et al., 2011b).

An interesting observation was that younger students depicted more cars and robot designers or engineers (13%) and less fashion/dress designers. A plausible explanation could be their less awareness of the popular media and less identification with the culture of fashion than the older students who are more familiar with the popular media and hence more influenced by fashion.

Regarding the perception of scientists and engineers, it has been reported in literature that students' perceptions of these professionals are likely to be influenced by a number of social and cultural factors such as those found at home and communicated to by parents (Barton, et al., 2001), those found in schools and communicate to by teachers and peers (Lee, 2002) or those that are found in popular culture and transmitted through different sources of media such as magazines, televisions, internet (Steinke, 2004).

In this study, more girls than boys were found to assign an occupational stereotype by depicting more female fashion designers than any other design professionals. This could perhaps be due to more exposure to fashion and trends in style in girls than in boys. According to Willemsen (1998), in many countries, the general interest magazines for teens are actually meant for girls consisting of gender stereotypic contents, whereas the teen magazines for boys are rare or do not exist. If the boys magazines exist, they usually cover topics which may be of interests to both boys and girls.

C. Summary: Inferences of actions

Students depicted their designers engaged in a variety of activities, namely as sketching, doing art work, making/modelling, displaying their completed work, handling things, reading/writing, trying/testing products, doing personal work like cooking, playing or doing labour job such as cleaning, painting walls and operating on something. More boys than girls depcited their designers as making, modelling or fixing somethings. More girls than boys, on the other hand, were shown to do passive work like displaying their finished products. Older students were found to depict their designers enagaged in sketching more often than younger students, suggesting that the former had a better understanding of the nature of design. Students depicted a variety of design professionals, namely, dress/fashion designers, artists (mostly painters), architects/interior designers, engineers (car/robot engineer), labourer, scientists, fashion models, teachers, doctors etc. It was observed that girls and older students depicted more fashion/dress designers while boys and younger students depicted more engineers. This could perhaps be due to the influence of the mass media on older students usually girls than on the younger students.

3.9.4 *Summary of students', teachers' and designers' ideas of design: Salient findings*

The survey provides useful insights into Indian elementary and middle school students', teachers' and designers' ideas of 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. The study aimed at indicating points of overlaps among the ideas of students, teachers and designers. The salient findings of the study can be summarized as follows:

3.9.4.1 *Students' ideas*

The survey (questionnaire and the interviews) reveals that majority of the students associated design with art, mostly painting on canvases, decoration or pattern-making. Even the examples of designed products seemed to suggest students' emphasis on aesthetics and appearances of products. Students also associated design with drawing, making, planning or inventing and few with ideating. While younger students presented simple views about design mostly as painting or making, older students held a more varied understanding of design, such as design as making, planning or drawing to show how things are made, ideating or shapes of things. Some students also portrayed spontaneous positive attitude towards design and design learning with remarks such as '*I like to design*'. Younger students tended to produce such remarks more often than the older students.

Students' understanding of design as art also gets expressed in their drawings of designers where most students (mostly younger students) depicted artists painting landscapes or engaged in some artistic work. Students' writings and drawings both are indicatives of the fact that students related design more with art and less with engineering and technology. Research studies on students' attitudes towards technology have found students' strong association of technology with computers, electric and electronic equipments (Khunyakari, Mehrotra, Chunawala and Natarajan, 2009; Jarvis and Rennie, 1998; Mehrotra, Khunyakari, Chunawala and Natarajan, 2007; de Klerk Wolters, 1989). Even students' drawings of engineers revealed students' depiction of machines, vehicles, rockets and robots (Knight and Cunningham, 2004; Cunningham, Lachapelle and

Lindgren-Streicher, 2005; Fralick, Kearn, Thompson and Lyons, 2009; Karatas, Micklos and Bodner, 2010; Capobianco, Diefes-Dux, Mena and Weller, 2011). In the present study however, students were not found to mention or depict any electrical or electronic equipments or machines as designed product. This observation can be extended to the analysis that students were not able to see any strong link between design and technology or design and engineering. Students' responses in the interviews suggested that although students showed an understanding of the link of design with technology, the link was found to be superficial with students' considering design as providing only aesthetics to technological products.

The most commonly cited designers by students in their spontaneous responses writing were fashion designers especially by the middle school students. This stereotype also gets reflected in their drawing of designers where many older students depicted fashion designers. While students' responses in the questionnaire could only reveal the professional stereotype that students' associated to designer, their drawings of designers exposed the gender stereotype that they associated with designers. Although 40% of students indicated that their designers were females, most of these female designers were stereotypically depicted as fashion or dress designers. Mostly 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.

In their drawings, students primarily conceptualized a designer as a fashion designer, artist, architects, engineer and a few as labourer and scientist. Designers as labourers or scientists were not evident in any of students' written responses. This was only seen in students' drawings. Younger students strongly seem to conflate artists such as painters with designers. Older students were more likely to think that designers were involved in designing mostly dresses, less buildings. According to students' depictions, the work of a designer was restricted to sketching, painting, displaying their prepared products or making or fixing and using artefacts such as dress materials, writing tools and painting tools.

Another aspect revealed in students' drawings of designers and the interviews was the location where designers worked. Most designers were depicted as working indoors either in offices or at home. This suggests that design was perceived as a professional activity, most preferably a ‘white-collar’ one in contrast to the ‘blue-collar’ activity mostly assigned to engineers in other studies (Fralick, et al., 2009; Karatas, et al., 2010). Design was also perceived as an everyday activity being performed at home. However, the design activity performed at home was mostly related to the designing/ decoration of dresses by dress designers/ makers. The activity of design taking place at home was also expressed by students in their interview responses where a few of them suggested that people engage in design in their daily life through activities such as sketching, painting, tailoring or garnishing food.

Interestingly teachers understood design as a general planning process. They emphasized the ideating process of design and considered ideas as central to designing which is consistent with the study by Newstetter and McCracken (2001) where graduate students considered ideation as important process in design. None of the teachers however, mentioned ‘planning before making something’ or ‘planning to make something’.

3.9.4.2 Teachers’ ideas

There were some overlaps and non-overlaps between students’ and teachers’ spontaneous ideas of design. For example, like students, teachers too associated design frequently with art. However, unlike students, teachers considered design as a general planning process and did not emphasize the planning-before-making aspect of design. Thus teachers’ ideas pertained to the design of intangibles while the contrast was true for students, who mostly gave examples of tangibles products of design such as dress, buildings and cars. Most examples provided by teachers pertained to the planning of curriculum and lesson plans. None of the teachers gave examples of any designed products which were related to electronics or electrical things (which were associated with technology or engineering by students in the literature). Like students, teachers also did not show any link between design and technology.

The fact that individuals form perceptions based on what they encounter in daily life was evident in teachers’ ideas of design. For example, teachers associated design very strongly with their own profession of teaching. They mostly cited examples of lesson plans or curriculum and even fate of students as things that teachers design. In contrast students did not view teaching as related to designing.

3.9.4.3 Designers' ideas

Unlike students and teachers who emphasized on the surface features of designed products, designers had a deep and rich understanding of design. Considering design fundamentally as human-centric all the designers believed design was done to serve a purpose. Each designer emphasized on one or the other significant aspects of design. Thus while the user interface designer primarily focused on the environment and suggested a holistic approach to designing products and systems, the product designer emphasized on the relationship between the designed product and its context of use.

3.9.4.4 Skills of designers

Students spontaneously suggested skills associated with designers such as creativity, imagination, having ideas, talent in design. Teachers also shared this belief and suggested two skills, creativity and imagination. Designers, however, suggested a different repertoire of skills associated with designing, namely, being open to perceptions, skills in observation, multidisciplinary, visualization skills, intuition etc.

3.9.4.5 Linguistic aspect

The different word/meanings for the English word 'design' in different Indian languages also reflected students' and teachers' 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 Indian words suggested by designers were closest to the meaning of design in English. These words were probably taught in their design courses.

3.9.4.6 Designing among animals

Interestingly while considering designing by animals and ancient humans, students and teachers focused on their making activities. However while considering design in general, they 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' and teachers' 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' written and drawn responses. However, on probing students' responses in the interviews, the purposes of design got revealed in a few students' responses.

3.9.4.7 Nature of design

Only a few students' ideas invoked two steps of the designing process (i.e., planning and making, or ideation and making in their spontaneous responses. The two steps of the designing process also get reflected in a few students' drawn responses where students depicted a variety of tools to depict different stages of the design process. Teachers accentuated the ideation phase of designing. Thus coming up with different ideas was emphasized by teachers. However none of the teachers attempted to elaborate on how those ideas could be developed through testing and evaluation.

Students' and teachers' responses to the structured questions on the nature of designing also suggest that they consider designing as an artistic rendering process. Designing was essentially associated more with art than with engineering by both students and teachers. Designers can be considered as artists to the extent that they bring their sense of aesthetics into their design but designing is much more than mere aesthetics and decoration. The findings of the study reveal that Indian middle school students have a lopsided understanding of design, since they associated the work of designers more with artistic design than with the technological or engineering ones. 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.

3.9.4.8 Design and stereotypes

Responses to the structured question also revealed students' sex-role stereotypes for certain professions such as cooking, teaching, jewellery designing, fashion designing, tailoring and interior designing. Most teachers and designers were not found to portray any sex-role stereotypes for any profession.

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. Nevertheless, Krathwohl, Bloom and Bertram (1964) suggest that students who have a positive attitude toward a subject are more often engaged in active learning both during and after instruction. Thus accordingly, if they exhibit a positive attitude towards design, they will be more likely to attain design and technological literacy through designing activities.

Most students attributed positive qualities to designers. Teachers however, being more experienced tended to select both positive and negative qualities for a designer. 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. Coming from the actual design field, all the designers attributed both the qualities to the designer.

An understanding of the role of modelling and testing as a part of design practice is fundamental to design thinking. However, this was never emphasized in either of the students' or teachers' responses. Although students did attempt to depict some form of testing or evaluation of design in their drawings, these were all strikingly related to the field of fashion designing. Even teachers were not found to report any ideas on testing or evaluating the lesson plans or activities that they often cited as designed products.

Designers can be considered as artists to the extent that they bring their sense of aesthetics into their design but designing is much more than mere aesthetics and decoration. The findings of the study reveal that Indian middle school students and teachers have a lopsided nature of understanding of design since they associated the work of designers more with artistic design than with the technological one.

The survey revealed that designers held a more rich and sophisticated understanding of design. In order that our students and teachers share those views we need to engage students in designerly activities. As suggested by the designers in the survey and also emphasized by researchers in literature (Hennessy and McCormick, 2002; Hennessy and McCormick, 1994; McCormick, Murphy and Hennessy, 1994) providing authentic contexts to an activity will provide avenues for problem-solving and designerly behaviours among students.

Both teachers and designers in the survey showed a positive attitude towards inclusion of design education in the general school curriculum. They both embraced the idea of the including design at the school level by recognizing its potential in fostering creativity and imaginative skills to students. However, although teachers emphasized that design would foster creative thinking among students, they were unable to identify what differentiated design education from other subjects in the curriculum and how it could be introduced into the curriculum. Designers on the other hand, holding a generalist and democratic view on design, suggested a holistic approach to the design integration in schools.

The findings from the survey indicate that although students' ideas of design were varied, they lacked depth. Students' ideas about design and designers, though partly accurate were found to be limited and biased. There is a need to introduce design at the school level as a distinct subject with design knowledge and skill requirements.

The complexity in today's design world has increased. Today with energy crisis and a need for a sustainable environment, an understanding which entails design as a plan or a pattern or just a plan before making is not enough. The present era demands that individuals have a holistic understanding of design which relies on taking responsibilities of not only designing products and systems but also purchasing them and using them. Individuals having a limited and a superficial understanding of design will tend to evaluate products based on their surface features. This is not only detrimental to oneself as a user but also to the society at large since a design ignorant individual would fail to make design decisions in public spheres.

Chapter 4

DEVELOPMENT AND TRIALS OF DESIGN ACTIVITIES

'The only source of knowledge is experience.'

Einstein

4.1 Introduction

The second objective of the study (Section 1.6) was to develop design activities through trials among middle school students. This chapter aims to introduce and discuss the development and implementation of the design activities with students from classes 7 and 8. The chapter begins with an introduction and brief overview of a number of issues and considerations related to the teaching and learning of design in schools in countries where D&T is already a school subject. This is followed by a discussion of the theoretical foundations underlying the activities that were developed. The criteria observed while designing those activities and objectives of each of those activities are then explained. The ultimate aim of the activities was to provide students opportunities to actively engage in design and have an experiential learning in and about design. The activities also served as intervention in bringing about change in students' ideas about design.

4.2 Teaching and learning to design

Design, if conceived of as bringing about an intended change in the environment, can be regarded to be an inherent ability possessed by all. However, there is more to design than just bringing about any change. So what should design in general education aim for? As mentioned in the literature review, Baynes (2008) argued that design education must attempt to foster people's ability to imagine, externalise, act socially, construct, and learn from experience. He further advocated that design education should aim to develop two basic intricately linked abilities in individuals: *design awareness* and *design ability*. While design awareness would enable an individual to know about and understand design by asking questions like why things are the way they are, design ability would encourage students to ask questions such as how things might be or can be shaped in the future, thereby facilitating the development of the skills to design.

This implies that although design is basic to all humans, it needs to be taught. What can be the best way to understand design and learn design? It seems obvious that the best way to learn design is to 'do design'. This approach is also characterised as the *experiential learning approach* or *learning by doing,* which underlies the assumption that experiences gained through 'doing' or working gets translated into meaningful insights into the subject matter, which in turn leads to increased curiosity and motivation for further learning among students. However, 'doing design' entails a number of issues concerning the kind of tasks and pedagogy that will promote design ability and skills that students must learn. For example, Welch (2007) suggests that one needs to ask the following questions while designing tasks to enable design learning,

- What kind of tasks will promote design learning among students?
- What pedagogy will effectively enable this learning?
- What design skills must students acquire in order to be successful as designers?

In the same vein, Christiaans and Venselaar (2005) state that design education entails the following the three aspects. Firstly, students need to become aware of the various stages of the design process and how each stage fits together in the entire process. This would enable competence in dealing with complex problems. Secondly, designing tasks entail an integration of many disciplines such as engineering, aesthetics, psychology, sociology, environmental studies, history, etc. Besides the disciplinary integration, design tasks also involve an integration of the application of theoretical knowledge and the final physical embodiment of the design.

According to Welch, Barlex and O'Donnell (2006), while the activity of design is complex in the professional domain since a designer has to attend simultaneously to many levels of detail and make several decisions, it is important to consider how such activity might be described in schools where it is being carried out by students. A review of literature reveals that pedagogically sound design tasks involve authentic, hands-on tasks; use familiar and easy-to-work materials; possess clearly defined outcomes that allow for multiple solutions; promote student-centred, collaborative work and higher order thinking; allow for multiple design iterations to improve the product; and have clear links to a limited number of science and engineering concepts (Crismond, 2001).

4.3 Kinds of tasks to promote D&T capability

In 1991, the Nuffield D&T Project in England headed by Barlex, developed ways of developing this design and technology ability among students through three tasks: *Resource Tasks*; *Case Studies* and *Capability Tasks*.

Resource Tasks are short and focused practical activities which were designed to teach students specific knowledge and understanding, design strategies or making skills that students might need while performing actual designing assignments. These tasks are active and require students to engage with design skills, technical understanding and making skills. Sequences of Resource Tasks help enable students acquire a repertoire of design, technical, constructional and aesthetic knowledge and skills.

Case Studies are true stories about design and technology in the world outside school. By reading them, students learn about the way firms / businesses design and manufacture goods and how those goods are marketed and sold. Students also learn about the impact that products have on people who use them and the places where they are made. These Case Studies thus help students understand the relationship between technology and society. Moreover, this type of activity can be coupled with appropriate Resource Tasks and can be applied for such areas of study as, products and applications, health and safety etc.

Capability Tasks are the designing and making assignments through which pupils develop their capability of designing and making. These tasks build on the learning experience of Resource Tasks and Case Studies. According to Putnam and Borko (2000), the Capability Tasks are authentic activities since these they reflect the practices of actual practitioners. These Capability Tasks provide opportunities to students to use the knowledge, understanding and skill they have been taught, in an integrated and holistic way. Through these tasks, students intervene and make improvements to the made world by designing and making products.

The Nuffield Project was instrumental in bringing about change in the National Curriculum for England. In 1995, the National Curriculum identified three kinds of tasks which were in direct correspondence with the tasks in the Nuffield approach of 1991 (Barlex, 1998). The tasks developed were,

- Investigative, disassembly and evaluative activities (IDEAs);
- Focused practical tasks (FTPs) and
- Design and make assignments (DMAs)

Investigative, disassembly and evaluative activities (IDEAs) provide opportunities to students to focus on and explore existing products regarding how they are made, who might use them and what materials are used to make them. These activities involve existing product analysis and facilitate students in gaining skills, knowledge and understanding which can then be applied in a design and make assignment. This, according to Barlex (1998), matches with the Case Studies of the Nuffield Project approach.

Focused practical tasks (FTPs) involve development of a range of techniques, skills, processes and knowledge in different contexts. FTPs are short tasks through which students learn the knowledge and skill required to do the designing and making assignments. This is in direct correspondence to the Resource Tasks as suggested by Barlex (1998).

Design and make assignments (DMAs) provide opportunities to students to combine their skills, knowledge and understanding in developing products that meet a real need. These tasks not only provide opportunities to gain skills and knowledge in designing and making but also in other areas such as problem-solving, teamwork, communication, and understanding global and societal issues relevant to the problems. DMAs are in accordance to the Capability Tasks described by Barlex.

All these three tasks make a differing but complementary contribution to developing students’ design and technology capability. Although the subject of D&T in the UK has gone through a number of revisions in the early years of its development, these tasks have essentially remained the same. However differential emphasis has been laid on the ‘making’ aspects in design. The next section presents a review of literature where educators and theorists have suggested inclusion or exclusion of making in the process of design in schools.

4.4 Designing and Making

Design and technology is about developing individual's capacity to identify human's needs and wants, to solve problems by designing and making products with the use of materials (Eggleston, 1994; Stables, 1997). According to Stables (1997), design and technology courses in schools should aim at developing a *holistic* capability among students, thereby enabling them to 'design what they make and to make what they design.'

There have been however, differences in opinions regarding the value of 'making' in design. While design is considered as the process of generating and developing ideas to solve a practical problem, these ideas need to be turned into reality through products before a designer is sure that the problem has been resolved (Newton, 2005; Ritchie, 2001). Many D&T educators argue that pupils learn to solve problems in a concrete manner through designing and making together (Baynes, 1985). Most believe that designing and making are intricately linked and provides a holistic view of the subject. Newton (2005) for example suggests that it is particularly important for primary school students to learn to develop design thinking and making skills together. Ritchie (2001) has also emphasized learning design through practical activity for young students.

Design activity is thus an exercise of the set of skills useful in planning, making and evaluating. According to Owen-Jackson, (2002), the process of design continues up to the making stage. Stables and Kimbell (2000), Stables and Kimbell (2006) and Kimbell and Stables, (2007) also assert the strong interaction between the mind and hand (inside and outside the head) during design and making activity, indicating that they are inextricably linked.

Making the products is considered to help students not only to refine their designs, but also helped them to clarify their understanding of related concepts and generate additional ideas (Ritchie and Hamson, 1996,). According to Stables (1997), students who are given more support to find out how things work, to make things work, and to create products have a better chance to develop design and technological capability.

Samuel (1991) explored ways of combining students’ making skills with drawing skills. He found that students’ often designed products that were impossible to make. He thus promoted the idea of introducing constraints on making and carefully structuring their learning of design skills. Harrison (1992) argued that in schools, most making is in fact modelling. While making entails a completion of the design process with a resultant finished product, modelling implies a continuation of the design process where ideas are still being explored before actually making the product. Harrison categorised the purposes of modelling as i) helping with thinking, ii) communicating form or detail, and iii) evaluating a design or selected features of it. Owen-Jackson (2002) asserts that making in schools has separate aims from designing. She suggests that the ‘making’ phase is not strictly a part of design, unless it is seen specifically as making a prototype or a model of the solution. However, she contends that without any kind of implementation of the design, students cannot develop practical capability. Consequently in order to design effectively, it is necessary that students model all their ideas appropriately to see if their designs fulfil that function or are feasible. Liddament (1993) also emphasizes the role of modelling in design by suggesting that modelling activities are extremely effective vehicles for teaching and learning since models can serve not only as information carriers, but also as pedagogic devices in the development of the learner’s understanding of new concepts and ideas. Thus although designing and making are not the same things, many design process models developed for use in schools include making or modelling.

There have also been voices by D&T educators against excessive emphasis given to the making of products. McCormick and Davidson (1996) for example provided research evidences on how emphasis on 'making' and finished product can lead to the neglect of the design process and problem-solving skills in D&T education. They found that both teachers and students gave emphasis to making the final products which undermined the problem-solving skills that teachers were required to foster among students. Not underrating the importance of making in design, they suggested that a ‘balance needs to be tipped more in favour of the processes of design and problem-solving.’

Barlex and Trebell (2007) argue that an overemphasis on making can obstruct collaboration between students. They also argue that students, who are limited by their personal making skills, cannot design solutions beyond their own design abilities. And this Barlex claims impedes creativity among students. The need to make a physical product too often dictates the range of D&T activity that students experience. The *Young Foresight* project, developed by Barlex, provides students opportunities to design but NOT make (Barlex, 2007). He terms these tasks as 'design-without-make' contrasting them to the traditional DMA activities as 'design-with-make' tasks. In design-without-make activity, students progress through the different stages of the design process in the same manner as they would in a design-with-make activity, but without prototyping their created design. This means that students are not limited by their construction skills. Barlex found that the design-without-make activity allows for greater freedom in creative designing for students of all ages. It also enables them to consider applications of new and emerging technologies that are not accessible to schools. Having identified the trends in teaching design in UK, the methods adopted in this thesis will now be described together with the program of implementation.

4.5 Designing the design activities

Based on the review of literature and our understanding of the Indian middle school students' ideas about design and designers that emerged through the survey, a number of design activities were developed for the students. The aim of these activities was to provide students an opportunity to engage in design activities thereby facilitating an experiential understanding of design as a problem-solving activity. 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 appropriate learning opportunities for hands-on activities were provided to students to develop their design skills and actively construct their own knowledge about design during the trials.

The design activities were developed keeping the four roles view of Robert's model (2005) and also 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 (see Section 2.8).

As indicated above in the review, investigating, disassembling and evaluating products served as a starting point for designing and making in most UK schools. Working with existing products not only helps students to develop an understanding of the designed and made world, an important outcome for its own sake, but enables them to develop designing and making skills and knowledge and understanding that assists them in their designing and making.

Our activities were thus based on the level of familiarity of students with artefacts. The initial exposure to design started with handling of familiar artefacts by students. The level of certainty can be considered to be high when one is familiar with the situation in hand. Designing is a multi-dimensional activity and one of the inevitable ingredients of a design task is uncertainty and designers need to manage it through rigorous planning and decision-making (Kimbell and Perry, 2001). Thus managing uncertainty is a critical design skill and designers need to learn to master this skill.

The tasks thus progressed from increasing levels of familiarity and certainty to decreasing levels of familiarity and certainty. This model was used as a vehicle for creating appropriate and effective design tasks in the present study.

As indicated in the review of literature Roberts (2005) suggested four basic roles that students may adopt during design tasks (see Section 2.6.7). These four roles are those of the *Observer, User, Designer* and *Maker*. As observer and user, students get involve in continuous judgment and evaluation of existing realities and state of affairs while as designer and maker, students plan, make mock ups, test and evaluate and make artefacts in the design classrooms.

In the Robert's model, each of the roles was identified with the design activities developed for the students. 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 modelling, respectively. The role of the Observer and Designer was identified with the activity of actually coming up with real world problems that could be resolved by creating artefacts.

Thus the themes and contents of the tasks were selected, formulated and coordinated to meet the learning goals. The learning goals were imbedded in the tasks. These tasks were developed over two trials: a pilot trial and a final trial. The pilot trials consisted of the following sequence of activities

- Handling and analyzing a few familiar artefacts,
- Reviewing the history of a familiar artefact,
- Handling unfamiliar artefacts, exploring and identifying them, and
- Designing an artefacts
- Evaluating the designs

The design tasks sequence consisted of the following 6 kinds of activities in the final study:

- Handling and analyzing familiar artefacts,
- Reviewing the history of the familiar artefact,
- Handling unfamiliar artefacts, exploring and identifying them
- Designing an artefact based on a given real world design problem
- Making artefacts and lastly
- Evaluating the designs and models
- Problem posing or looking for real world design problems in society

4.5.1 Criteria observed while designing the design activities

A number of important considerations were taken into account while designing the activities. Following are the criteria observed while developing the design activities for Indian middle school students.

4.5.1.1 Acknowledging students' perception of design

Learner's prior knowledge (whether accurate or inaccurate) affects new learning. Consequently effective teaching involves acquiring relevant information about students' prior knowledge and using that knowledge to inform classroom teaching and practices. In the study reported in this thesis, students' prior ideas about design were collected through the pilot survey (see Section 3.6.3). The findings from the survey informed the contents of the design activities. The design activities and their learning goals were identified and aimed at developing students' narrower perception of design as an artistic rendering process to a more technological notion of design as a problem-solving process.

4.5.1.2 Understanding of design in the design education literature

A synthesis of literature indicates most design and technology educators and researchers consider design as an iterative problem-solving process where individuals are required to make a series of interconnected decisions regarding every feature of the design. The ideas about design in the literature proved significant in developing design activities for students not having D&T education in their schools. A review of literature and researcher's own conceptualization of design facilitated the designing of the activities. Attempts were thus made to engage students in activities through which they may understand design as a technological problem-solving process rather than an artistic one.

4.5.1.3 Classroom resources

The design activities cannot be designed independent of the resources that need to be used in the classrooms. The resources available affected the design activities. All the activities were designed such that materials were easily accessible to the researcher as well as the students during their designing and making phases. Attempts were made to make use of the resources and materials available with the researchers in their laboratory or those very easily accessible. The primary reason behind using everyday materials for the design tasks was to help students perceive 'design' in everyday products. For example, the everyday materials that were easily accessible to the researcher and made use in the design activities were fountain and ball-point pens, electric iron, pairs of tongs etc. The other artefacts such as knife sharpeners and most of the unfamiliar artefacts in Workshop 2 were available with the researcher in the laboratory. Besides the materials, tools and resources listed by students in their designing and making activities, additional tools and resources were provided to the students. These resources included stationery (papers, pencils, erasers, different coloured pens and markers, geometric set, cardboard, glue, cello tape, etc.), carpentry tools (hammers, hacksaws, nails, measuring tapes, adhesives, etc.), sewing tools (thread, needles, wool etc.), decoration tools (different types of coloured and textured papers, beads, decorative flowers etc.) and other everyday materials such as ice-cream sticks, elastic-bands etc.

4.5.1.4 Gender-neutral activities

Attempts were made to design activities which would engage boys and girls equally throughout the extended period of the activities. Students were asked to form groups or dyads on a voluntary basis. This ensured that students form groups of members that they are comfortable to work with. In cases where researcher had to form the groups/ dyads (Activity Trial) single sex groups or dyads formation was encouraged. This was done to prevent any sort of dominative behaviour on the part of boys. Some artefacts were chosen from the kitchen since they were suitable for a given activity. However, it was found that these artefacts were equally familiar and unfamiliar to both boys and girls.

4.5.1.5 Setting authentic tasks

Hennessy and McCormick (1994), Hennessy and McCormick (2002), McCormick, Murphy and Hennessy (1994) emphasized authenticity of activities at two levels. At the first level is personal authenticity wherein a student has to be involved, and the learning has to be meaningful to the student. Thus if a task involves solving problem, the student should find problem personally relevant and meaningful. At the second level is cultural authenticity. A design task is culturally authentic if it relates to the world outside of school. There was an attempt to make all the activities 'authentic' by setting them in a context familiar to all the students. Design activities provided students opportunities to make significant design decisions (such as, identify the user, specify the product, propose solutions etc, and not just make decisions about the color and aesthetics of the product).

4.5.1.6 Promoting collaboration

Collaboration here refers to what Hennessy and Murphy (1999) suggests as '*pupils actively communicating and working together to produce a single outcome, talking and sharing their cognitive resources to establish joint goals and referents, to make joint decisions, to solve emerging problems, to construct and modify solutions and to evaluate the outcomes through dialogue and action*' (p. 1). All the design activities aimed at providing opportunities for students to work in collaboration with each other and work for a common goal. In all the trials, students were asked to work in dyads or in groups of 3-4 members. The design activities required students to write about their contributions towards the activities thus ensuring participation from each individual in a group or dyad. For most of the trials, students were asked to form the groups on a voluntary basis. No imposition was laid on the students to form any groups or dyads for the activities. Effort was also taken to see that students respected each other and work collaboratively. The researcher and her colleagues assisting her mediated whenever there were conflicting issues arising and between groups or dyads. All sorts of competitive behaviours were discouraged. Another form of collaboration was also encouraged, that is between the researchers and the students. Students' points of view were always acknowledged and the researcher did not dominate students' discussions or their suggestions in any of the activity but instead acted as a facilitator. Students were encouraged to seek help from the researchers whenever they required any.

4.5.1.7 Encouraging reflection

Reflection is embedded in the entire design and making process (Schön, 1983). However, fostering reflection is a key challenge to educators in D&T education since students do not question and reflect on their processes (Mawson, 2007; Jones and Carr, 1994). Reflection was however, built into all the activities designed for students by providing opportunities to students evaluate their own and peer' ideas in most activities. Each group had to present their ideas to the other groups and thus had to evaluate their peers and their own ideas of design. Self and peer evaluations of designs facilitated reflection throughout the activities. The activities also allowed students to communicate their ideas to others, allow for peer review and critical evaluation of each other's ideas.

4.6 Methodology

4.6.1 Design and Technology education workshops

The development of the design activities occurred through two trials in two workshops. Between these two trials was a small intermediate trial. These trials were a learning experience for the researcher and insights gained from the previous trials helped to make changes in the next trials. This is discussed in detail in the later sections.

The first workshop or Workshop 1 (WS1) was a pilot trial of the design activities and was carried out in the month of April, 2009, the second workshop or Workshop 2 (WS2) was carried out in the month of October, 2009. An intermediate trial or the Activity Trial (AT) was carried out in the month of August, 2009. The pilot study (WS1) was conducted to provide a preliminary evaluation of the workshop approach, format, activities, and measures.

WS1 and WS2 were similar to each other in the following ways:

- Both WS1 and WS2 were done with students of Classes 7;
- Both these were organized in the form of workshops. There were 25 students in WS1 which was a 5 day workshop and WS2 was an 8 day workshop with 16 students;
- Both WS1 and WS2 involved a ‘one-group pre-post-intervention’ research design having the following three phases:
    i. Survey of middle school students’ ideas of design and designers (described in Section 3.7). The survey was conducted through a questionnaire for all the students and interviews of a few;
    ii. Trials of specific design-related activities;
    iii. Studying the impact of design-related activities on students’ understanding of design and designers after their engagement in design activities;

One of the objectives of WS1 and WS2 was to implement the design activities with students and observe the influence of those activities on their ideas about design and designers.

The intermediate trial or the activity trial (AT) was done with 6 students of Class 8. Each day 2 students of the 6 students were interviewed in a dyad mode for about 2/3 hours, where they handled a set of products and the researcher observed and interviewed them. This activity lasted over a period of 3 days. The AT involved trying out a single set of activities with Class 8 students. No pre-post surveys were involved in it.

4.6.2 How was WS1 different from WS2?

As mentioned above WS1 and WS2 were carried out with Class 7 students with the aim to develop and implement design activities with middle school students. WS1was carried out when the survey questionnaire on students’ ideas about design itself were being piloted. After the validation and development of the survey questionnaire, the intention was to try out more developed and slightly modified sets of design activities with a different batch of students of Class 7. Insights from WS1 proved beneficial in carrying out the activities WS2. In both the trials the same framework of handling familiar, unfamiliar artefacts and then designing artefacts was utilized and where students assumed the roles of observer, user, designer and then maker.

Figure 4.1: The progression of the research study

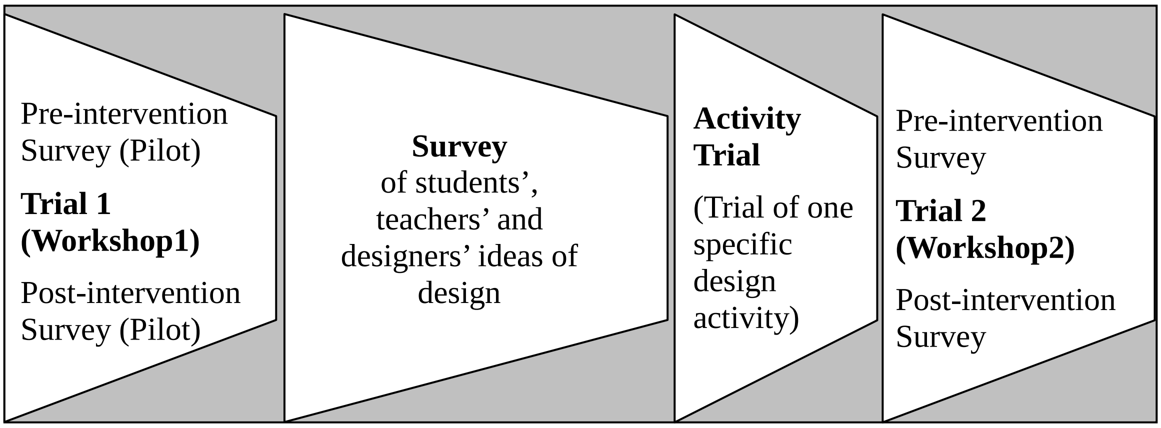


Figure 4.1 depicts the progression of research study in a chronological order. The survey was the main focus of the research study. A variety of design activities were developed and tried among middle school students in Trials 1, 2 and in 'activity trial'. Trials 1 and 2 were similar to each other in their research designs while activity trial involved testing one specific activity with a small group of students.

4.6.3 Sample description

The aim of the study was to develop design activities for middle school students. Students of class 7 and 8 are of the age group of 11-14 years. They are able to articulate their thoughts and ideas in writing as well as understand written matter, while students of younger age may not. In the first trial (WS1), 25 students of Class 7 (7 girls and 18 boys) from an urban school in Mumbai participated. For the Activity trial, 6 students (2 girls and 4 boys) from Class 8 and for the second trial (WS2), 14 students (6 girls and 8 boys) from Class 7 from the same urban school participated.

While the workshops and the Activity Trial were conducted with a small sample of students, this was not a limitation. According to Yin (1989), small sample size (as in this study) is not a barrier to external validity provided that each study is detailed and analysis of data reveals elements of practice relevant to the study at hand.

The students for AT and WS2, came from a different school than those who participated in WS1. However, the two schools were located near each other. Both the schools were co-educational and were located within the vicinity of the researchers' institution. The samples for all the trials were from the city of Mumbai. It was thus convenient for the researchers to conduct all the trials at the researchers' institution. The vicinity of researcher's institution and the rapport between the researchers' and school management also influenced the selection of the samples.

The trials occurred during the school vacation period (WS1 and WS2) or after school hours (AT). For all the trials of the activities, permissions were initially sought from both the principals of the schools. A permission letter was given to the principal to seek his agreement to conduct the activities with the students (*Appendix G, H*). The letter briefly indicated the nature of the activities that the researcher and her colleagues were going to carry out with students. It also asked for his permission to audio and video record the sessions with the students. Once the principal agreed with the request, consent letters were distributed to the students to be given to their parents, seeking their permission to allow their ward to participate in the activities (*Appendix I*). Students who were willing to participate in the activities accepted the letters. For WS1, 40 letters were distributed to the students of one section of Class 7, for WS2 25 letters were given to the students of Class 7 who were interested. For AT 30 letters were given to students from Class 8. For the first trial the researcher got the approval and consents from parents of 25 students while for the second trial approvals from parents of 14 students were received. For AT approvals from parents of 15 students were received. In all the cases, even though there was an attempt to maintain gender equity, the number of approvals received from girls' parents was always less than from the boys' parents in all the 3 cases.

Both these schools were run by the Atomic Energy Commission of India and were located in the urban residential area of the Atomic Energy Research Centre. The parents of these students worked for the Atomic Energy Research Centre with their professions varying from trades people to scientists. However, most parents of the students in the final survey were either scientific officers, scientists or engineers. In about 50% of the cases, both the parents were working. Most students spoke in their native language at home, while the medium of instruction in school was English. The language used by the researcher was also English. Both the schools did not have Design and Technology education in the school curriculum. However, these students had art and craft as a subject in their schools.

Prior experiences with the dynamics involving mixed sex groups (Khunyakari, 2008; Mehrotra, 2008), where these researchers reported that students did not volunteer to form mixed sex groups on their own and at times they were forced to do so, led the researcher impose no preference for group formation among students in both the workshops in this study. Students were asked to form a group of 3-4 members in WS1 and 2 groups of girls and 5 groups of boys were formed. In WS2 students were requested to form a dyad of 2 members; 3 dyads of girls and 4 dyads of boys. For AT, single sex dyads of students were formed by the researcher.

4.6.4 Lessons learnt from Workshop 1

4.6.4.1 Regarding number of students working in a group

In WS1, the number of students participating was 25 and they worked in groups of 3-4 members. It was found that students working in groups of 4 members usually formed into dyad with the two dyads working non-collaboratively. In one group with 3 members, a student was almost left out by the dyad formed. Although the researcher tried to intervene and encouraged students to work collaboratively, the process was not very favourable to collaboration. This experience was utilized in WS2 and AT where dyads were formed.

4.6.4.2 Regarding number of activities in the workshop

After WS1 it was realised that there was a need to increase the number of activities and provide students with more exposure to the design activities so the researcher-student interaction was prolonged from 5 days to 8 days and the number of activities was increased.

4.6.5 Overview of the activities in WS1, WS2 and AT

In this section, the activities developed for the students in WS1, WS2 and AT are described. Before each of the trial (WS1, WS2) each group/dyad was asked to come up with a name for their team/group. Group name was encouraged for two purposes: identification of the teams and building team spirit. In WS1 most names of groups seemed influenced by the group formation itself and tended to signify some sort of unity or collaborative whole. For example in WS1, the names of the 7 groups were: *Krazzy Four* (a group of 4 boys); *Synchronizing Daffodils* (a group of 4 boys); *The Extreme Boys*: (a group of 3 boys); *De Designers* (a group of 3 boys); *The Loute* (a group of 4 boys); *The Majestics* (a group of 3 girls); *Futuristic Brains* (a group of 4 girls).

The names of the 7 dyads in WS2 were *Awesome Twosome* (girls); *The Incredible Twos* (girls); *Just Rock* (girls); *Future Developers* (boys); *Danger Rangers* (boys); *Extremers of the world* (boys); *The Universe* (boys);

For each of the activities students were reminded that there were no 'right answers' to any exercise; instead, they were asked to write down whatever they thought was appropriate. In each of the trials, each dyad/group was provided with a folder in which they had to enter their (a) pre and post survey responses, (b) responses to all the activities, (c) design drawings, (d) self (dyad/group) and other dyad/group evaluation sheets and (e) sheets where they made rough sketches/writings.

4.6.5.1 Creating a design language

Communication is one of the main activities of designers and for communication they need to be familiar with the design vocabulary. Throughout the workshops (WS1 and WS2) and the Activity Trial, attempts were made to maintain a design language during all the discourses. There were several occasions which were made use of to stimulate interactions where design language was used. As for example, during presentation of the design brief to the students for the first time, students were explained what a design brief was. Again in WS2 when the students were decorating their models with beads and coloured paper, careful use of the words 'design', 'decoration' and 'patterns' were done to ensure that students understand the differences among them. Students were also introduced to some of the vocabulary in design such as a plan view, front view, side views, working models, technical drawings etc. (see Section 4.7.5.4; Section 4.8.4.1). Students were also encouraged to use the language of design while discussing their designs or models with the researchers and communicating their designs and models to the others.

4.6.5.2 The activities in WS1, WS2 and Activity trial

Table 4.1 indicates the kinds of activities that students engaged in WS1 and WS2, thereby suggesting the differences in the kinds of activities in the two workshops. It also suggest the role that students assumed while doing each of the activities.

Table 4.1: Description of the activities in WS1, WS2 and the Activity Trial

Activities in Workshop 1	***Activity trial***	***Activities in Workshop 2***	***Role assumed by students***
Handling familiar artefacts	Handling familiar artefacts	Handling familiar artefacts	User
Discussing history of familiar artefacts		Discussing history of familiar artefacts	Observer
Handling unfamiliar artefacts	Handling unfamiliar artefacts	Handling unfamiliar artefacts	User
Designing artefacts	Redesigning artefacts	Designing artefacts	Designer
---		Making artefacts	Maker
---		Look for design problems in the real world	Observer / User/ Designer

4.7 Workshop 1

A tabular representation of the researcher-students interaction during WS1 is presented in Table 4.2. The interaction lasted for 5 days.

Table 4.2: Researcher-student interaction in WS1

Sessions	*Researcher-student interaction in WS1*
Day-1	-Pre-intervention survey of students' ideas about design [~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 artefacts 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 solutions. [~80 min] -Post-intervention survey on students' ideas about design.

4.7.1 Handling familiar artefacts

An important element of what designers do is analysis. Analysis of a product involves looking closely at existing products in order to understand how they work and how they can be improved. By analyzing the structure and function of an existing artefact, designers and engineers can improve upon previous designs. This process of analysis requires careful observation, disassembly, documentation, analysis and reporting.

A synthesis of literature revealed that for naïve designers investigating, disassembling and evaluating products is often used as a starting point for designing and making (Schön, 1983). Working with existing products not only helps students to develop an understanding of the designed and made world which is an important outcome for its own sake. It also enables them to develop designing and making skills and knowledge and understanding that assists them in their designing and making.

4.7.1.1 Learning objective of 'handling of familiar artefacts'

- Provide students with the skills to be able to conduct a structural and functional analysis of familiar and unfamiliar products;
- Explorations of materials, their properties and functions in a product;
- Introduce students to the structure and function relationships of artefacts and 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;
- Students may thus become sensitive to design; the fact that each part of the product was added to serve some purpose besides adornment and thus enabling them to understand the key decisions (whether conceptual, technical, constructional, marketing or aesthetic) that a designer has taken while designing the product;
- Ability to critique the product made by others;
- Explore how the product could be modified or made better;
- Provide them opportunity to take decisions on the design of the product (design decisions such as conceptual, technical, constructional, marketing and aesthetic);
- Exploring possible uses and alternatives of the artefact, thus providing opportunity for creative thinking;

4.7.2 Familiar Artefacts used in WS1

The familiar artefacts selected for this task were fountain pen, electric iron, hurricane lantern, ball-peen and claw hammers. Table 4.3 provides a description of the familiar artefacts given to students in WS1.

Table 4.3: Description of the familiar artefacts in WS1

Familiar artefacts in Workshop 1	***Description of the artefacts***
	The fountain pen given to the students was a simple one with few parts. It consisted of the barrel or reservoir for storing ink, section for holding the nib and the feed and the cap for covering the pen.
	The electric iron provided to students was an automatic one with a thermostat to regulate temperature. It includes other parts such as a Bakelite handle, cord with a swivel and a base plate.
	The hurricane lantern The lantern has a number of parts including a metallic frame, the base of which includes a container for fuel and a glass chimney housing a burner.
 	A ball-peen hammer has a head, one end of which is flat and the other end is hemispherical in shape. It is usually employed in metal work for beating or striking on metals. The claw hammer has a head, one end of which is split in the shape of a ‘V’. It is usually used in woodwork for extracting nails.

4.7.2.1 Structure & implementation of ‘handling familiar artefacts’ activity in WS1

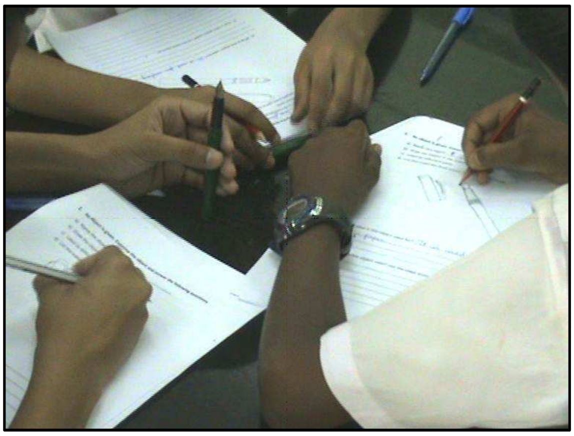
Fountain pen task

The first tasks with familiar artefacts involved fountain pen. Each group was first handed the fountain pen and a response sheet (*Appendix J*) was given to each student in the group. Students were asked to do the following:

- Observe the pen carefully;
- Take it apart;
- Draw the pen and its parts on the response sheet;
- Label its different parts;
- Indicate the most important part/s of the pen;

- Suggest its users; and
- Suggest other objects that could be used to do the same function (alternatives) as the fountain pen;

Figure 4.2: Students' depicting the fountain pen in WS1



All the students in the sample indicated that they had used fountain pens. Students worked in groups and explored the pen. All the groups then disassembled the different parts of the pen. The task was a different experience to students' normal school activities. The activity provided opportunities to students to explore this simple artefact that they use in their daily life, in great depth. They discussed among themselves but were asked to respond to the questionnaire individually (Figure 4.2). The role of the questionnaire was to facilitate students in externalising their thoughts. All groups took about 20 minutes to complete this task.

Electric iron task

After completion of the investigation of fountain pens, the groups were handed the electric iron and a response sheet was given to each member of the groups (*Appendix K*). In case of electric iron, the response sheet had a picture of the iron with indications for students to label a few parts of the iron. They were asked to do the following:

- Observe the electric iron carefully;
- Identify as many parts as they can and label those different parts;
- Suggest materials of each of the parts labelled;
- Indicate what the iron was used;

- Suggests its users; and
- Suggests the alternatives of iron

Figure 4.3: Students' exploration of the electric iron in WS1

All the students indicated in writing that they were familiar with the electric iron provided to them and had used it. Students handled the iron, discussed with other members and responded on the response sheet. They took about 20 minutes to complete this task.

Hurricane lantern task

The traditional artefact, hurricane lantern was given last. Each group was provided with one hurricane lantern and a response sheet was given to each student (*Appendix L*). The response sheet of the hurricane lantern also consisted of a picture of the lantern where they were asked to label specific parts already marked by the researchers. They were asked to do the following:

- Observe the hurricane lantern carefully;
- Label the different parts of the lantern on the picture provided by the researcher;
- Suggest materials of each of the parts labelled;
- Suggest what the lantern was used for
- List the steps involved in using the lantern;
- Suggests its users; and
- Suggests alternatives of the lantern;

Figure 4.4: Students' exploration of the hurricane lantern in WS1

Students reported that they had just seen a hurricane lantern but had never used it. Each group showed a great deal of curiosity while handling the lantern (Figure 4.4). After exploration and learning about the different parts of the lantern, students responded to the response sheet.

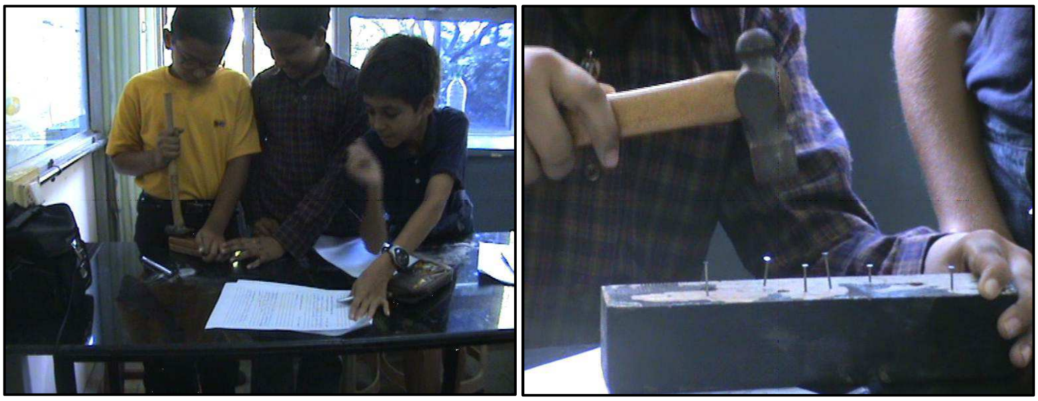
Hammers task

Each group was also given the 2 hammers (ball-peen and clawed hammers) to use and try on blocks of wood. A response sheet was given to each student, which included the pictures of the hammers with their essential parts labelled (along with the indication of the materials used to make them) (*Appendix M*). In the response sheet students were asked to do the following:

- Suggest similarity/ies between the two hammers;
- Suggest differences between the two hammers;
- Explain the consequences of changing the material of the handles of the two hammers from wood to metal;

There was only 1 set of these hammers available and each group explored with the two hammers by striking nails on a rectangular log of wood. All the students revealed that they had never got the opportunities to use them. While handling the hammers too, students demonstrated high a level of interest and eagerness to use both the hammers (Figure 4.5). A certain extent of unfamiliarity in the artefacts such as the lantern and the hammers perhaps, triggered interest and curiosity among students. Each group wrote their responses in the response sheets after their exploration with the hammers.

Figure 4.5: Students' exploration of the two hammers in WS1



4.7.2.2 Lesson learnt from **WS1** *regarding the 'handling familiar artefacts' activity:*

- Though it was assumed that hurricane lantern would be familiar to all the students, only a few groups had seen the lantern and none of them had actually used it. The potential danger risk involved in handling the hurricane lantern (the glass cover could break) led us to replace this artefact in WS2.
- Another important factor that was realized was that except for the fountain pen, none of these artefacts could be disassembled without damaging them. The hurricane lantern could be taken apart to an extent though, and also involved the potential risk of breaking and hurting students. The electric iron could not be disassembled at all. The fountain pen had a limited number of parts, the modern ones having fewer parts than the older ones.
- The aim of the study was also to probe students further on the functions of the parts of the products, so the nature of the questions in WS2 was modified to an extent.

4.7.3 History of artefacts

According to Crismond (2001), there is a general perception among people that design is something which is given. That an artefact has conscious decisions involved behind its particular form and structure is often missed. Margolin (1996) asserts that young students who enter into design programs do not have a clear understanding of design. Thus one of the functions of teaching design history is to explain to them that design is not a fall-back profession for aspiring artists, but an independent practice with its own culture.

Design history can show students how many possibilities there are for making things, and, in this way, serve as a way of socializing them into their profession.

4.7.3.1 Learning objectives of the 'history of artefacts' activity

- The history of everyday technological products fascinates children (Bold, 1999). Looking at technological change conveys the essence of the design and technology process and helps children to learn meanings of 'meeting needs' and 'fitness for purpose.'
- To humanise design. Historical perspectives humanise design by demystifying the designers and the design processes that contribute to our understanding of the made world. It enables students to reflect that design is not something which is given but it is due to the activity of an agent, the designer.
- Encourage careful reflection on the historical developments of present day products that in turn would encourage then to explore the relationships between the structure and function of any given product.
- Encourage students to question the development of the design aspects of artefacts and encourage them to question why products change over time
- Make them appreciate that artefacts have undergone intentional and purposeful changes;
- To help students develop investigative, deductive reasoning. Students draw conclusions from information they have got about artefacts.

4.7.3.2 Artefacts used in 'history of artefacts' activity in **WS1**

A presentation on the history of writing instruments was made the researcher. The presentation included pictures along with descriptions of writing tools starting from the Stone Age to the present day.

4.7.3.3 Structure & implementation of 'history of artefacts' activity in WS1

The history of writing instrument activity was more of a researcher-led activity. Here we gave a small presentation on the history of writing tools. The presentation was done on a computer and projected by an LCD. The presentation discussed how writing tools have changed from Stone Age to the modern pens. The historical presentation was aimed at encouraging students to question the development of design aspects of writing instruments. After the presentation, there was a discussion among students on why the changes came about in the tools of writing.

Each individual was then given a home task where they were asked to make any writing tool that they had seen in the presentation. Most students made a feather pen and brought it the next day.

4.7.3.4 Lesson learnt from WS1 *regarding the 'history of artefacts' activity*

The activity on history of artefacts in WS1 was mostly researcher-led. So in WS2 this activity was redesigned such that it became interactive and engaging for students and also gave them opportunity to reflect while they responded to the questions on history of artefacts.

4.7.4 Handling unfamiliar artefacts

The designer intends to cause the existence of an artefact which would serve the purpose in hand. In order to do that she might design the artefact with an appropriate structure that would allow the realisation of the intended function. The function that was intended by the designer is called the 'proper function' of the artefact (de Vries 2005, Vermaas and Houkes 2006). However, 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.' For example, a hammer, used for driving nails into planks, can also be used as a defence against robbers. But how does one get clue to the multiple possible uses of an artefact. The structure of the artefact becomes a clue to its function. In other words, it provides the *affordances* (Gibson 1979/1986) indicating the possible actions that could be performed on/with that artefact. Thus an artefact providing multiple affordances may serve for multiple uses. .

4.7.4.1 Learning objective of 'handling unfamiliar artefacts' activity

- 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;

- Provide opportunities to develop observation skills;
- Encourage creative and lateral thinking by engaging students into imagining alternative functions of products
- Introduce an element of uncertainty in the task before the actual design tasks which is full of uncertainties and risks.

4.7.4.2 Unfamiliar artefacts used in Workshop 1

Coming up with products that students are unfamiliar with is a daunting task. We looked for products in the market and even asked a few colleagues to provide us with products that were unique and different and which students might not have used or encountered before. The problem with such selection is that one can never be sure that the student has not seen the product before. Also the level of familiarity could not be controlled for, since one can be familiar with a product to the extent of having just seen the product while another student could be familiar to the extent of having even used the product. The products that were used in WS1 were as follows.

4.7.4.3 Unfamiliar artefact: Pictorial task

In WS1, a set of three pictures of unfamiliar artefacts was displayed one at a time, from a computer screen and projected on a wall. These artefacts were: a book holder, a boiled egg lifter and a mouse trap (Table 4.4). Each artefact picture contained a brief structural description of the artefact in terms of its size and a list of three possible functions that could be performed by that artefact. Students were required to do the following in this activity:

- Watch the picture carefully;
- List the materials used to make this object;
- Select any one option as the correct function of each artefact;

For the book clamp/ carrier, for example, the following description and the three options were provided to students:

‘This object is 12 inches long (the size of a long ruler).

Some possible uses of this object are given below. Choose the one which you feel is most appropriate. (Tick any one).

1. This object is used for hanging clothes. You loosen the rope and hang the clothes in between the two planks.
2. This object is a musical instrument. You can hit the two planks with each other to make a musical sound.
3. This object is used for carrying books. You loosen the rope, place the books in between the two planks and hold the handle.'

The details of the options for the other two unfamiliar artefacts are appended in the end (*Appendix N*).

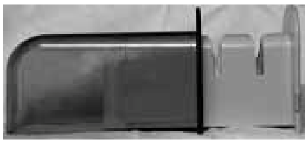
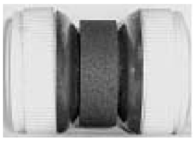
Table 4.4: Description of the pictures of unfamiliar artefacts in WS1

Pictures of unfamiliar artefacts	***Description of the unfamiliar artefacts***
	***Book clamp/carrier:*** This object is 12 inches long and consists of 2 opposable planks of wood with a metallic handle which can be turned around to loosen the rope and allow the two pieces of wood to be separated. It is used for carrying books.
	***Mouse trap*:** This object is made entirely of wood and is hollow inside. It is about 8 inches long, 4 inches wide and 6 inches high. The wire fixed at the top of the handle goes under the latch near the back. The latch is connected to the bait tray.
	***Boiled egg retriever*:** The object is about 8 inches long and consists of a wooden handle and a metallic rod. It is used for retrieving eggs from boiling water.

4.7.4.4 Unfamiliar artefact: Tangible artefact task

In WS1 another task with unfamiliar artefacts involved three knife sharpeners. In contrast to the previous task with pictures of unfamiliar artefacts, this task was important since it afforded hands-on exploration of the actual products. The three types of knife sharpeners, used in this trial were labelled as 'A', 'B' and 'C' (Table 4.5). The sharpeners were simple with few or no movable parts and their structures did not give an obvious clue to their functions. Knife sharpeners are not common in Indian kitchens where people usually sharpen knives on steel files, flat ceramic stones or on the edge of any rough surface available. Many people get their knives and scissors sharpened by peddlers using a footoperated grinding wheel. It was assumed that students were not familiar with these knife sharpeners and this assumption was true of the six groups used in the study. Another group which was initially a part of the study was found to be familiar with the artefacts and hence data from this group was excluded from the analysis.

Table 4.5: Description of the unfamiliar artefacts in WS1

Unfamiliar artefacts in WS1	*Description of the artefacts*
	***Object A*:** Has a single slot with steel and ceramic wheels; steel for sharpening and ceramic for honing
	***Object B*:** Has 2 slots and a sliding cover; coarse carbide wheels for sharpening (right) and fine ceramic wheels for honing (left)
	***Object C*:** Has a single carbide wheel in between two plastic-supported steel wheels creating two slots for sharpening

4.7.4.5 *Structure & implementation of 'handling unfamiliar artefacts' activity in* WS1

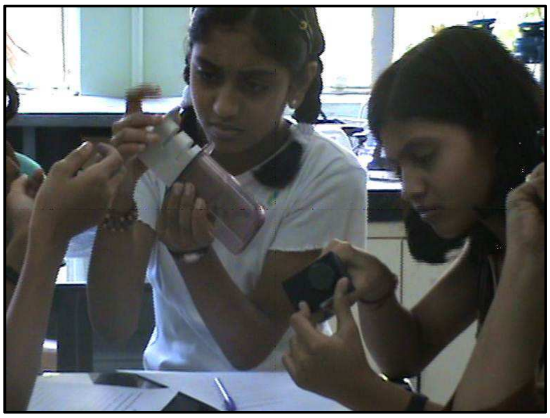
Pictorial task

The pictures of the three unfamiliar artefacts were displayed from a computer screen and projected on a wall. The artefacts were displayed one at a time. Students were asked to guess the function/s of the artefacts by looking at their structures and make a tick mark at one of the provided options. Students were given 10 minutes to observe each artefact and respond to the response sheet.

Tangible artefact task

For the knife sharpeners, each group of students was interviewed for about 40 minutes, when they were handed the three knife sharpeners and were asked whether they had seen any of them before. Students were asked to observe the artefacts carefully and suggest the function of each of them. This activity promoted a great deal of interest and discussion among students (Figure 4.6).

Figure 4.6: Students' exploration of the knife sharpeners in WS1



Each student in a group was provided with a questionnaire (*Appendix O*). Students could discuss among themselves but had to respond to the questionnaire individually. The role of the questionnaire was to enable students in externalising their thoughts and assist them in identifying the functions of the artefacts. The transcripts of the videos of the interactions among students while handling the artefacts were matched with the questionnaire responses to avoid any discrepancy. Students were also requested to think-aloud or verbalise their thoughts. The groups were encouraged to speak in English but two groups who chose to speak in Hindi, the Indian national language, were allowed to do so. As students suggested and talked about the ideas for the artefact functions, this activity provided opportunities to students to develop vocabulary in design. The active discussions among group members provided them opportunities to express their ideas, thus facilitating language development.

4.7.4.6 Lesson learnt from **WS1** *regarding the 'handling unfamiliar artefacts' activity*

- The structures in the pictures of unfamiliar artefacts could not give much clue to diverse and multiple uses of the products since they could not be touched and explored; neither were there materials identifiable. We thus replaced the pictures with actual unfamiliar products
- The handling of knife sharpeners by students and their interview occurred separately for each group which was highly time-consuming and tiring for students. Though it provided useful insights into the designerly behaviour of students, we removed the constraints of interviewing each dyad in WS2.

- More unfamiliar artefacts were included since we assumed that a few dyads might be familiar with some of the products.

4.7.5 Designing an artefact

The ability to design is one of the fundamental capacities of human beings. Just as we all use language but realize that authors are expert in writing, so too is the status regarding with designing by professional designers. Professional designers are expert in design but it does not preclude the fact that we all can design. The 'design an artefact' activity provided opportunities to students to behave as designers and generate solutions for a real world problem.

4.7.5.1 Learning objective of 'designing an artefact' activity

- Work collaboratively to come up with solutions for a real world problem
- Generate ideas
- Sketch ideas,
- Design solutions, in terms of artefacts, for a real world problem;
- Identify constraints,
- Make design decisions,
- Take risks and manage uncertainties
- Build confidence and ownership of ideas for meeting human needs and wants
- Consider values (ethical, aesthetic etc)
- Integrate concepts from different disciplines as also scientific concepts
- Evaluate their designed solutions in terms of the given criteria
- Communicate their designs to others
- Evaluate other's designed solution in terms of the given criteria

4.7.5.2 The design problem

The same design problem was used in WS1 and WS2:

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

4.7.5.3 The context of the design problem

The design problem set to students had come up during consultation with a Professor of Industrial Design Centre, Mumbai. The professor had designed a very simple device for picking up used up pins in offices and homes. This gave us a clue to the traditional problems of elderly Indian women who knit sweaters and sew clothes. In order to make the design problem challenging and engaging for students we added the criteria that the device designed should be capable of picking knitting needles as well. Knitting needles are long and usually made of aluminium which is non-magnetic. Thus students were cognitively challenged to include aspects in their design besides using magnets. We also recognized from observation and experience that elderly women in India do knit or sew even with poor vision and back ache problems. These led us to add other criteria of poor vision and problems of bending. Thus the original problem was slightly modified for the purpose of our study where it served as a design activity.

4.7.5.4 Structure & implementation of 'Designing an artefact' activity in WS1

Before asking the students to design a solution, a short introduction to technical drawings was given to the students in both the workshops. Students were taught the strategies to make technical drawings, including details of measurement, use of dimensions and units and labelling of their drawings. To set the context, simple objects like cell phones, books, bottles etc. were drawn from different viewpoints.

The design problem was given on a sheet of paper, along with the constraints and considerations that needed to be considered while designing (*Appendix P*). The design problem was then read aloud by the researcher. The students were asked whether they understood the problem. About half an hour was spent on discussing about students' experience of having a grandparent, the common problems associated with old age, on why grandmothers continued to indulge in such practices of knitting and sewing even with poor vision and aches and pains. Next the researcher led the discussion to the experience of sewing and knitting, how many of the students were familiar with or engaged with the act of knitting or sewing; what materials were usually used to make these knitting and sewing needles.

Figure 4.7: Students designing collaborativley in WS1

Groups were then asked to work collaboratively and make a sketch of an artefact to solve the given problem. They were asked to take into consideration, factors related to users (old woman with poor vision and back ache problems), materials (aluminium/plastic knitting needles and iron sewing needles), the size of the needles (knitting needles are much longer then sewing needle) and making. Each group was asked to sketch two different solutions for the given problem. Students worked collaboratively for three hours to sketch their solutions and write design proposals (Figure 4.7). On the second day of the designing, each group's best designs were scanned on computer and projected on a screen. Students then presented their designs to the other groups who provided feedback and suggestions on the presented design solutions.

The primary data of the study included design productions of each group and their written design proposals. The entire interactions were video-recorded.

4.7.5.5 Lesson learnt from WS1 regarding the ''Designing an artefact' activity

Students came up with very diverse solutions for the design problems given to them. These solutions ranged from the simplest solution to the most complex one. The result was that though creative most designs turned out to be either too ambitious/big, expensive or too complicated and could not be constructed by students. This led us to include making aspects in WS2.

The researchers were now interested in giving the same problem to different students of the same class and ask them to design as well as make their designs. There were two purposes for including making in WS2. These were

i. The first aim was to provide students an exposure to the making aspects of design. The objective was to engage students in the entire cycle of generating ideas, designing solutions and making their designs such that they assume the four roles as suggested by Roberts.

ii. The second aim of including making in the designing tasks was to see the difference in the designed solutions of students from the first trial (who were free from the constraints of making) and second trial (who were asked to make what they had designed). Thus we wanted to explore how the solutions to the design without make activity differed from that of the design with make activity.

Another important aspect incorporated in WS2 was the inclusion of researcher-generated criteria for evaluating self and peers' designs and models. In WS1, researcher relied on students to generate their own criteria for evaluating self and peers' design ideas. Although students generated several criteria to evaluate their own and peers' designs, important evaluative criteria such as feasibility, aesthetics were not considered by many groups. This led the researcher to facilitate evaluation of students' self and peers' design ideas and models by providing them researcher-generated criteria besides their own evaluation criteria.

4.8 Workshop 2

4.8.1 Handling familiar artefacts

Card sorting exercise

In WS2, after the pre-intervention survey, students were given a picture sorting exercise. The pictures were of everyday artefacts, such as book, eyeglasses, hammer, pencil, computer etc. The following table shows the pictures used.

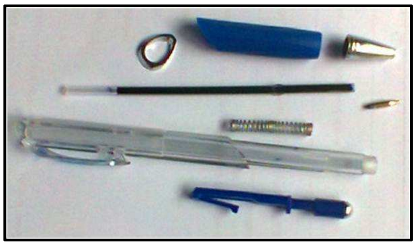
Table 4.6: Artefact pictures used in Card sorting exercise

Air conditioner	Electric guitar	Necklace	Slide
Bird's nest	Doll	Pastries	Socks
Blanket	Electric iron	Pencil	T-shirt
Bridges	Eye glasses	Potted plant	Taj Mahal
Book	Flower vase	Roads	Towel
Car	Hammer	Sewing machine	Tabla
Computer	House	Train	Painting
Computer disc	Mobile phone	Sickle	Sculpture

Ball-point pen task

A click or retractable ball-point pen was used on the second day of WS2. The description of the pen used in the trial is given below (Table 4.7).

Table 4.7: Description of the familiar artefact (ball-point pen) in WS1

Familiar Artefact used in WS2	*Description of the artefact*
A click ball-point pen with all its parts 	The ball-point given to students in WS was a click or retractable kind. It has an internal ink reservoir and a ball-like sphere for a point. The ink is viscous in nature and is dispensed at its tip during use by the rolling action of the small sphere which is usually made of tungsten carbide.

Why the click ball-point pen was chosen

From the wide range of products available, it was very difficult to select one or two products that could be effectively used in our study. After much thought the retractable ball-point pen was selected. It was selected for a number of reasons:

- The retractable ball-point pen is one of the most familiar products that students interact with, almost every day. In fact it is so familiar that it is probably taken for granted by all.
- We wanted to make use of reasonably cheap resources and that may be accessed easily and in large quantity (one for each dyad).

- Another reason why a click ball-point pen was selected was due to the large number of its parts. A click ball-point in comparison to other pens has more parts. It was essential for us to choose such a product that has many parts for which students can analyse their functions.
- A click ball-point pen is also easily assembled and disassembled in comparison to other use-and-throw pens. Thus it could easily be taken apart and also put together by students. It was also assumed that ball-point pen would be easier for students to understand since it did not involve any internal circuitry or other sophisticated mechanisms which middle school students might not be aware of. All the parts of the ball-point pen could be seen nothing remains concealed (except the ink).
- It occupies very less space and so storage was not an issue in this case. In fact it could be used by people once the activity was over.

4.8.1.1 Structure & implementation of 'Handling familiar artefacts' in WS2

Card sorting exercise

Each dyad was provided with the set of 32 cards along with a response sheet (*Appendix Q*). Each card consisted of a picture of a real object. These pictures were presented in 9.5*7.55 cms coloured printed format, within an 11*8.5 cms transparent lamination. Labels were provided underneath each picture (Figure 4.8).

Figure 4.8: An example of a picture card provided to students

They were then asked to sort the cards into different categories- as many as they liked- and give a title to each of the categories. Students were instructed that a card be placed only into one category. They were also asked to give reasons for placing the pictures in different categories. Each dyad had to discuss and give a single response. There was no time constraint. Most dyads were seen to initiate this task by first spreading the cards out on the table (Figure 4.9). This has been reported in literature to be an effective strategy while sorting the cards into different categories (Spencer, 2009). This strategy also ensured that the cards were viewed easily by both the members of the dyad so that they could work on the sorting collaboratively. Students took about 40 minutes to sort the cards into categories.

Figure 4.9: Students engaged in the card sorting excercise in WS2

Ball-point pen task

A retractable ball-point pen and a response sheet were given to each dyad (*Appendix R*). Students were asked to work collaboratively with their dyad member and then respond to the individual activity sheets after mutual discussion. They were asked to do the following:

- Identify the artefact (ball-point pen) and indicate its function
- Disassemble the pen by taking it apart
- List the different parts of the pen
- Mention the function of those parts
- Note and write how the loss of each of the part that they had mentioned would affect the functioning of the pen
- Decisions taken while designing the pen
- Provide alternative uses of the pen/pen parts
- Identify the alternatives of a ball-point pen

Figure 4.10: Students' exploration of the ball-point pen in WS2

All the dyads were familiar with the pen and had used it. Each dyad disassembled the pen and observed the parts carefully and noted their observation in the activity sheet after mutual discussion (Figure 4.10). Students completed this task in about 40 minutes. After completion of the task, each dyad was asked to share their ideas/response with the other dyads.

4.8.2 History of artefacts

4.8.2.1 Artefacts used in WS2

No actual artefacts were used for this activity. Only, pictures of writing instruments from the past and present were used in the response sheet.

4.8.2.2 Structure & implementation of 'history of artefacts' activity in WS2

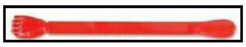
A response sheet consisting of images of writing surfaces probed students on the nature of the writing instruments that could have been used on those surfaces. Students thus had to keep in mind the time these surfaces were used and respond accordingly. One response sheet was given to each dyad and they were asked to discuss between them and then write in the responses (*Appendix S*).

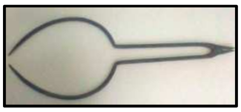
4.8.3 Handling unfamiliar artefacts

4.8.3.1 Artefacts used in WS2

Seven products were used in the third trial, labelled as 'A' through 'G' These artefacts were: Lemon squeezer (Object A), Nut cracker (Object B), Cup-and-ball toy (Object C), Apple core extractor (Object D), Lever nut cracker (Object E), Chakli maker (Object F), Backscratcher (Object G) and a Pair of tongs (Object H). The description is given in Table 4.8.

Table 4.8: Description of the unfamiliar artefacts in WS2

The unfamiliar artefacts in **WS2**	***Description of unfamiliar artefacts (only for the readers; not provided to students)***
	***Object A***: It is a lemon squeezer. Entirely made of stainless steel, it consists of two overlapping flap, joined on one edge through a hinge. A half lemon is kept in between the flap and pressed on the tongue like small handle to squeeze the juice.
	***Object B***: This cup shaped artefact is a nut cracker. Made from wood, it consists of a cup shaped container with a rotatable wooden screw. To crack a nut, it is simply placed inside the 'cup' and the screw rotated. The cracked nut and its fragments remain contained in the cup.
	***Object C***: It is a toy known as 'cup-and-ball'. It consists of a wooden cup with a handle, and a ball attached to the cup by a string which might be 35 to 40 centimetres in length. The main goal of the game is to get the ball into the cup
	***Object D***: It is an apple core extractor. Made entirely from aluminium this artefact is very light and thin. The rugged end goes into the apple core and is then pulled back.
	***Object E***: It is a lever nut cracker. It works on the principle of second class levers. To crush a nut, the nut is kept in the hollow towards the fulcrum and force is applied on the two arms by pressing them.
	***Object F***: It is a 'chakli maker'. Chakli is a traditional Indian food. Chakli maker is a kind of a noodle maker.
	***Object G***: It is a backscratcher usually employed to scratch the back or body areas that cannot be easily reached. The one given to the students was a cylindrical rod made of plastic, one end of which was made in the form of a human hand for scratching.

	***Object H****:* A pair of tongs to lift hot utensils. This pair of tongs is not common in urban households, but is usually locally made to serve the needs of rural women in certain parts of the country. Usually made of wrought iron, it is used to lift a hot utensil with a rim around it.

4.8.3.2 Structure & implementation of 'handling unfamiliar artefacts' activity in WS2

Eight products were selected for this activity. Each dyad received one product randomly and two response sheets for responding. Students were asked to respond to the sheet after mutual discussion (*Appendix T- 'A' through 'H'*).

Figure 4.11: Students' exploration of unfamiliar artefacts in WS2

Students were asked to observe one product at a time very carefully and note down their observations in the response sheet as required. Each dyad was asked to complete their investigation of the product within 15-20 minutes and then pass on the products to the dyad sitting on their right. Like in the unfamiliar tasks in WS1, students in WS2 also showed a great deal of interest in doing this exploration activity (Figure 4.11). The entire room was filled with a lively discussion between students while doing this activity, a few even finding some artefacts funny, especially the backscratcher. The entire investigation was completed in 2 hours. Once the investigation was complete a break of 30 minutes was provided to the students. After the break was over, researcher initiated a discussion with all the dyads. For each of the artefacts, each dyad was asked to present their ideas about what they thought the given artefact was for. All the dyads read out their justifications from their response sheets and answered questions posed by other groups.

4.8.4 *Designing an artefact*

4.8.4.1 *Structure & implementation of 'Designing an artefact' activity in WS2*

The structure and implementation of this activity was very similar to that in WS1. The only difference was in the amount of time spent on teaching technical drawings to students. Thus while only 20-25 minutes was spent in WS1, teaching and learning about technical drawings took about 45-50 minutes in WS2. After the discussion on technical drawings, each dyad was asked to depict top, side and front views of common objects like cell phones, computers and chairs. Students were then taught about what a 3D model was and the purpose of the model.

The same design problem then was provided to all the dyads and was read aloud by the researcher as in WS1 (*Appendix U*). Students were then asked to design a device that would resolve the concerned person's problem in the design task. The dyads were first asked to 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 would require for their model and hand them to the researchers at the end of their designing. The materials were decided by the students themselves for designing their models. Each dyad was asked to list the materials with detailed specifications. Students were also asked to estimate the cost of making their model.

Figure 4.12: A girl dyad enagaged in discussion while designing in WS2

During the designing task, students actively engaged in generating ideas for their devices. As in the designing phase in WS1, here too, in a few dyads, one of the partners was found to be more active in generating ideas, while the other partner was usually seen as either challenging or accepting the ideas (Figure 4.12). Students made exploratory sketches during brainstorming of ideas. While making exploratory sketches, students mostly worked on the same sheet of paper and both the members actively contributed to the design. In the few dyads where one member was more leading than the other, in generating ideas, even there the less active member contributed to the design by making exploratory sketches on the same paper. Once the students were convinced about their ideas, they made their final drawings in detail with measurements and different points of view. Students took about an hour and half to generate the solutions and sketch their devices.

After the completion of the designing, each dyad's design were collected and scanned on a computer. After a snack break of about half an hour, each dyad was then asked to present their designed solutions (which were scanned during the break) to the other dyads. Each dyad presented their designed solutions to the other groups. A design evaluation sheet was provided to each dyad, where they evaluated their own designs and the designs of others during the presentation (*Appendix V*). After each presentation, other students critiqued and provided feedback on the designs of their peers. In the design evaluation sheet students were required to choose one option from the given three options: 'yes', 'not sure' and 'no' for each of the researcher's provided following criteria:

- Is the design clear?
- Does it solve Rita's grandmother's problem?
- Is it easy to make?
- Will the design be easy to use?
- Will it be safe to use?
- Will it be easy to carry?

Students had to rate their own and other dyads' design ideas. Besides each dyad was also asked whether they liked their own and other dyads' design ideas and why they did or did not. They were asked to indicate and justify whose idea/s they liked the best besides their own ideas. A question asked at the end of design evaluation pertained to the dyad's own design ideas wherein they had to suggest whether they would or would not like to improve their design and how they would go about doing it.

Each dyad then critiqued or provided feedback on the presented designed solutions. The dyads incorporated feedback and suggestions from the other dyads.

4.8.5 *Making an artefact*

Making an artefact is a conceptually demanding activity since it involves the implementation of one's design idea which is on paper to a tangible product. It also involves understanding of the structure, how it would be constructed and made to work and the nature and choice of materials. According to Baynes (1992) though interrelated, the ability to imagine something is not the same as the ability to make something. Making not only gives reality to imagination but it also stimulates it since in making, one finds out more about one's imagination and tries to develop and refine it.

4.8.5.1 *Learning objective of 'making an artefact' activity*

Provide opportunities to students:

- To make what they have designed,
- Choose and select materials for modelling
- Develop skills in making, fixing and using tools like hammer
- Evaluate their products in terms of the given criteria
- Develop pride and ownership of their product in meeting human needs and wants

4.8.5.2 *Structure & implementation of 'making an artefact' activity in WS2*

The making of the artefact happened on the next day of the designing activity. The materials that each dyad required had been procured either from the laboratory or purchased from the market and given to them before their making phase. Only at certain occasions (when the materials asked were not available in the market) were the students requested to make a compromise. The materials were provided to each dyad and they were also told about the cost of each item. Each dyad noted down the price.

Making was a moment of active engagement by all dyads (Figure 4.13). It was observed that all the 7 dyads' design resorted to the use of magnets in their design and models. None of the dyads considered the problem of picking of knitting needles in their designs.

For some students it was the first time that they had used tools like hammers and hacksaws. Students found difficulties in fixing magnets to the end of the rod or plastic pipe that they had asked for. One dyad of boys found it difficult to fix the magnet at the base of a paper plate since paper plates are light and the magnets that they asked for was very strong and heavy. This dyad found that their plate was getting bent at the centre and was very fragile.

Figure 4.13: A girl dyad making their model in WS2

The additional problem that they faced was due to the use of four wheels that they wanted to make their model mobile. These wheels were to be added at the base of the plate. This made the paper plate and their model even more fragile. However, researcher and her colleagues provided continuous support to the students in fixing and resolving issues faced during the making of the models.

Another dyad found it difficult to make a groove on a plastic rod. This dyad was planning to install a small switch in the groove of a hollow plastic rod. Since the rod was thick, they found it challenging to cut the plastic and make a groove in exactly the same size as the switch and requested help from the researcher (Figure 4.14).

Figure 4.14: Researcher providing support in construction of the model in WS2

After completing the making of the artefact, each dyad was asked to evaluate their designs. Each dyad was asked to assume that they were Rita's grandmother and sit on a chair and test their own and others' models and evaluate them (Figure 4.15).

Figure 4.15: A dyad testing their model in WS2

A product evaluation sheet (*Appendix W)* was given to each dyad after the completion of the model making wherein they were required to evaluate their own model and others' model on the basis of the researchers' given criteria and also based on their own criteria. Students again had to rate other dyad's model as 'yes' 'not sure' and 'no'. Some of the criteria set by the researcher were as follows:

- Does it completely solve the problem faced by Rita's grandmother?
- Does it look good?
- Is it safe to use?
- Is it costly?
- Will it last long?
- Is it easy to carry?
- Is it easy to use?
- Does it work well?
- Is it easy to make?

Besides students were also asked whether they considered their own model as best, whose model they liked the best besides their own model, justify why they liked it and if it was possible to make their model again, how they would improve it.

4.8.6 Problem posing activity

One of the first steps to developing technological literacy among students is to teach them a technique that will enable them to need and wants of people and how these could be met. Students could thus be encouraged to look at products that meet those needs, or look for those needs. In other words, students could be encouraged to identify human needs in terms of design problems and pose it for others. According to Lewis, Petrina and Hill (1998), problem-posing has been a neglected aspect in D&T. They claim that problem posing activities have immense potential to foster creativity among students. They argue that posing of problems is not limited to finding completely new problems but it might also include reformulating given or existing ones.

4.8.6.1 Learning objective of 'Problem posing' activity

Problem posing activities provide students opportunities to

- Identify needs and understand the need to design for others
- Communicate like a designer
- Learn how to write a design brief.
- Provide students a context so that they can link signifier to signified and be able to generate meaningful communication to facilitate their learning.
- Helps students acquire positive attitude towards the subject by providing them a sense of ownership of the design task.

4.8.6.2 Structure & implementation of 'Problem posing' activity in WS2

Students were asked to identify some everyday problems that people or they themselves face and write the problem down on the paper. They were asked to write a design brief and also identify the criteria that that the designed solution should meet. Blank sheets were provided to each dyad and they were asked to work together on this activity and write a design brief for the problem. After the completion of the activity, each dyad was asked to communicate their design problems to the others along with their design briefs.

4.9 Activity trial

4.9.1 Product evaluation

The researcher-student interaction during the third trial lasted for 8 days. The details of the interactions are presented below.

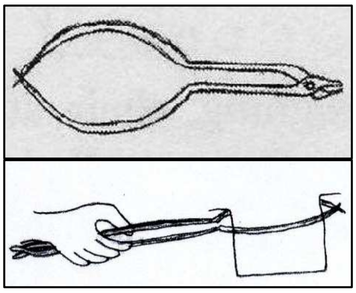
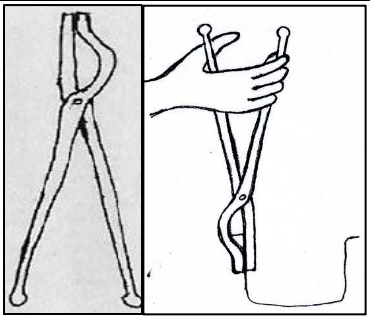
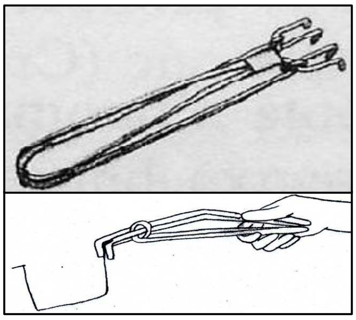
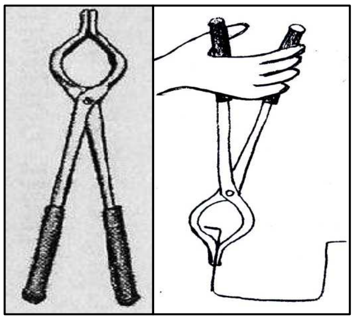
Table 4.9: Researcher-student interaction in Activity Trial

Sessions	***Researcher-student interaction in Activity Trial***
Each day 2/3 hours with each dyad for 3 days	*6 student worked in dyad and handled and evaluated 4 different kind of vessel lifting tongs* *All the dyads redesigned the tongs*

4.9.1.1 Artefact used for Product evaluation in Activity trial

A set of 4 products meant for similar functions (utensil lifting tongs), were used in the study (Table 4.10).

Table 4.10: Artefacts used in Activity Trial with their methods of use

Artefacts in Activity Trial with their working mechanism			
T_A		T_B	
T_C		T_D	

A pair of utensil lifting tongs is commonly known as *pakkad* in the national language (Hindi). These are commonly used in Indian kitchens for holding and lifting hot utensils that do not have handles. The 4 pairs of tongs were labelled as TA, TB, TC and TD. While TA, TB and TD had only one structural configuration, TC could be rotated through 360 degrees to get another configuration which enabled lifting different kinds of utensils.

4.9.1.2 Learning objective of 'Product evaluation' task in AT

Analysis and evaluation of existing products allows students

- To appreciate the ways in which different products meet the same need,
- How products are designed and manufactured
- Develop observation and communication skills.
- Help students use what they have learned to inform their own designing and making,
- To identify and explore how, and in what way, a product might be used
- To learn how a product is made
- To learn how other designers develop solutions
- To explore value judgements and issues inherent in the making and marketing of products
- Raise awareness among students, of the possibilities, the materials and processes used

4.9.1.3 Structure & implementation of Product evaluation task in AT

The entire activity was carried out for 2/3 hours per day over 3 days (Table 4.9). Each day only one dyad met the researcher after school hours. The 4 products were shown to the students and a sequence of activities was carried out as described below.

***Identifying the functions of the given products and testing them*:** Students were asked to identify the functions of the given products. They observed/handled the pairs of tongs and suggested functions for each pair of tongs (Figure 4.16). If the function of at least one pair was guessed correctly, they were allowed to test the tongs on different kinds of utensils provided to them.

Categorising products**:** Students were asked to group the given pairs of tongs and provide reasons for their sorting. The aim of this activity was to identify the criteria that students use to classify the products and whether they were based on superficial or functional features.

Comparing products**:** In this phase students were asked to compare the tongs in each group that they had formed and suggest reasons for considering one pair better than the other/s.

Redesign: Students were asked to suggest improvements and redesign any or all of the four given pairs of tongs by sketching on paper.

Figure 4.16: Students' exploration of pairs of tongs in the Activity Trial

Each student had to respond to a questionnaire individually, although they had to discuss between themselves (*Appendix X*). Students were also requested to think aloud. The entire interactive session with each dyad was audio and video recorded. Portions of the video were transcribed and corroborated with the written responses.

4.10 Data

The design activities generated semi-structured and unstructured responses to questionnaires, drawings, design proposal drawings, redesign proposal drawings, oral presentations, finished products and researchers' written records of the classroom interactions, audio and video recordings of interview responses classroom interactions and transcribed responses. In summary, this study employed five types of data including,

- Students' written and drawn responses to all the activities;
- Video and audio recordings of students' interactions,

- Video and audio recordings of interviews with students,
- Researchers' written records of the classroom interactions
- Students' finished products

4.10.1 Students' written and drawn responses

The primary source of data included students' textual and graphical responses to all the activities. The written responses included both semi-structured and unstructured collective responses from the students. The drawn responses included drawings, design exploration drawings, design drawings and redesign drawings of artefacts.

4.10.2 Video and audio recordings of classroom interactions

Two digital video cameras were used to record students' interactions in the classroom. At a time there would be a special focus on any one group. Thus one of the cameras was always placed in front of or to the side of a dyad or a group to record their interactions for the entire time that they engaged in the activities. The other camera recorded the activities of the entire class.

4.10.3 Video and audio recordings of interviews

For the activities of handling unfamiliar artefacts in WS1 and the activity trial, each dyad/ group was interviewed separately. Each of the interaction of the dyad/ group was both audio and video recorded. During the interviews students were requested to think-aloud or verbalise their thoughts. In all the interviews, the role of the researcher was more of an observer. The researcher, however, intervened at places for clarifications or to probe them on certain aspects, or when students stopped interacting with one another. The dyads/groups were encouraged to speak in English but those who chose to speak in Hindi, the Indian national language, were allowed to do so. The conversations (both formal and informal) that occurred within dyads/ groups were transcribed verbatim. The transcripts also included the description of actions and gestures executed by students and the time taken to perform the actions.

4.10.4 Researcher's written records of classroom interactions

Researcher also made notes on the classroom observation. The notes focused on interesting observations in the classroom. Researcher also made observations regarding improvements and suggestions for the next trials.

4.10.5 Students' finished products

In the second workshop, students also completed a working model of their design. These models served as important data in analysing students' solutions to design-with-make and design-without-make activities.

Students' written and drawn responses were corroborated against their interview data and audio video recordings. The different sources of data therefore naturally served to triangulate some of students' responses.

4.11 Summary

The development and trials of the design activities for Indian middle school students, described in this study occurred through three separate interventions. Two workshops were held with students of Class 7 where they got the opportunities to engage in a variety of design activities. Another trial took place with Class 8 students, where a single design activity was tried with them.

Since artefacts are the first manifestations of technology and design that we come across in our day-to-day life, it was reasonable to assume that the act of designing should commence not just from playing with ideas but the actual handling of artefacts-both familiar and unfamiliar. The basic aim of these activities was to introduce to the students the structure-function relationship of artefacts. The students were then introduced to the evolution of one of the familiar artefacts in the course of history, before they actually engaged in the designing and making activities. The tasks were aimed at encouraging students to question the development of the various design aspects of the artefacts and to make them appreciate that artefacts are not something which are a given but are an intentional and purposeful manifestations of humans; thereby attempting to foster the two inherent capacities of all humans: design awareness and design ability.

The learning objectives of each of the activities were identified and matched with the aims of the research study undertaken in this thesis. The development and trials of the design activities involved an iterative process. The lesson and feedback from each trial fed into the design of the subsequent trials that led to the refinement and improvement of the design activities.

The activities were developed around the idea of design as an iterative problem-solving and decision-making process. Gaining insights from the literature, the activities acknowledged students' own understanding of design and provided them opportunities to work collaboratively towards a common goal, reflect on their work through gender-neutral and authentic tasks.

The next chapter (Chapter 5) will present an overview of the results generated from all the design activities conducted in the workshops and the Activity Trial with Indian middle school students.

Chapter 5

ANALYSIS OF THE DESIGN ACTIVITIES

Look and you will find it. What is unsought will go undetected

Sophocles

5.1 Introduction

The previous chapter (Chapter 4) described the design activities that were developed for middle school students through two trials in the form of workshops (WS1 and WS2) and one short Activity Trial (AT). The aim of the activities was to provide middle school students opportunities to have an experiential understanding of design. One needs to 'do' design to 'learn' design. Indian students do not get an opportunity to engage in design activities. Their designing experiences are limited. It was thus deemed necessary to give them opportunities by which they can assume roles of different stakeholders in the design process. Students' engagement with the activities resulted in the generation of a variety of data such as written and drawn responses, audio and video recordings of the different activities, classroom observations, researchers' own notes and students' finished products. The next phase of the study involved the analysis of these data through employment of a suitable analytical framework. The analysis of a number of activities have already been published either in a peer reviewed journal (Ara et al., 2009b) or peer reviewed conference publications (Ara et al., 2009a; Ara et al., 2010; Ara, et al., 2011a). The aim of the present chapter is to bring together the entire trial activities and make a coherent analysis of them by utilizing analytical frameworks from the literature and from researchers' own understanding of the design activities. Thus this chapter will provide an overview of the results generated from all the design activities conducted in the workshops and the activity trial with students of classes 7 and 8. The chapter begins with the research questions addressing the broad objectives of analyzing the design activities. It then outlines the framework which formed the basis for analyzing the activities in terms of certain aspects such as structure-function relations of artefacts, students' creativity, their evaluation strategies and their design-decision-making skills.

5.2 Research questions

The two workshops and the activity trial with the students generated a multitude of responses from the students. While analyzing all the details of the activities was beyond the scope of this thesis, a few research objectives in the form of research questions were formulated to guide the process of analysis and sense making of the data. The following research questions were postulated which guided the analysis of the activities.

1. To what extent do students identify the functions of familiar and unfamiliar artefacts?
2. To what extent do students identify the different parts of familiar and unfamiliar artefacts?
3. To what extent do students ascribe functions to the different parts of familiar and unfamiliar artefacts?
4. What criteria do students employ to categorise pictures of, and actual familiar artefacts?
5. What strategies do students employ to identify the functions of unfamiliar artefacts?
6. What criteria do students employ to test or evaluate familiar/unfamiliar artefacts, self and peers' design ideas and models?
7. What design decisions do students take while redesigning familiar/unfamiliar artefacts?
8. What design solutions do students come up with for a real problem in a design-without-make activity and the design-with-make activity?
9. What design decisions do students employ in the design-without-make and design-with-make activities?
10. How does design-with-make activity compare with the design-without-make activity?
11. What elements of creativity are evident in students' design-without-make and

design-with-make activities?

12. What different design problems do students come up with in a problem posing activity?

These research questions guided the researcher in analyzing the responses of the students.

5.3 Data sources

As mentioned in Chapter 4, the researcher utilized the following data for analyzing the activities of students. Data sources are reiterated briefly here.

- ***Students' written and drawn responses***

Students' responses to the activities were in terms of writings and drawings. These served as a primary data for most of the analysis. The written responses included the responses to the structures and semi-structured questions and discussions in the activity sheets for different activities.

The drawn responses included students' drawings, designed and drawn solutions to the design problems and also included the redesigned solutions to certain activities. Students' exploratory sketches also served as data for analyzing the responses

- ***Video and audio recordings of students' classroom interactions***

The observation of students' engagement in the design activities were made through audio and video recordings. The video and audio recordings also served as the primary data for the analysis of many of the activities.

- ***Video and audio recordings of interviews with students***

For some of the activities, students were interviewed in detail while working in a group/dyad. The interview data was transcribed verbatim and served as a primary data for those activities.

- ***Researchers' written records of the classroom interactions***

The researcher had also maintained a log book where specific events or interesting observations such as students' remarks, gestures or conflicts etc. were noted down.

- ***Students' finished products***

In Workshop 2, students were required to make a model of their designed solutions. These models made from everyday materials served as a data for the design decisions made by students.

5.4 Framework for analyzing the design activities

Attempts were made to bring all the trials under a coherent whole by employing an analytical framework suitable to the study. Following are the frameworks employed for analyzing most of the activities in the three trials.

5.4.1 For analyzing the activities involving handling artefacts

Even before we realize that technology is a body of knowledge, that it entails designing and producing and that it is part of our human being (Mitcham 1994), we encounter designed artefacts. However, these artefacts tend to be overlooked. They become a part of the environment and thus it is easy to forget that they were constructed for a purpose (Moore, 2010). Thus one naturally does not focus one's attention on the artefacts but rather on the task that one is attempting to accomplish with those artefacts. Artefacts help one to perform actions on the environment hence an understanding of the artefacts would enable one to understand the task at hand. According to Frederik, Sonneveld and de Vries (2011) studying the nature of these artefacts, is the most natural starting point for teaching and learning about technology.

Artefacts are designed for some purpose and the purpose that it serves is called the artefact's *function*. Artefacts have a dual nature – *physical nature*, having properties such as size, colour, shape, weight, smell etc. and *functional nature* (Kroes 2002, de Vries 2005, Kroes and Meijers 2006). A designer intends to cause the existence of an artefact which would serve the purpose in hand. In order to do that she might design the artefact with appropriate structures that would allow the realisation of the intended function. The function that was intended by the designer is called the 'proper function' of the artefact (de Vries 2005, Vermaas and Houkes 2006). A user on the other hand, may go the other way round. She may try to infer the possible function or functions of an artefact by perceiving its structure. She might identify some other functions of that artefact which were not intended by the designer. These functions not intended by the designer, are called the ‘accidental functions.’ For example, a hammer, used for driving nails into planks, can also be used as a defence against robbers.

From the cognitive science perspective, while reasoning about artefacts adults seem to adopt what is called the ‘design stance’ (Dennet 1987 in Matan and Carey 2001), an abstract explanatory schema in which people assume that artefacts are created by a designer with the intention of serving a purpose. ‘Design stance’ becomes evident in categorisation tasks which show that adults tend to judge an object’s category on the basis of (i) its intended function rather than its appearance; e.g. an object that looks like a lampshade but was intended to be used for protecting against rain is judged to be an umbrella and not lampshade (Rips 1989 in German and Johnson 2002) and (ii) its intended function rather than its accidental function; e.g. an object that was intended to be a watering-can but now used as a teapot was judged to be a watering-can and not teapot (Matan and Carey 2001).

So, when in human cognitive development does the design stance originate? Children rapidly learn about the typical functions of an artefact by observing the adult members of the society (Casler and Kelemen 2005). Some cognitive science researchers believe that children as young as four years can reason about artefacts in terms of design stance (Kelemen 1999). Others argue that it is only after six years that children are capable of making use of design information in categorisation and function tasks (Defeyter and German 2003).

What about artefacts which are unfamiliar to us? How do we know about their intended functions and what to do with them? The intended function of an artefact constrains the artefact’s structural properties and its materials. For example, a coffee mug should have a closed bottom, an open top, must be graspable, must not be made of ice etc. (Matan and Carey 2001). Thus the structure of the artefact becomes a clue to its function. In other words, it provides the *affordances* (Gibson 1979/1986) indicating the possible actions that could be performed on/with that artefact. Thus, a designer attempts to construct affordances that are necessary to support a particular activity through that artefact. People perceive those affordances, thereby perceiving the use intended by the designer. However, in other situations, those same affordances may support other functions which were not intended by the designer. For example, a hammer can be used for hitting nails or a robber. In still some other cases, people may perceive multiple affordances in an artefact and may put the artefact to unintended uses. For example a pen can afford grasping, writing with, piercing with, playing catch with, etc.

According to de Vries (2005), the physical nature of artefacts exists independent of our intentions but the functional nature is not intrinsic to the artefacts since designers and users ascribe functions to artefacts. So intentions are involved in not only creating the artefacts but also in using them to achieve users' goals. Since a user may come up with unintended functions for an artefact, a designer's responsibility does not end in mere formulation of structures. She too has to look for the possible uses that her designed product could be put to, before it gets into the hands of the users.

Kroes and Meijers (2006), in their 'Dual Nature research program', suggest that technical artefacts have a dual nature: physical structures and functional properties and thus a full account of a technical artefact can only be given by describing both its function and its structure. Since an artefact may be used for different functions and one function can be realized through different forms/structures, it is inadequate to explain an artefact by describing alone either its structure or function. For example, there can be many artefacts with a shape similar to a hammer, such as an axe; also there can be many artefacts that can be used to strike nails such as a rock.

The proper uses and functions of an artefact are not directly determined by its physical nature. An increasing awareness of the role of users in ascribing functions to the artefact in a particular context and thus the failure of the design has led to a broader understanding of the functions of artefacts. Thus the use/s of an artefact depends not only on its physical properties but also on the conditions created by the social structure and context. For example, a knife sharpener commonly used in the West is not commonly used in India and hence its function may not be easily recognized by merely perceiving its physical structures. The meanings and functions of an artefact are socially constructed (Pinch and Bijker, 1987). Technical artefacts are thus not mere physical objects but they are also social entities.

Adopting an ethnographic perspective and considering everyday objects as 'not just things' but rather a reflection of the wider lives of communities and individuals, Riggins (1994) considered everyday objects to be serving the following purposes:

Intrinsically active objects refer to objects which are intended to be used or handled (e.g. a corkscrew); *intrinsically passive objects* refer to those that are intended for contemplation or decoration (e.g. a painting); *status objects* indicate social status, whether intended or not (e.g. cars); *esteem objects* reflect personal self-esteem (e.g. a framed university degree); *collective objects* represents wider social ties (e.g. national flags); *stigma objects* which are associated with spoiled identities, embarrassment or something which is socially unacceptable (e.g. dirty laundry and dishes); *social facilitators* foster social interaction (e.g. a pack of cards); *occupational objects* are tools or materials associated to some profession or trade (e.g. beakers and flasks with scientists). Riggins scheme is not mutually exclusive since an *intrinsically active object* can also be an *occupational object* such as a pen or a spade. However it does reflect an interesting perspective into how artefacts can be perceived within a larger social context.

5.4.2 For analyzing the activities of designing and making

Students working in groups in Workshop 1, engaged in a design-without-make activity while dyads in Workshop 2 engaged in a design-with-make activity.

A **design-with-make** activity is a traditional approach to D&T education in which students design, build and test solutions to real world problem. Technology educators use this approach to provide students an opportunity to design solutions for a problem and them model their solution, test the model and then finally make it. Kipperman and Sander (2007) outlines 6 basic steps in every technological design and make activity, either working in teams or individually:

- Identify and clarify problem
- Conduct research which might involve investigation
- Generate one or more design proposals
- Develop these so that they can be scrutinized for predicting performance and social and environmental impacts.
- Construct a prototype of the most promising design, experimenting with subcomponent design as necessary

- Test/evaluate the constructed solution.

Design-without-make activity was a 12 week program for 14 year olds (*Young Foresight*) started by David Barlex in his D&T initiative. It aimed at developing communication and collaboration skills among students who worked in groups to design future products (Barlex, 2007). Design-without-make activity challenged the orthodox approaches to teaching D&T and relied on focused practical tasks and product analysis exercises in the following ways: Students design but do not make; they design products and services for the future; use new and emerging technologies in their design proposals; write their own design briefs; and work in groups.

Barlex (2007) encourages teachers to challenge students using design-without-make activities which force students to design products based on conceptual (what it does), technical (how it works), aesthetic (what it looks like), constructional (how it fits together), and marketing (who it‘s for) criteria without actually having to manufacture a final product for grading (Barlex, 2007, Barlex and Trebell, 2007). Banks and Jackson (2007), state that despite many students being motivated to take technology courses, the hands-on process of physically making a product demotivates them. Design-without-make activities break the challenges imposed by the making of artefact and thus provide students an opportunity to develop and boost their creativity.

Students in both the activities explored their design ideas on sheets of papers, either individually or collectively. A variety of design ideas were generated by students in both the workshops. Creativity and design decisions in students' solutions were analyzed using three analytical frameworks.

A. NACCCE (1999) features of creativity

The National Advisory Committee on Creative and Cultural Education (NACCCE, 1999) report adopted a democratic conception of creativity. Considering all human beings to be creative, NACCCE recognized that creative potentials can be expressed in all fields of human activity. According to the NACCCE report, creativity in education can be considered from two perspectives: elitist and democratic. The elitist view upholds creativity as an innate ability possessed by a gifted few that cannot be taught. The democratic view of creativity recognizes creativity in all students which can be facilitated and nurtured as an essential life skill through appropriate school curriculum. The report suggested that creativity can be developed in all areas of the school curriculum, including the sciences and the arts and defines creativity in terms of four characteristics:

1. ***Using imagination***

   It involves the process of generating something original, providing alternative to the expected and the conventional. Imaginative thinking is generative in which one attempts to expand the possibilities of a given situation by looking at it from a new and fresh perspective, combining existing ideas and forming unusual connections.

2. ***Pursuing purposes***

   It involves acting imaginatively to achieve a goal of producing something in a deliberate way. Creative insight is achieved while pursuing the overall objective of solving the problem.

3. ***Being original***

   Creativity involves originality and NACCCE identifies three types of creativity-individual (a work is original in relation to the person's previous works); relative (a work is original in relation to a person's peer groups); historic (the work is original in terms of anyone's previous output in a particular field.

4. ***Judging value***

   Creativity also involves an evaluation mode of thought. The outcome of the imaginative activity can only be creative if it is of value in relation to the task at hand. Values refer to the judgment of some property of the outcome related to the purpose. There are many possible judgments according to the area of activity: effective, useful, enjoyable, satisfying, valid, and tenable. Thus creativity involves critical thinking.

B. Barlex and Rutland (2004) framework of design decisions

Barlex and Rutland (2004) proposed that design in school involves making at least five different types of design decisions. They are:

- Conceptual decisions require the student to think about the overall purpose of the design, that is what sort of product it will be, what it does;

- Technical decisions require the student to consider 'how the product will work' and the nature of the components and materials required to achieve this;
- Aesthetic decisions involves students to think of 'ways in which the product will appeal to the senses' – sight, hearing, touch, taste and smell;
- Constructional decisions requires the student to consider ‘how the product will be made’ and the tools and processes needed to achieve this and;
- Marketing decisions requires the students consider ‘who the product is for’, what is its cost’, where will it be sold.

Barlex (2007) argues that all the decisions are interconnected with each other and interconnected is of utmost importance. A change of decision within one area of the design decision will affect some, if not all of the other design decisions.

C. Additional criteria as proposed by Barlex and Trebell (2007)

Barlex and Trebell (2007) suggested other criteria such as elements of feasibility, use of scientific and technological concepts evident in students’ designed solutions as suggestive of the presence of creativity in students’ designed solutions.

The NACCCE (1999) and the Barlex and Rutland (2004) framework along with the additional criteria suggested by Barlex and Trebell (2007) were combined in our framework to analyse students’ designed solutions to the design problem given to them in Workshop 1 (WS1) and 2 (WS2). The Barlex and Rutland’s model of design as decision-making activity was also employed to analyse students’ responses to some of the items in familiar and unfamiliar artefacts (such as decisions taken by a designer while designing those artefacts) and redesign activities of pairs of ball-point pens in WS2 and pairs of tongs in the Activity trial.

5.5 Analysis

The analyses are presented in terms of the research questions asked. The researcher would like to point out that while an attempt has been made to integrate all the activities within the proposed analytical frameworks, the depth of analysis for different activities varies across trials. This is mostly attributed to the aims of analysis and an attempt to avoid repetition across trials. The mode of data collection involved for the activities also affected their analyses. For example while students' handling of unfamiliar artefacts (3 knife sharpeners) in WS1 was analysed in detail to reveal students' strategies of identifying unfamiliar artefacts and mostly relied on video and audio recorded data, a similar activity of handling 8 unfamiliar activities in WS2 did not probe students' strategies to the same extent and mostly relied on students' written responses.

5.5.1 Determining the structure and functions of familiar and unfamiliar artefacts

This analysis was applicable to the familiar and unfamiliar artefacts used in WS1, WS2 and AT. The analysis is first presented for the familiar artefacts used in WS1, WS2 and AT and next for the unfamiliar artefacts handled in the two workshops and AT.

5.5.1.1 Familiar artefacts

A. Workshop 1

The artefacts handling activities provide evidence of user role activities. It aimed at having students think about the fact that artefacts are designed to serve specific needs of human and that they can be made up of many parts of different materials serving specific needs or purposes. In WS1, five familiar artefacts were used: fountain pen, dry electric iron, hurricane lantern, ball-peen and claw-hammers.

a) Fountain pen

In the fountain pen exercise, each group was handed a simple fountain pen and an individual response sheet was given to all the students (*Appendix J*). They were then asked to disassemble the pen, explore the different parts, draw a sketch of the pen with its different parts and label those parts. Students were then asked to indicate the users of the fountain pen, the steps involved in using it and the most important part/s (according to them) without which the pen would not work. They then had to justify why they considered that part/s important. Although students were given individual sheets to respond to, they worked in groups and discussed with their group members before responding to the activity.

Fountain pen: Structure

Fountain pens are used by many elementary school students in India. In fact it is a compulsory writing instrument in many Indian elementary schools where students shift from writing with pencils to writing with pens for the first time in schools. It was believed that fountain pens improved one's handwriting. However, lately there has been an increasing use of gel pens and ball-point pens even in the elementary schools merely for their ease of use.

When asked to explore the pens by taking its parts out, many students were reluctant to disassemble the pens in the beginning. This could perhaps be due to the fact that students were familiar with the pen and did not consider it worth exploring by disassembling its parts. However, upon urging, these students disassembled the pens. Students' reluctance was also reflected in their drawings of the fountain pens. When asked to depict the pen, its different parts and label those parts, all the groups opted to depict the entire pen and not the disassembled parts (Figure 5.1). Although the responses of students in a group were individual, most students made similar drawings in a group. This usually happened since all the students in a group would decide in advance how they would depict the pen (whether with the cap on or not, the kind and number of parts labelled).

The fountain pen provided to the students in WS1 was one of the simplest varieties. However it consisted of at least 14 parts (including the subparts), as identified by the researcher. The parts of the fountain pen identified were: the nib, the tip, slit, wings, breather hole, feeds, feed channel, fins, body/barrel, grip/section, threads, cap, finial and clip.

However, most groups in WS1 could identify only up to 6 parts namely, nib, grip, ink holder/body, cap, clip/handle and nib tip. The part that was shown disassembled most often was the cap (Figure 5.1). Only 2 groups depicted the section of the pen or the nib holder (Figure 5.2). Perhaps students considered a part of the pen as distinguishable only if they were able to disassemble it without effort. Thus none of the groups attempted to disassemble the feed from the pen and perhaps it was not considered a separate part. The feed of the fountain pen remained unidentified by all the groups. None of them mentioned it in their writings or labelled it in their drawings.

Figure 5.1: The drawing of the fountain pen in WS1 by a student in a group

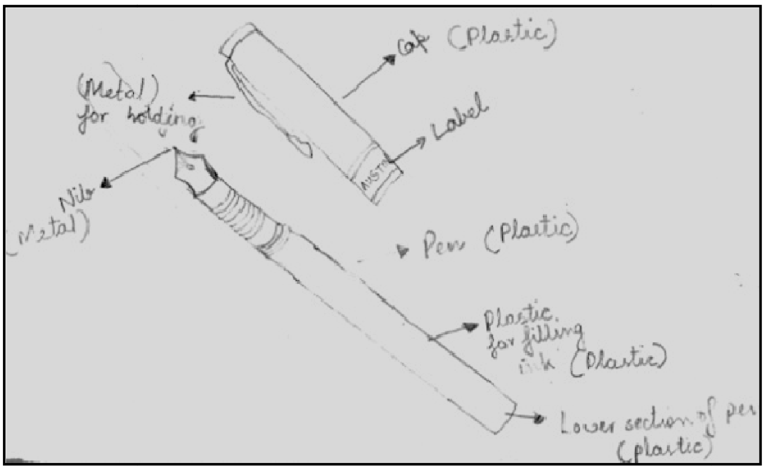
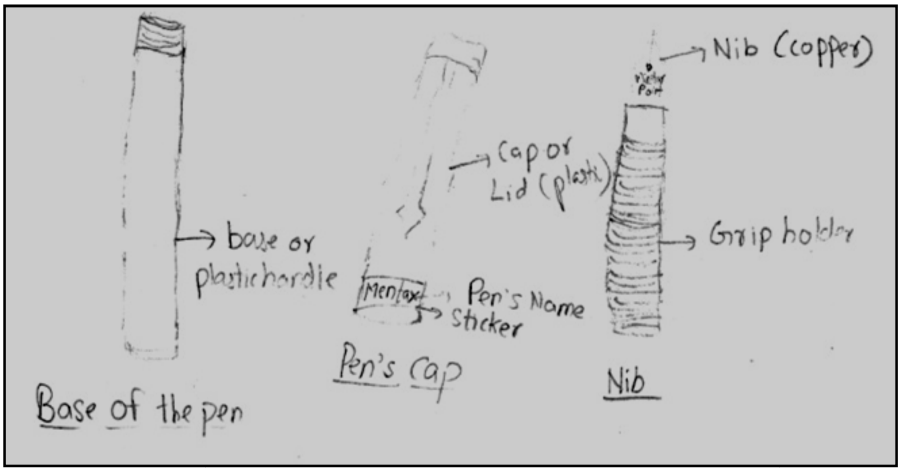


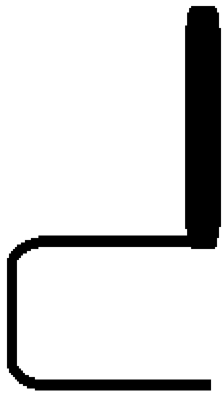
Figure 5.2: The drawing of fountain pens in WS1 by a student from a groups



Students were also found to be unfamiliar with the names of the different parts of the fountain pen. Most groups introduced their own terms/phrases for describing parts of pen such as 'part from where ink goes to nib', 'finger grip', for the nib holder; 'part where ink is put' for the ink holder. These phrases usually indicated the functional properties of those parts.

In the context of this analysis pertaining to structure and function of familiar artefacts, it would be useful to quote an anecdote. The researcher had asked most of her colleagues whether they had seen a 'chair with only two legs' and whether it was possible to design such a chair. Interestingly all her colleagues suggested that they had never seen such chairs and they could not imagine how its design would look like. However when reminded to them that they were all actually sitting on one such chair (most of the chairs in the researcher's institution are two-legged) (Figure 5.3), made them extremely surprised since they realized that they had failed to notice its design even while they had been using it since a long time.

Figure 5.3: A chair with two legs (side view)



This reflects what Moore (2010) suggests. According to Moore once we become familiar with a technology it is easy to forget that it was constructed for a purpose since one tends to focus one's attention on the task that one is attempting to accomplish with that tool than on the tool itself.

Fountain pen: Function

When asked to indicate the function of fountain pen, all the groups suggested that a fountain pen was 'used for writing'. However, only two groups mentioned that it was used to write only on a paper. They seemed to have assumed 'writing' indicated writing only on a paper and seemed to have ignored that writing could involve writing on different kinds of paper, boards, slates, type writers and even computers etc. This is easy to understand since students seldom get opportunities to write on any other media besides paper. This can also be explained from students' responses to another question, '*What other objects can be used instead of this object for the same purpose?'* where almost all the students suggested writing tools corresponding mostly to papers, such as 'ball-pens, sketch pens, pencils, markers, gel pens.' The lack of context specificity in students' responses to artefact function also indicates their inattention to the effect of artefact function on the environment. The function of the artefact seems to exist on its own.

The context of artefact use from the point of view of designers however, has been considered important in literature. According to Hughes (2009), a designer suggesting the function/s of an artefact, must be able to say what that artefact does, how it does and *when one must use it*. Hughes argues that contexts of use have largely been ignored in the literature but it remains an important feature that designers need to consider. For example giving an example of a ball-point pen, the author suggests that the early designers of this pen perhaps did not consider a gravitational field as part of the normal context of use for this pen. However, the fact that ball-point pens do not work in zero gravity has made this realization relevant for at least to NASA, even though it might not be relevant for other users.

While suggesting the users of fountain pen, groups came up with different kinds of users, ranging from a broad to very specific user categories. For example a few group suggested 'every human'/ 'all people' while one group suggested 'calligraphers' as users of fountain pen. Most groups suggested a diversity of users generally office-goers, teachers and students. From a designer's point of view, it is imperative that she recognize the right users for her product, in order for the designed product to succeed. By defining the users, the designer can look at the system or product from their perspective and also gather useful feedback from them. Students, by suggesting a broad user category demonstrated a naive approach to design since they failed to assume that products are designed keeping specific users in mind.

b) Electric iron

After their completion of the fountain pen task an electric iron was handed to each group, and a response sheet was given to each student in the group. Several questions pertaining to the structures, functions and the working mechanism were asked to students (*Appendix K*). A picture of an actual iron was given on the response sheet and students were asked to identify as many parts as they could, label those parts and suggests materials used to make them. They were also asked to suggest the users of the iron and the alternatives of electric iron.

Electric iron: Structure

An electric iron is a commonly used electrical appliance in most urban households. While most people in India iron their clothes at home, there are also many who get their clothes ironed outside of home by professional laundry persons called ‘dhobis’.

All the students indicated in writing that they were familiar with the electric iron provided to them and has used something like it before. An interesting thing which was observed for electric iron was that students hardly explored the iron for its different parts. Most of the time throughout the iron task, the iron was lying on the table with students handling it for a few seconds or so. The only time few groups were interested in it was when they were labelling the swivel cord of the iron (Figure 4.3). This could perhaps be explained by the nature of the activity itself. All the students were familiar with the iron provided to them. They were asked to explore the different parts of it but were not asked to disassemble it. Also the response sheet had a picture of iron so the students kept referring to the picture without actually looking at the real iron.

For the electric iron, students were asked to mark and label the different parts of an iron, and mention the materials used to make them. Researcher identified at least 6 different parts as follows: handle, steel cover, Teflon plate, thermostat control knob, lamp and swivel cord. It was found that even though all the students had shown an agreement in using the electric iron, only one boys group could differentiate and label all the visible parts correctly. The others either missed one or two parts or did not mark them correctly. Most groups came up with around 5 parts, namely the plate, handle, cord, thermostat and lamp. Groups were also not aware of the materials used to make those parts. Most of them were not familiar with the materials that were used to make those parts, such as Bakelite, Teflon. Two of the 7 groups mentioned the use of conductors (metals) for the handle of an iron.

Electric iron: Function

They all suggested that an iron was used for 'removing the crease/wrinkles from clothes'. Coming up with alternative artefacts that can do the same function as that of an electric iron, is rather difficult since there are only kinds of irons which can be used instead of the given iron. Thus this question posed a challenge to the students. However, while 2 groups suggested using steam iron and 2 other groups suggested using charcoal iron, there were 3 groups which suggested alternative ‘ways’ of ironing the clothes. The three groups (2 girls' and 1 boys' groups) suggested folding the clothes and keeping them under the mattress overnight to keep them pressed.

When asked to suggest the users of the electric iron, the responses across the groups for the iron task varied from a broad user category to specific users, similar to the fountain pen task. For example, a few groups (2 boys' groups) reported 'all people' as users of electric iron, whereas one group suggested 'housewives and mothers' as specific users of electric iron. Two groups put emphasis on the utilization of electric supply for using the iron and so they restricted the users to those who have electric supplies at home.

c) Hurricane lantern

After the completion of the iron task, each group was handed a hurricane lantern and a response sheet was given to individual students (*Appendix L*). A hurricane lantern is a traditional artefact, mostly used in towns and villages. It is used as a portable light source in most rural and semi urban regions of India. Unreliable electric supplies in these areas have led to reliance upon lanterns in these parts of India. In urban areas, these lantern and their different varieties are used mainly for decorative purposes.

Several questions pertaining to the structure, functions, materials and working mechanisms and alternatives of the lantern, were asked to students. A picture of a hurricane lantern was provided in the sheet and 8 parts of it were already marked with arrows on the picture and students were asked to label those parts and mention the materials used to make them. The 8 parts were the handle, the crown, glass/globe, glass support, lifter, wick, knob and tank.

Hurricane lantern: Structure

The students mentioned that most of them had just seen a hurricane lantern before, either an actual one or its pictures in books, newspapers or movies, but they had never handled or used it. As mentioned above in the sample description (see Section 4.6.3) these students resided in an urban locality within the residential area of the Atomic Energy Research Centre, where there are continuous supplies of electricity. People hardly experience any power cuts within this residential area. Thus they hardly feel the need to keep alternate sources of light. Even if they do, the battery-backed emergency light serves the purpose in an urban locality.

The video data showed that in contrast to the pen and iron tasks, students showed a great deal of curiosity and enthusiasm while handling the lanterns (Figure 4.4, Figure 5.4). The data also shows students' attempt and hesitation as they tried to explore the lantern. Although the lantern task was met with great enthusiasm and curiosity on the part of students, none of them attempted to take apart the lantern. Students expressed a perception of risk while performing this exploration. Many also indicated that adult supervision was necessary while handling the lanterns.

None of them knew how the lantern could be lighted and used. A demonstration was given by the researcher to the students, wherein they were shown how the lantern was lighted, how the different parts could be manoeuvred and taken apart.

Figure 5.4: A girls' group exploring the hurricane lantern in WS1

Almost all groups introduced their own terms for the various parts of lantern, for example, 'part from where CO_2 and O_2 pass' or 'exhaust' for the crown; 'burning material', or 'flame producer' for the wick. Thus after knowing the function of a part of an artefact, students used the knowledge for naming the part of the artefact.

Hurricane lantern: Function

Function of the hurricane lanterns was known to all and they all suggested that it was used as a 'source of light' in villages. Two groups even mentioned it as a 'non-electrical source of light'.

All groups suggested 'villagers' as the users of hurricane lantern. Two groups (1 girl and 1 boy groups) also suggested poor people having no supply of electricity as users, while 1 group (a boy group) identified miners as users of this artefact. This group argued appropriately that mining activities produces inflammatory gases and this lantern was used as a safety lamp in mines.

While identifying the products used instead of a hurricane lantern, all the groups suggested various sources of light that were either run by electricity (such as tube light, bulbs) or backed by battery (such as emergency light, torch, candles etc). At least four groups suggested sources of light run by electricity indicating that they only considered the function of lighting but not the portability of light as an essential criterion while selecting the alternatives of the lantern.

d) Ball-peen and claw hammers

After the hurricane lantern task, students were given two different kinds of hammers- ball-peen and claw hammers to handle and look for similarities and differences between the two. Hammers are one of the most common tools present in most households, whether urban or rural. At home hammers are mostly used for driving nails, fitting parts or breaking up objects. In the present study however, all the students revealed that they had never got an opportunity to use them. They showed a great deal of interest during this activity, with each student in a group waiting eagerly to try his/her hands on the two hammers.

Hammers: Structure

In case of the hammers, students recognized the difference between the two only after handling and using the two different types of hammers and (ball-peen and claw hammers). Students were given pieces of wood and nails to use with the two hammers. They were then asked specific questions about the two hammers mainly related to the materials of the different parts of the hammers (*Appendix M*). For example they were asked to explain the consequences of replacing the materials of the handle from wood to metal, that it how the replacement would affect the workings of the two hammers. Almost all groups reasoned that the metal handle would make the hammer heavy so it might slip or might be hard to carry. A few groups also reasoned that metal might also vibrate or rust and thus hurt the hands of the users.

Hammers: Function

All of them suggested that the function of the two hammers was to 'hit nails'. Students identified the overall functions of the two hammers. When asked to suggest the differences between the two hammers, students could identify the apparent structural differences between them. However none could spontaneously suggest the riveting functions of the ball-peen hammer. It was only after using the two hammers on blocks of wood and plucking nails, did students realize the different functions of the two hammers.

B. Workshop 2

a) Ball-point pen

A retractable or click ball-point pen was used as a familiar artefact in WS2. Each student in a dyad received a response sheet while a single pen was given to each dyad. A number of questions were asked which probed students’ understanding of the structure and functions of ball-point pen (*Appendix R*). All the dyads were familiar with the pen and had used it. Like the sample in WS1, these students too were hesitant to dismantle the pen. Even when given the freedom to explore the pens in whatever way they wanted, most students were reluctant to take the pen apart. However, upon researchers' insistence, students disassembled the pen. Both these observation of students’ initial hesitation in WS1, WS2 perhaps might also reflect their didactic approach to learning in schools where students do not get an opportunity to explore things on their own.

Ball-point pen: Structure

The number of ball-point parts identified by the researcher was around 10. The parts identified were nib, ball, ball-cap, refill, spring, push button, section, grip, body/barrel, threads and clip. However, responses from the students indicate that overall 8 parts were identified by all the dyads, ranging a minimum of 5 to a maximum of 7 parts identified by each dyad. The parts identified by all the dyads included body/cover, refill, spring, grip, push button, nib holder, nib and ink. Here also the parts which could not be disassembled by students were left unidentified. For example none of the students marked the ball of the nib as distinct from the nib.

Ball-point pen: Function

They all mentioned the function of the pen as ‘writing’, but as in WS1, none except only two dyads mentioned ball-point pens to be designed for writing on papers. This suggests students’ lack of attention to artefacts which are most familiar to them.

Interestingly for an artefact that they use day in and out, that is a ball-point pen, students presented a very superficial understanding of the functions of the different parts of the pen in WS2. 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. Many parts remained unidentified by students. Some of the functions were also incorrectly understood. For example, students identified the functions of the ball of the pen as ‘to protect the nib’ or refill cap ‘to protect the ball’ grip ‘makes easy to write’ etc. It is to be mentioned that the function of the ball of ball-point pen is to let ink flow out of the pen in a controlled state and prevent the ink from drying.

When asked how the ball-point pen or its parts could be used by a tribal person in different ways other than writing, all dyads came up with alternate uses of the pen considering a tribal person as the user.

Table 5.1: Alternate uses of ball-point pen and its parts generated by students in WS2

Click Ball-point pen parts	***Alternate uses***	***Number of Dyads***
Body	Toy	4
	Whistle	3
	Tear bark of tree	3
	Tear animal skin	2
	Shooting weapon	2
	Striking weapon	2
	Dig earth for water	1
Refill	Make markings	5
Ink	Poison	2
Nib holder	Funnel	1

As seen from Table 5.1, students ascribed functions to the different parts of the pen, based on the context provided to them: a remote tribal location.

When asked how the loss of each of the parts mentioned by the students affected the function of the pen, almost all the dyads suggested dysfunction of the pen without giving any specific description of how the loss would affect the functioning of the pen.

For example, almost all the dyads except one suggested that the ‘pen will not function properly’ for the loss of any of the parts of the pen, without mentioning the specificity of the dysfunction. This suggests students’ lack of knowledge about the specific functions of the different parts of the pen. Only one dyad mentioned how the loss of each part of the pen specifically affects the function of the pen. For example, for the loss of the spring in the pen, they wrote, *‘the refill will either remain loose free or fixed. We will not be able to write if it is loose.’*

C. Activity Trial

In the Activity trial, four pairs of tongs used for lifting vessels were used. The pairs of tongs T_B, T_C and T_D are common in most Indian kitchens and people use them to lift hot utensils while cooking. All the dyads were familiar with the tongs, T_B, T_C and T_D but none had seen T_A. The tongs T_A is locally used in certain parts of the country.

Pairs of tongs: Structure

Students were asked a number of questions pertaining to the structures of the given pairs of tongs. As indicated in Table 4.10 in Chapter 4, the four pairs of tongs T_B and T_D were perceptually very similar to each other and both of them slightly resembled a part of $T_{A.}$ T_C was very different to look at than the other three pairs of tongs. Students’ readily recognized the perceptual similarities and differences among the pairs of tongs as evident from their categorisation task where they were required to categorise the pairs of tongs which they considered similar and provide justifications for the formation of those categories (see Section 5.5.1.4 for detail analysis on this task). All the dyads categorised T_B and T_D together indicating a strong perceptual basis to the categories.

Although students were familiar with T_C, none of the dyads knew that it could be rotated through 360 degrees to have a different configuration. This however they came to realize as they explored and handled the tongs with the help of researcher's support.

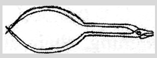
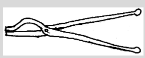
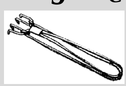
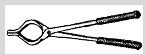
When asked to indicate the materials used to make the given pairs of tongs, each dyad expressed confusion regarding the materials used in T_A, T_B and T_D. Each member in all the three dyads however unanimously agreed that the material used to make T_C was stainless steel perhaps due to its finish and shine.

Pairs of tongs: Functions

Students could identify the functions of the other three tongs as the vessel lifting tongs spontaneously, but with much exploration could identify the function of $T_{A.}$ Students' exploration of T_A has been dealt with in a later section where students' strategies to identify unfamiliar artefacts has been discussed (Section 5.5.1.3).

When asked to indicate how each pair of tongs could be used in different ways other than lifting hot vessels, all the three dyads came up with alternate uses of these pairs of tongs. Some of the alternate uses are suggested by the 3 dyads are provided in Table 5.2

Table 5.2: Alternate uses/functions suggested by dyads for the 4 pairs of tongs in AT

Dyads	***Tongs T_A*** 	***Tongs T_B*** 	***Tongs T_C*** 	***Tongs T_D*** 
Dyad 1 (Boys)	• Digging soil	• Holding test tubes • Moulding clay	• Digging soil	• Pulling objects • Plucking nails
Dyad 2 (Boys)	• Plucking nails; • Breaking wires	• Breaking emergency glass • Hunting birds • Plucking nails	• Mixing eggs • Making patterns on cakes or in art • Straining oil from snacks	• Exercising palms
Dyad 3 (Girls)	• Defence	• Cracking walnuts • Holding and carrying bottles	• Catching crabs • As a wall paint brush by putting sponge on its edge	• Catching snakes • Turning *chapattis* on *tawa* (flat pan)

As indicated in Table 5.2, students came up with a variety of functions for the 4 pairs of tongs. However, more accidental functions or alternate uses for all the pairs of tongs were generated by Dyad 2, while least was generated by Dyad 1. It was found that for each of the functions identified for the pairs of tongs, students emphasized on different structural properties of the tongs. For example, for digging the soil with T_A, Dyad 1 relied on the bigger rounded arms of it but for plucking the nails, Dyad 2 relied on its smaller pivoted section. Again while for plucking nails with T_B, Dyad 2 relied on its pivoted portion, the same dyad realised that T_B could be used for breaking emergency glass or hunting birds by virtue of its weight (heaviness). If the proper functions of the pairs of tongs (that is, holding/grasping) are excluded from the students' generated alternate functions, then it was found that the most creative functions suggested by all the dyads were for T_C. Gibson (1979, 1986) suggested that an object provides *affordances* or structural clues to identifying the actions that could be performed on/with the artefact. Thus artefacts that provide more affordances, will be put to more uses than artefacts that provides less affordances. As can be seen from students' responses in Table 5.2, tongs T_A, T_B, T_D were put to similar uses (mostly related to their proper functions of holdings such as carrying, pulling, plucking etc.) perhaps because they were similar in structures. T_C was different in structure from these three pairs of tongs and it also afforded more actions than the other tongs (since it could be rotated through 360 degrees and had a slightly different configuration than the previous one). Hence it was put to different and more uses than the other tongs.

5.5.1.2 Unfamiliar artefacts

A. Workshop 1

a) Pictures of 3 unfamiliar artefacts

Structure and function of the 3 pictorial artefacts

In WS1, students were first given a set of three pictures of unfamiliar artefacts. The three artefact pictures were of a book holder, a boiled egg retriever and a mouse trap. For each of the pictures, students were asked to identify or guess the materials used to making each part of the three artefacts. Analysis of students' responses indicates that students could correctly infer the materials of the artefacts from their pictures. However, confusion among group members usually seemed to stem over the parts which were made of metals. This is evident from multiple kinds of responses in a group regarding the metallic parts of the artefact picture. For example, in a few groups, some members suggested that the handle of the ‘book holder’ was made of aluminium while other wrote ‘iron’, while still few others wrote, ‘wrought iron.’

Each artefact picture contained a list of three possible functions that could be performed by each of those artefacts. Students were required to select any one option as the correct function of each artefact. Except two groups, all the groups could correctly infer the function of the mousetrap. However, confusion seemed to stem around the functions of the book holder and the boiled egg retriever. Even while having the correct options before them, students suggested alternate functions of these two artefacts. In order to make use of an artefact one needs to perceive the possible actions that could be performed on or with it. Pacey (1983) indicates that if an artefact is to be used, it must fit into the pattern of activity that belongs to a particular lifestyle and set of values. Thus even though students read the correct or proper functions of the book holder and the boiled egg retriever, they did not select those options because these artefacts are not heard of in the Indian society. They tended to select those options that fitted with their own pattern of activity and lifestyle. Thus most considered the book holder as a ‘clothes hanger’ or a 'musical instrument' and the boiled egg retriever as a ‘damaged water heater.'

b) Knife sharpeners

In Workshop 1, another task with unfamiliar artefacts involved three knife sharpeners, which were provided to each group who were then interviewed separately for about an hour and half while they handled the three sharpeners in an attempt to identify the function of each. Of the 7 groups in WS1, one was familiar with all the three knife sharpeners, hence they were removed from the analysis. Again while all the 6 groups explored the three sharpeners, only three groups could successfully infer the functions of all the three artefacts. This study has been published in detail in a peer reviewed international journal (Ara, Natarajan and Chunawala, 2009b). However, for the sake of coherence, a brief analysis of this interesting study is provided in this thesis.

Knife sharpeners: Structure

As discussed in Chapter 4, Section 4.7.4.4, there were similarities and differences among the three knife sharpeners provided to students in WS1. The perceptual similarities between knife sharpeners ‘A’ and ‘B’ were the presence of slots and the orientation of wheels within those slots. The obvious similarity between ‘B’ and ‘C’ was the sharpening material used. There was no obvious structural similarity between ‘C’ and ‘A’. Students were asked to find the similarities in the knife sharpeners. It was found that only the girls’ groups (Groups 1 and 2) observed these similarities between the knife sharpeners. While other groups also found the similarities among the 3 artefacts, these were limited to the material and the superficial appearance of the artefacts. The identification of the similarities in the knife sharpeners served as an important strategy while identifying the functions of these sharpeners which were unknown to all the groups. This aspect ahs been discussed later in Section 5.5.1.3.

Knife sharpeners: Functions

While handling the three unfamiliar knife sharpeners, students employed a number of strategies to explore the artefacts and infer their functions (has been discussed later in Section 5.5.1.3). While only three groups could successfully infer the functions of all the three knife sharpeners, all the groups came up with several accidental functions for these while they were exploring the artefacts.

Table 5.3 provides the accidental functions identified by students for the knife sharpeners. Although accidental functions for the artefacts were suggested by all groups, successful groups later rejected these accidental functions. Although students attempted to identify the affordances provided by the artefacts and suggest functions on the basis of those structural affordances, most of these affordances did not match with the uses that it could be put to. As seen from

Table 5.3, most of the accidental functions of the three artefacts provided by students were inappropriate in terms of their structures. For example knife sharpener C was very light, however at least 4 groups suggested that it was a paper weight. Perhaps students tended to see the overall perceptual similarity of C with the compact structure of a paper weight and assumed it to be so. This can be confirmed from the analysis of students’ responses to the alternate functions of the four pairs of tongs in the Activity Trial (see Table 5.2).

Table 5.3: Accidental functions generated by students for the knife sharpeners in WS1

Group 1 (Girls' Group)	*Group 2 (Girls' Group)*	*Group 3 (Boy's Group)*
Intended functions of ***A, B, C****:* Identified *Accidental Functions*: ***B:*** • pencil sharpener ***C:*** • toy • paper weight	*Intended functions of* ***A, B, C****:* Identified *Accidental Functions*: ***A:*** • for binding papers • smoothening paper ***C:*** • to clean surfaces • smoothen wood • smoothen metal • file nails	*Intended functions of* ***A, B, C****:* Identified *Accidental Functions*: ***A:*** • for cutting papers • putting stamps on paper • paper holder
Group 4 (Boy's Group)	***Group 5 (Boy's Group)***	***Group 6 (Boy's Group)***
Intended functions of ***A****:* Identified*;* ***B and C****:* Not Identified *Accidental Functions*: ***B:*** • for storing blades ***C:*** • for wrapping thread around • for wrapping paper around • for wrapping cello tape around • for wrapping cloth around as bandages • as a paper weight	*Intended functions of* ***A, B, C****:* Not Identified *Accidental Functions*: ***A:*** • act as a lever • to straighten something ***B:*** • cover for a torch ***C:*** • paper weight • as wheels of a car • yo-yo toy	*Intended functions of* ***A, B, C:*** Not Identified *Accidental Functions*: ***A:*** • act as a lever • gear • handle of door • part of lathe machine • part of compound microscope • for cutting papers • for making circles on paper ***B:*** • for storing something ***C:*** • wheels of remote-controlled car • a two wheeled toy car

While all the pairs of tongs were heavy and thus could appropriately be used as paper weights, none of the students in AT suggested so, indicating that they considered compactness as one of the essential characteristics of paper weights.

In WS2, students also showed this tendency of comparing the structural similarity of the given knife sharpeners with some of their known and familiar artefacts and suggesting the function based on the known artefact. In doing so they came up with functions which were inappropriate. For example, the functions of knife sharpener ‘A’ was conceptualised as *for binding papers* (similar to stapler) *or for smoothening papers, for cutting papers, to straighten something, act as a lever, gear, part of lathe machine* etc. The functions of ‘B’ were suggested as *for storing blades, for storing something or cover for a torch.* Similarly for ‘C’, students suggested for *wrapping paper around, as wheels of a car or a paper weight.* These functions seemed to be derived from students’ prior experiences with structurally similar artefacts. Students just replaced those known artefacts with the knife sharpeners without pondering about their structures.

Some of the accidental functions listed by students were typically related to their daily activities: *toy, pencil sharpener, paper weight, wrapping for cello tape or bandages, handle of a door etc* suggesting that students tried to fit the uses of those artefacts into their own pattern of activity and lifestyles (Pacey 1983). 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.

An important observation regarding the possible functions or the accidental functions of the three knife sharpeners is that of the 3 sharpeners, most students across all groups came up with fewer accidental functions for ‘B’ (4) than for either ‘A’ (14) or ‘C’ (16). As mentioned earlier in order to make use of an artefact one needs to perceive the possible actions that could be performed on/with it. Gibson (1979/1986) uses the term *affordances* to refer to the close link between the perceived properties of an artefact and the possible actions that could be done with it. None of the students of the six groups were familiar with the 3 artefacts used in the study. Hence the clues to identifying the intended functions of the 3 artefacts were the structural properties that afforded particular actions. For example, ‘A’ was highly graspable with a handle while ‘B’ and ‘C’ were not (Table 4.5). Both ‘A’ and ‘B’ had slots through which something thin could be drawn. ‘C’ was rotate-able whereas ‘A’ and ‘B’ were not. Artefact that affords more actions would be put to use in more ways than another that affords fewer actions.

Students came up with fewer accidental functions for ‘B’ than for ‘A’ or ‘C’ suggesting that ‘B’ offered fewer perceived affordances and hence fewer possible uses than ‘A’ or ‘C’.

Alternate uses of ball-point pen compared to the alternate uses of knife sharpeners

An attempt was made to compare the kinds of alternate uses that students arrive at for the three knife sharpeners and the ball-point pen and its parts, it can be seen that overall more alternate uses were suggested for the three knife sharpeners (except 'B') than for the ball-point pen parts. For example, overall students came up with 14 different uses for knife sharpener 'A' and 16 uses for knife sharpener 'C' while only 4 for 'B' (The fewer number of uses for 'B' has been explained earlier). In case of ball-point pen however, students came up with only 10 different alternate uses. This can be explained on the basis of two probable grounds. Firstly the literature on design stance suggest that familiarity with an artefact can inhibit an individual from coming up with alternate uses of an artefact (German and Defeyter 2000; Defeyter and German, 2003). This means that if an individual is familiar with the affordances supporting an artefact's proper use, then it is difficult for her to detect alternate or atypical uses of that artefact. The individual is said to demonstrate what is known as *functional fixedness.* If the individual is unfamiliar with an artefact, she will demonstrate less fixedness on design functions. Thus students unfamiliar with the knife sharpeners came up with more and varied alternate uses then students handling the ball-point pen, an artefact very well-known to them.

Another reason that students handling the pen came up with less number of uses could be related to the nature of the task itself. While students in the knife sharpeners task explored the artefacts with an aim to unravel their functions, students in the pen task were required to suggest functions that the pen would serve to a tribal person. Hence they perhaps, were constrained to imagine alternate uses of the pen from a specific user's point of view which was not the case in the knife sharpener task.

B. Workshop 2

In WS2, there were 8 unfamiliar artefacts that were provided to students to guess their functions. Each dyad was given one product randomly and response sheets for responding. Dyads responded to the sheet after mutual discussion with each other. They had to identify the artefacts and suggest what provided them clue/s to the identification of the functions. Table 5.4 provides the detail of the functions of the unfamiliar artefact provided by students.

Table 5.4: Functions of unfamiliar artefacts suggested by dyads in WS2

Unfamiliar artefacts in WS2	***Function/s of artefacts***	***No. Of dyads***
A 	Mould to make impressions on clay/ dough/ biscuits	3
	Crush vegetables	5
	Hold something	1
B 	***Crack nuts (proper function)***	3
	Store things/ drinking tea or coffee	2
	Crush fruits and vegetables for juices	5
	Grinding spices/ mortar and pestle	1
C 	***Toy (proper function)***	6
	Bell	1
	Pendulum/ hynotising ball	1
	Weapon	3
D 	Make juice	2
	Part of a grinding machine	1
	Mould	2
	Candle stand	1
	Peeler	1
E 	***Crack nuts/shells (proper function)***	6
	Tighten nuts and bolts	1
	Cut wires/ grass/ ginger	1
F 	***Mould for dough/ clay (proper function)***	5
	Paper weight	1
G 	***Scratch back (proper function)***	7
	Dig soil	5
	Comb hair	1
	Pull objects towards oneself	4
	Tap on people' back	1
H 	***Lift hot utensil/ to pick up objects (proper function)***	2
	Turn hot 'chapattis'	1
	Chop grass	1
	Weapon	3

As suggested from Table 5.4, most dyads could appropriately guess the functions of Objects ‘C’, ‘E’, ‘F’, and ‘G’. While a few could guess the function of ‘B’ as nut cracker, most suggested it to be used for crushing vegetables, fruits for making juices or for storing things like tea of coffee. None of the dyads could identify the functions of Objects ‘A’, ‘D’ and ‘H’. Although two dyads did mention that Object ‘H’ was used for lifting hot vessels, they emphasized on the pivoted part of ‘H’ and not the actual bigger rounded vessel-lifting portion of it. Students’ justification for how they arrived at the function of each of the artefact has been discussed in the next section.

5.5.1.3 Strategies employed in the identification of unfamiliar artefacts

This analysis was relevant in the context of unfamiliar artefacts used in WS1 and WS2 and one pair of tongs in Activity Trial. In WS1 each group was interviewed at a time in detail and observed while they handled and explored 3 knife sharpeners. Their interaction with each other while handling the sharpeners were audio and video recorded. The researcher identified their strategies of guessing the functions of the sharpeners from the analysis of the audio and video data. In WS2, the dyads handled 8 different artefacts in the same setting. Each dyad was asked to mention how they identified or guessed the function of the given artefacts. The dyads were not interviewed individually as in the case of knife sharpener activity in WS1. The researcher, thus mostly relied on students’ written responses where they mentioned what provided them clues to the given artefact functions. In the Activity Trial dyads handled four different pairs of tongs. However it was observed that all the three dyads in AT were unfamiliar with only one pair of tongs. Hence this section of the analysis pertains to only that pair of tongs, T_A.

The details of the strategies utilized to identify the three knife sharpeners and the pairs of tongs have been published in a peer reviewed journal (Ara, Natarajan and Chunawala, 2009b) and a peer reviewed conference publications (Ara, Natarajan and Chunawala, 2011a) respectively. However, the main results have been reported in this thesis.

While students handled the unfamiliar artefacts in the two workshops and the Activity Trial, they discussed among them actively and explored the artefacts to find clues to their functions. Students’ written responses to these activities, the video-recorded data on students’ verbal interactions through active discussions, gestures and handling of the given artefacts, were all analysed to look for students' strategies in identifying the unfamiliar artefacts. For the knife sharpener task in WS1 and the pair of tongs task in AT, the video recordings served as the primary data to identify students' strategies as each of the groups and dyads were interviewed individually as they explored the artefacts. However, for the activity of handling unfamiliar artefacts in WS2, students' written responses served as the primary data, since all the dyads handled the artefacts at the same time and they were asked to indicate in writing, the clues to the function of the given artefacts.

In WS1, from the video data, the statements, utterances, gestures and actions which were indicative of any strategy were identified. Several strategies used by the groups were identified and classified into: ***cognitive strategies*** and ***handling strategies***. These strategies were identified while students handled the knife sharpeners in WS1. However, the researcher aims to identify whether these strategies were also utilized while handling the different artefacts in the other two trials (in WS2 and AT).

Cognitive strategies

What are cognitive strategies? For the purpose of this research, cognitive strategies include the active discussions that took place among group members while identifying the functions of the artefacts. It was found that while discussing about the intended functions of the knife sharpeners, members in a group adopted either of these cognitive strategies: 'suggest new ideas', 'question/seek justification from others', 'reject ideas', 'defend their own ideas', 'reiterate ideas', 'direct others attention towards a particular structure of the artefact', 'acknowledge others ideas', 'enquire from others', 'consolidate all the ideas' that were presented by all the members in the group, 'use gestures' and 'use the idea of similarity' between the knife sharpeners. The cognitive strategies adopted by groups while handling the knife sharpeners have been studied in detail and the analysis of it follows below.

a) Knife sharpeners in WS1

As mentioned earlier, none of the six groups were familiar with any of the 3 knife sharpeners. Three groups- Groups 1 (girls), Group 2 (girls) and Group 3 (boys) could correctly infer the intended functions of the 3 sharpeners while 2 of the groups (Groups 5 and 6) were unable to identify the intended functions of even one of the artefacts. Group 4 could identify the intended function of only 'A'. Each group had one or more dominant strategy/ies. It was observed that all the groups adopted nearly similar strategies but the frequency of use of these differed in groups.

Table 5.5: List of cognitive strategies use by groups while handling knife sharpeners

Cognitive Strategies	***Group 1*** (Girls)	***Group 2*** (Girls)	***Group 3*** (Boys)	***Group 4*** (Boys)	***Group 5*** (Boys)	***Group 6*** (Boys)	***Total***
Suggest new idea	**62**	44	34	**59**	43	47	**289**
Question/seek justification	**39**	8	13	12	5	**1**	**78**
Reject ideas	**24**	5	9	**29**	5	**3**	**75**
Defend Ideas	**17**	**17**	4	7	2	**0**	**47**
Reiterate ideas	**21**	6	6	10	6	11	**60**
Direct others attention	**29**	16	8	8	27	**4**	**92**
Acknowledge ideas	14	8	7	**16**	4	**2**	**51**
Enquire from others	**36**	17	6	4	16	18	**97**
Consolidate ideas	**5**	1	1	3	0	0	**10**
Use gestures	15	14	12	9	5	9	**64**
Use similarity idea	Used	Used	Used	Not used	Not used	Not used	**---**
Total interactions	***262***	***136***	***100***	***157***	***113***	***95***	

An overview of the frequency of cognitive strategies utilized by each group is indicated in Table 5.5. 'Suggest new ideas' referred to any new idea suggested by a student in a group about, (i) materials; e.g. Group 1 (girls), S3: *'I think this material is stone,'* (ii) structure; e.g. Group 2 (girls), S4: '*there is a stone in between the wheels,'* (iii) function; e.g. Group 4 (boys), S4: *"B' can be used for storing blades,'* (iv) affordances provided by the artefacts; e.g. Group 2, S4: *'…something should enter from this side and come out from the other side,'* (v) actions through which a function would be achieved; e.g. Group 2, S3: '*see, this thing* ('C') *can rotate like this* (shows a rotating action with her hand) *and rub any wood or metal* (vi) possible orientations of the artefacts; e.g. Group 3 (boys), S3:

'see, both can be placed horizontally' and (vii) similarity between the artefacts; e.g. Group 3, S2: *'the metals in 'A' is oriented in this way and the material in B is also placed in this way'.*

It can be seen from Table 5.5 that almost all groups suggested a fairly large number of ideas (289). The number of ideas suggested was highest for materials (92), followed by functions (52) and affordances provided by the artefacts (40) for all the artefacts across all groups (Table 5.6). The higher frequency of suggestions for materials could be explained by the nature of the task, where students were asked to identify the materials of the 3 artefacts, while no such probe was used for the structures of the artefacts.

Table 5.6: Sub-categories of new ideas suggested by the groups in WS1

Sub-categories of 'Suggest new idea'							
Material	***Structure***	***Function***	***Affordance***	***Action***	***Orientation***	***Similarity***	***Total***
92	37	52	40	23	7	38	289

In the category 'question idea/seek justification,' students posed questions to each other or asked for clarification of others' ideas. For example, Group 1 (girls), S1: *'How can this be a stone? This is so light.'* Students also posed questions to themselves regarding the presence of any structure. For example, Group 1, S2: *'Suppose if 'B' is a knife sharpener then what about these* (pointing to the grooves on the inner side of 'B'). *Why are they there?'* As shown in Table 5.5, Group 1 posed the largest number of questions (39) to or sought explanation from others in their group followed by Groups 3 (13) and 4 (12), while Group 6 (boys) questioned its own members least (1). Groups who did not question the ideas of others but accepted all ideas without objection were unsuccessful in identifying the intended functions of the artefacts. So even though students in Groups 5 (boys) and 6 suggested ideas these were not questioned, critiqued nor was any justification sought. This also explains why there were less rejections or defence of ideas in these two groups (Table 5.5). Both the girls' groups defended their ideas more often than the others and tried to prevent rejection of their ideas by justifying their ideas to others.

Students defended their ideas by (i) showing structural evidence; e.g. Group 2, S4: ''C' *can be used for smoothening any metal or wood because of its rough surface'* (ii) showing affordable action; e.g. Group 1, S2: *'Both* ('A' and 'B') *has slits through which* *knife can be passed and sharpened'* (iii) testing; e.g. Group 3 (boys), S3: *'it* (wheels in B's slot) *is sponge.'* Saying this, S3 puts his pen refill in the slot of 'B' to check (iv) logical reasoning; e.g. Group 1 (girls), S1: *'this* (material in 'C') *is something else. It is so light; if it was a stone it should be at least a bit heavier.'* and (v) using analogy; e.g. Group 2, S4: *'see, it* (sharpening material in 'C') *looks like sand paper. Just like sand paper is rubbed on a rough surface to smoothen it, 'C' can also be used for rubbing on wood or metal.'*

Figure 5.5: A student pointing at a part of knife sharpener 'C' in WS1

Students directed attention of others to relevant aspects of artefacts that they were handling, through gestures such as pointing or through words such as *'see'* (Figure 5.5). When students directed attention of others, they ensured that others contributed to the identification process. Groups 1, 5 and 2, had directed attention of other members of their groups more often while Group 6 did so least. Gestures were usually made by students to (i) probe the artefact; e.g. gesture of twisting the head of 'A' (ii) direct others attention through pointing (Figure 5.5) (iii) communicate actions through which a function would be achieved by the artefacts; e.g. drawing hand/pen/finger through the slots of 'A'/ 'B' and (iv) communicate structure of the artefacts; e.g. showing the orientation of wheels in the slot of 'A'/ 'B' with hand. Pointing is a dominant form of gesture when students collaboratively make sketches of routes (Heiser, Tversky and Silverman, 2004). In the present study too, from the video analysis, pointing was found to be prominent among the gestures used by students.

One important strategy utilised by the students of Groups 1, 2 and 3 was in dealing with the question of whether there was any similarity among the 3 artefacts. For example the most obvious similarities between ‘A’ and ‘B’ were the presence of slots and the orientation of wheels within those slots. The obvious similarity between ‘B’ and ‘C’ was the sharpening material used. There was no obvious structural similarity between ‘C’ and ‘A’. Both the girls’ groups (1 and 2) made use of the above similarities in identifying the function of ‘A’, ‘B’ and ‘C’. Although other groups did find a few similarities among the 3 artefacts, these were limited to the material and the superficial appearance of the artefacts.

Interactions of any kind helped groups in deciphering the functions of artefacts. As depicted in Table 5.5, Group 6 was the least interactive group (95 statements/ utterances/ gestures) and Group 1 was the most interactive (262 statements/ utterances/ gestures). In fact Group 1 was successful at identifying the intended functions of the 3 artefacts while Group 6 was unsuccessful.

In this context, it is reasonable to compare the cognitive strategies discussed above with the ‘exploratory talk’ as suggested by Mercer, Wegerif and Dawes (1999) due to their striking similarity. According to them exploratory talks provide opportunities to students to critically and constructively engage with each other’s ideas. Like cognitive strategies mentioned above, during exploratory talks, students may suggests ideas which may be challenged and counter-challenged by the others. In the process, alternate hypotheses may be proposed which may again be subjected to challenges and justifications.

b) Unfamiliar artefacts in WS2

In case of unfamiliar artefacts identification in WS2 students handled 8 different unfamiliar artefacts. As the identification of the cognitive strategies relied on students’ interactions with other members in the groups/dyads, it was not possible to study students’ strategies in WS2, in a similar way as the knife sharpener task in WS1, since each dyad in WS2 was not observed and interviewed in detail while handling the artefacts. Students instead were asked to provide justifications/clues to the identification of the functions which then served us to categorise these as strategies.

Students indicated the structures of artefacts as providing clues to their functions. Most dyads wrote specific structures of artefacts that indicated their functions. For example, Object ‘A’ could be used to crush vegetables as it had had ‘2 opposable parts and 2 handles' or 'hinges present'. However interestingly students did not attempt to provide justifications or explanations of how those structures afforded certain function. For in the above example, students just wrote the presence of specific structures but perhaps assumed that the affordances were understood from those specifications.

Table 5.7: Students' indication of clues to the function of the given artefacts in WS2

Artefacts in WS2	*Function/s of artefacts*	*Clues to the function/s*
'A'	As mould	Presence of 'design' on it
	Crush vegetables	2 opposable parts and 2 handles/ hinges present
	Hold something	Spoon-shaped
'B'	Store things	Cup like structure
	Crack nuts/ Crush fruits and vegetables/ Grinding spices	Cup-like structure, screw/rotating handle and hollow cavity
'C'	Toy/ Pendulum/ hynotising ball	Cup is connected to ball via thread
	Bell	Makes sound on hitting
	Weapon	Cup is connected to ball via thread , thus can be spun in oscillatory motion
'D'	Make juice/ mould/ peeler / part of a grinding machine	Sharp teeth/ curved edges
	Candle stand	-
'E'	Crack nuts/shells/ tighten nuts	Second class lever/ Lever shaped/ scissors-like
'F'	Mould for dough/ clay	Discs/plates with patterns/designs, cylinder and screw/rotating handle,
	Paper weight	-
'G'	Scratch back/ dig soil/ comb hair/ pull/ tap	Hand-like shape
'H'	Lift hot utensil/ to pick up objects / turn *chapattis*	Pointed tip/ small tip/ Plier like end
	Weapon	Rounded shape for catching

Again for example one of the most typical responses for an unfamiliar artefact, 'back scratcher' was *'it has a long handle and a hand like structure at one end.'* Students did not attempt to explain what action, the 'long handle' or the 'hand-like' structure afforded. For all the artefacts, most dyads just listed the structures of the different artefact handed to them but did not expose or elaborate on the purpose/s that those individual structures would serve. Only one girl dyad suggested possible affordances provided by each of the artefacts due to their respective structural orientations. For example for the same artefact mentioned above they wrote, *'it has a handle with which we can hold and it has a hand-like shape with which we can scratch our back.'* This was found to be true for most of the structures listed by students.

c) A pair of tongs in AT

In Activity Trial, all the dyads were familiar with all the pairs of tongs except tongs T_A. Students' interaction while handling the tongs, were video recorded. Hence both students' writing and video recording served as data for identifying students' strategies while handling the tongs. However it is to be noted that there was an important distinction between the activity of knife sharpeners and tongs tasks. The distinction was in their aim. While the main aim of the knife sharpeners task was to discover the strategies employed by students in identifying the functions of the knife sharpeners, the main aim of the tongs task was to discover students' strategies and criteria for evaluating the tongs. Hence not much time was spent in identifying the functions of the most unfamiliar tongs, i.e. $T_{A.}$ Dyads who were unsuccessful in identifying the functions of T_A even after much exploration were eventually provided hints and encouraged to see if they could lift the vessels with it.

However, an analysis of their identification strategies revealed students used similar cognitive strategies to identify the function of T_A. However, the frequency of use of these strategies was very low since there were only two students identifying the functions in contrast to 3-4 students in a group in WS1 knife sharpeners task.

Students mostly used the strategies of suggesting ideas, directing others attention acknowledging ideas and using gestures. Questioning of ideas or defending one's own ideas was less in frequency in case of the tongs task.

Handling strategies

For the sake of this research study, handling strategies were characterised by handling and manipulation of the artefacts. Any sort of handlings or manipulation of artefacts by students for the purpose of identification was regarded as handling strategies. These were found to include actions such as c*asual handlings, focused observations, probing the* *artefact with finger/pen/other, doing possible actions on the artefact (such as orienting, tabbing, shaking, rubbing, pressing, rolling, rotating etc.)* and *checking predictions.*

a) Knife sharpeners in WS1

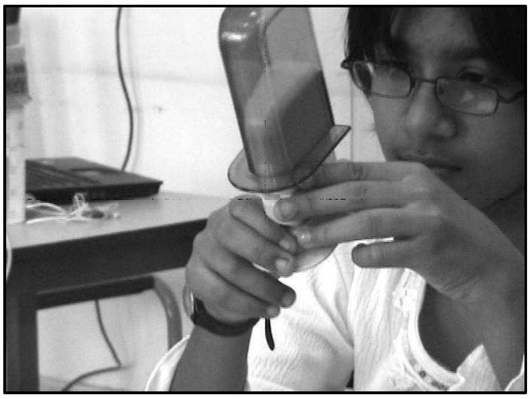
As shown in Table 5.8, students used a variety of handling strategies such as observation, probing, trying out possible actions, checking predictions. While handling the knife sharpeners.

Table 5.8: List of handling strategies use by groups while handling knife sharpeners

Handling strategies	***Group 1***	***Group 2***	***Group 3***	***Group 4***	***Group 5***	***Group 6***
Casual handlings	20	40	11	33	17	**21**
Focused observations	63	**85**	50	44	**39**	**16**
Probing the artefact with finger/pen/other	7	13	7	7	20	1
Possible actions (orient, tab, shake, rub, press, rolls, rotate)	15	34	22	18	43	17
Checking predictions	6	16	5	2	9	1
Total	***111***	***188***	***95***	***104***	***128***	***56***

'Casual handlings' involved handling the artefacts without looking at their features, while 'focused observations' implied looking at the artefacts' features with the purpose of identifying them (Figure 5.6). The frequency of focussed observation was higher in most groups as compared to casual handlings except in Group 6. While Groups 1 and 2 had higher frequencies of both casual handlings and focussed observations, Group 3 had the least number of casual handlings and comparatively more focussed observations.

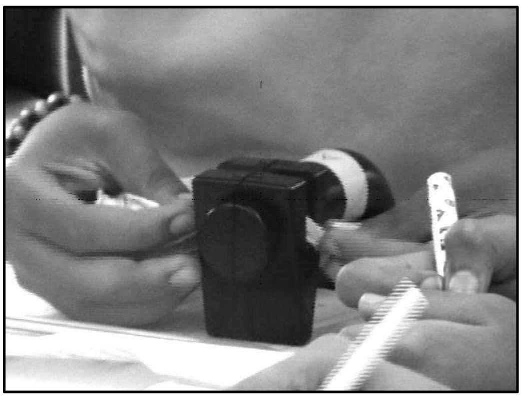
Figure 5.6: A student observing knife sharpener 'B' closely in WS1



What caught the attention of most students in all the groups were the significant functional features of the 3 artefacts, for example the slots of ‘A’ and ‘B’, and the sharpening surface of ‘C’. Students probed the 3 artefacts with anything that was available to them at the moment: finger, pen, pencil, paper, handkerchief, wooden bangle, etc. (Figure 5.7). As evident from Table 5.8, Group 5, whose main strategy was handling, probed the 3 artefacts most often. Students when probing with pen would often insert the nib into the slots of ‘A’/ ‘B’, either to check the material or rotate the wheels. Students tried several actions with the 3 artefacts, such as testing possible orientations, tapping the surface, shaking, rubbing, pressing the sides of the slots of ‘A’, rolling ‘C’ on table and rotating ‘C’ in hand. Groups 2 and 5 manipulated the artefacts more often than others.

Students tested several of their predictions through actions. These included predictions about (i) material; e.g. testing whether the material of ‘C’ was magnetic by probing the surface with pen nib (ii) structure; e.g. by probing the slot of ‘A’ to check whether the wheels inside the slots were moving or not (Figure 5.7) (iii) function; e.g., by rubbing wooden bangle on ‘C’ to see if ‘C’ could be used for rubbing on wood. Group 2 tested their predictions most often (16) while Group 6 did so least often (1). Groups which were able to identify the 3 sharpeners, asked for a knife to test their predictions. They were provided with a blunt knife available in the laboratory. While all the four groups could use ‘A’ or ‘B’ in the intended way, none, except one student, could use ‘C’ in the intended way. However, since the material of the sharpening surface of ‘C’ was rough they did not reject their hypothesis of ‘C’ as a knife sharpener.

Figure 5.7: Probing the slot of knife sharpener ‘A’ with handkerchief in WS1



Each group had one or more dominant strategy/ies for investigating the artefacts. For example, the dominant strategies utilised by Groups 1 and 4 were cognitive strategies, especially suggesting more ideas to the groups, questioning others, seeking clarifications, defending and rejecting ideas. The dominant strategies adopted by Groups 2 and 5 on the other hand, were mainly handling strategies. These two strategies were balanced in Group 3 and quite low in Group 6.

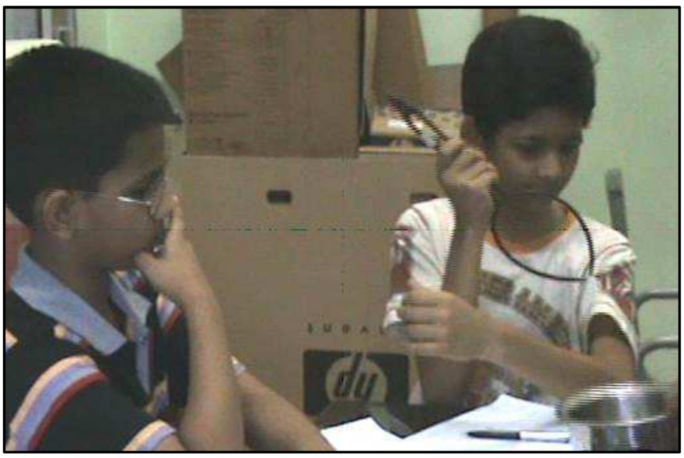
b) Unfamiliar artefacts in WS2

This analysis was not relevant for unfamiliar artefacts handled in Workshop 2 since students were not observed handling the artefacts individually.

c) A pair of tongs in AT

Handling strategies were also very prominent in the Activity Trial where students explored the different types of tongs especially while identifying the tongs T_A. The video data revealed that students mostly attempted to lift things with the rounded part of T_A. All the three dyads held T_A in a similar fashion as the other tongs and tried to grab objects with it (Figure 5.8). While most initial exploration in case of T_A was done to identify it, once the identification was known, all the dyads emphasized on checking their predictions about the functions of all the pairs of tongs. The testing of the pairs of tongs has been dealt with in a later section, revealing students' strategies of testing and evaluating the tongs.

Figure 5.8: A student in a dyad testing a pair of tongs while the other watches in AT



5.5.1.4 *Strategies employed in categorizing pictures of and actual artefacts*

Two tasks in two different trials involved categorization of artefacts. The first task which involved categorization was done in WS2 where students were provided with 32 cards consisting of pictures of common artefacts. They were asked to categorise the cards in any way that they liked and provide a basis for their categorization. The second categorization activity was done with students handling the tongs in the Activity Trial. They were asked to categorise the four tongs on any basis that they liked and provide reason/basis for their categorization.

A. Card sorting task

In the card sorting task in WS2, students were asked to sort 32 cards (consisting of pictures of artefacts) into different categories- as many as they liked- and give a title to each of the categories and provide a basis for the formation of each category. Each card was to be placed only into one category.

The total number of categories generated by all the 7 dyads was 71 with a mean of 10.14±1.34 categories per group. The number of categories that emerged ranged from a minimum of 8 to a maximum of 12 categories.

Table 5.9: Description of categories for cards generated by students in WS2

Total # of categories	***Mean ± St. dev of total no. of categories***	***No. of categories***	***No. of cards per category (range)***	***Mean ± St. dev of cards per category***
71	10.14±1.34	21	1-7	3.13±1.48

The number of card in each category varied from a minimum of 1 to a maximum of 7 cards. The qualitative analysis of categories was done to assess the kind of categories generated by each group. In order to understand the bases or the criteria on which students categorised the artefacts, the explanations provided by them were analysed. The analysis of all the justifications revealed that the students' overall generated criteria were of the following kinds: *functional, artefact family, material, theme, energy source, skill, location, origin and value*. Students used either of these criteria to sort all the cards into different categories.

Functional criteria meant students' categorization of artefacts based on their functions or use. For example a dyad sorted the picture of a house and Taj Mahal together in one category by suggesting, *'they are used as shelters'* (*functional criteria*). Another dyad used functional criterion for sorting blanket, socks, T-shirt and towel together in a group by suggesting, *'they are used for covering our body'*. Again another dyad sorted the same 4 artefacts (blanket, socks, T-shirt and towel) together by suggesting, *'they are all clothes'* (*artefact family*). Still again another dyad sorted all these 4 artefacts on the basis of the *material* used to make them, *'they are made of fabric'* (*material criteria*). A few dyads used *thematic criteria* while sorting a few cards. For example one dyad sorted, book, blanket, eyeglasses and Taj Mahal together by suggesting that '*they are all needed while travelling'* (*thematic criteria*). Interestingly all the dyads sorted electric iron, electric guitar, mobile phone, air conditioner and computer on the basis on one single criteria *'energy source'*. All of them suggested that '*they all run on electricity'*. Surprisingly electric guitar which is a musical instrument was never put together with 'tabla', another musical instrument by any of the dyads. This could be since the label used for the picture of the guitar was 'electric guitar' and so students tended to put it with their so called electrical equipments. While mobile phone would more appropriately be regarded as an electronic equipment rather than an electrical, many dyads placed it in the electrical equipment category. Also students showed a confusion of the use of the word 'electronic' since a few dyads used the label interchangeably with electrical. A few even put CD into this category.

A few dyads used some criteria related to *skill*. For example one dyad sorted *tabla,* painting and sculpture together by propose that '*one needs talent to learn these'* (*skill criteria*). One dyad also used the criteria of *'location'* to sort some cards such as potted plant, slide and bird's nest by suggesting *'they are found outside the house.'* Two dyads sorted artefacts such as potted plant, pastries and bird's nest on the basis of their origin. For example they wrote *'...these came from nature'*. The criterion of '*va*lue' was used by 1 student dyad who put Taj Mahal, necklace flower vase, necklace, painting and sculpture, together by suggesting *'...are precious and need to be preserved.'*

The sorts thus produced, provides a picture of how the technological artefacts are mentally represented by students who generated a rich set of categories and labels for those categories. Students tended to sort the cards mostly on the basis of the functions served by the artefacts. The indiscriminate use of label, 'electronics' for all appliances for the above category by most of the students' dyads reveal their limited understanding of what electronics and electrical mean. This also reveals that students think about the attributes of artefacts in similar ways. Barsalou (1983) points out that the ability to manipulate the environment by creating categories allows the individual to build new relationships and thus to create new information whose value exceeds the simple grouping of objects in the environment.

B. Tongs task

While sorting the nut crackers and bottle openers, Crismond's sample of designers generated several criteria (Crismond, 2001). The criteria used by the naïve teams were *familiarity, appearance* and *body parts* employed to use the devices. The novice teams sorted on the basis of which devices converted *rotary motion into translational motion.* The expert teams' criteria involved *engineering concepts, rational physics principles,* and a list of criteria such as *durability, manufacturability, quality of performance, complexity of design, context of uses.*

In the present study it was found that all the dyads sorted T_B and T_D together based on different qualifying criteria. Table 5.10 indicates the 3 dyads' criteria to classify the tongs.

Table 5.10: Categories for pairs of tongs formed by dyads in AT

	Group 1	***Basis for categorisation***	***Group 2***	***Basis for categorisation***	***Group 3***
Dyad 1	T_B, T_D	have similar structures *(appearance*)*	T_A		T_C
Dyad 2	T_B, T_D	for carrying rimmed and rimless utensils *(functions)* made from metals *(materials)*	T_A		T_C
Dyad 3	T_B, T_D	have good grips for carrying big and small, light and heavy, rimmed and rimless made from same material *(materials)*	T_A , T_C	do not have good grips for carrying utensils which can easily fit in them *(functions)* chances of slippage *(ergonomics)*	

(*words in italics are researchers' interpretation of students' criteria)

As indicated in Table 5.10, Dyad 1 classified T_B and T_D on the basis of only 1 criterion; *appearance,* Dyad 2 used 2 criteria, the qualifying criterion being *function* (which utensils they could lift), and an additional criterion of *materials.* Dyad 3 used *ergonomics* (having a good grip) as their qualifying criterion and the additional criteria of *functions* and *materials.* While dyads 1 and 2 formed 3 groups and sorted T_A and T_C individually, Dyad 3 formed only 2 groups by placing T_A and T_C together on the basis of *ergonomics* and *functional* criteria. Dyads 1 and 2 who placed T_A and T_C together did not provide any adequate justification for why they placed the two pairs of tongs individually. However, from the analysis of video recordings of the interaction between the two members of the dyads, it is more likely that they relied on the criterion of *appearance* and *functions*. Thus T_A and T_C looked different from each other. Also while T_C could be used to lift all kinds of utensils, T_A could be used effectively for lifting rimmed utensils only.

5.5.1.5 Strategies employed in the testing/evaluating artefacts

This analysis specifically pertained to the tongs task in the Activity Trial, where students worked in dyads to test and evaluate the efficacy of the different tongs on different kinds of utensils. Martin (2007) suggests that product evaluation allows students to appreciate the ways in which different products meet the same need, see how their own work relates to the world around them, develop observation and communication skills and widen their ‘success criteria’. Besides, evaluation of products raises awareness among students, of the possibilities, the materials and processes used, function and fitness for purpose and the values inherent in the making and marketing of products. Product evaluation may involve investigation, identifying strengths/weaknesses, justifying, prioritising, recognizing conflict, testing ideas and communicating. Systematic and rigorous evaluation is based upon the considered selection of criteria such as*, choice and use of materials, aesthetics of the outcome*, *values of the makers and users, quality* and *function* (Ritchie, 2001).

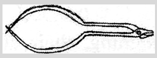
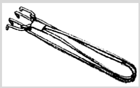
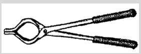
Barlex (2007) provides a framework that can be used as an interrogative tool for evaluating any product. The framework consists of a comprehensive list of questions pertaining to the *technology, people's needs and wants, the society* and *the market*. In professional fields, product evaluation is usually employed by product developers/industrial designers for improving a product line or proposing a new one (Crismond, 2001), or by ‘focus groups’ including designers and target users to the designer's ability to empathise with a wider variety of users and contexts (Denton and Mcdonagh, 2003). McLellan and Nicholl (2009) found that product evaluation is a starting point in most D&T classrooms in schools. They argue that product evaluation as an idea generation strategy restricts thinking and can lead to fixation among children. Crismond (2001) however, argues for the potential of product evaluation activities in inspiring naïve designers to identify features/ mechanisms in the products that can be adapted/ redesigned while they explored these products. Literature also suggests the potential of product evaluation in developing self-esteem of children (Garvey and Quinlan, 2000), revealing stereotypical views concerning technology from a range of cultures (Siraj-Blatchford, 1995), exploring value judgements (McLaren, 1997), developing technological literacy (Martin, 2007), identifying underlying socio-cultural factors influencing design (Moalosi, Popovic and Hickling-Hudson,2007), identifying strategies used by students while exploring unfamiliar products (Ara, Natarajan and Chunawala, 2009).

A skill very closely related to evaluation is testing (Gustafson, 2000). Testing could involve: 'testing the performance of a product'; 'conducting trials', or 'assessing the effectiveness of a product' (Johnsey, 1995). In this phase, students were provided with 4 kinds of utensils- smaller rimmed and rimless, larger rimmed and rimless utensils. The aim of this phase was to allow students to test the pairs of tongs on the utensils. The 4 pairs of tongs were tested by the researcher on the 4 utensils to check for their ease of handling (Table 5.11).

Thus, T_A could lift only small rimmed utensil, while T_D could lift all the 4 utensils. T_B, in one of its orientations (flat side inside the utensil) could lift all 4 while in the other orientation (round side inside the utensil) could lift none. Similarly T_C in one configuration could lift all 4 utensils while in the other configuration (rotated through 360 degrees) could lift the rimmed utensils only.

Table 5.11: Pairs of tongs tested on utensils (by researcher)

<table>
<tr><th>Abstracted view of utensils

Pairs of tongs</th><th colspan="2">
small rimless</th><th colspan="2">
small rimmed</th><th colspan="2">
large rimless</th><th colspan="2">
large rimmed</th></tr>
<tr><td>T_A </td><td colspan="2">✗</td><td colspan="2">✓</td><td colspan="2">✗</td><td colspan="2">✗</td></tr>
<tr><td>T_B 
(2 orientations)</td><td>✓</td><td>✗</td><td>✓</td><td>✗</td><td>✓</td><td>✗</td><td>✓</td><td>✗</td></tr>
<tr><td>T_C 
(2 configurations)</td><td>✓</td><td>✗</td><td>✓</td><td>✓</td><td>✓</td><td>✗</td><td>✓</td><td>✓</td></tr>
<tr><td>T_D </td><td colspan="2">✓</td><td colspan="2">✓</td><td colspan="2">✓</td><td colspan="2">✓</td></tr>
</table>

The testing strategies of the 3 dyads differed slightly. These strategies spread across the entire activity. Of the 16 possible testing options, 8 were used by the students in the study (Table 5.12).

Table 5.12: Testing strategies and their frequency of use for pairs of tongs in AT

Variable 1 (pair/s of tongs)	*Variable 2 (kind/s of utensils)*	*Labelled as*	*Dyads who used it*
1	1	1 on 1	Dyad 2
	2	1 on 2	Dyad 1
	4	1 on 4	Dyad 1 and 2 (twice at different times)
2	1	2 on 1	Dyad 1 (twice at different times) and
	2	2 on 2	Dyad 1
3	1	3 on 1	Dyad 1 and Dyad 2
4	1	4 on 1	Dyad 2
	4	4 on 4	Dyad 3

These varied from the most systematic testing strategy i.e. testing the 4 pairs of tongs on the 4 kinds of utensils (Dyad 3) (Figure 5.9) to unsystematic/discrete strategies such as testing only 1 pair of tongs on only 1 kind of utensil and judging about its effectiveness (Dyad 2).

Figure 5.9: Dyad 3 testing of pairs of tongs in AT in a systematic manner

Figure 5.10: Dyad 2 testing pairs of tongs in AT by filling utensil with water

An important point to note is that the most 'systematic' testing strategy may not be the most optimal strategy. For instance, a student may visually notice that T_A cannot lift rimless utensils without actually testing it. Also the unsystematic strategies were used by some students to check their predictions about the effectiveness of particular pair/s of tongs in lifting particular kind/s of utensil/s. For example, Dyad 2 students checked their predictions about the efficiency of T_B in lifting a heavy small rimmed utensil after filling it with water (Figure 5.10). Often each individual in a pair tested the tongs independently with the other partner watching. Both dyads 1 and 2 students were not very methodical in the beginning, but later used systematic testing. An important thing to observe was that though students in dyads 1 and 2 used unsystematic strategies, all the discrete strategies used by them taken together compensated for the limitation in one strategy.

Dyad 3 were systematic from the beginning. It was also observed that though dyads 1 and 2 tested the bigger utensils they did not include the size or weight as the criteria for evaluating the tongs in the later phase. Nonetheless, all the 3 dyads used the evidence acquired during testing, in generating both the categorising and evaluative criteria.

All evaluation depends on the ability to make comparisons (Baynes, 1992). These comparisons could begin by asking questions such as ‘Which product works best? Looks best? Is most reliable? etc. In this activity students had to compare the tongs in the groups formed by them and give reasons for considering one better than other/s. Dyads 1 and 2 considered T_D better than T_B, on the basis of nearly similar criteria, namely *functional efficiency* (e.g. ‘can carry all utensils better'), *multi-functionality* (‘can be used for breaking/joining wires or holding/turning chapattis’), and *ergonomics* (‘should have a plastic handle’ and ‘better grip’). Dyad 3, in contrast, suggested that T_B was better than T_D on the basis of only one criterion, *functional efficiency* (e.g. small gap will hold the rimmed utensils tightly or chances of slippage in T_D due to the presence of serrations on the inner side of the gripping part). Besides, dyads 1 and 2 also used another important *ergonomic factor* to suggest the problems with T_B. For instance, while the flat-round gripping part of T_B was intended for a better grip (as suggested by Dyad 3 and its design), dyads 1 and 2 considered that a user required some time to consider which side of T_B (flat or round) should be placed inside the utensil for better holding and may therefore be unsafe when used in haste. In the second group proposed by Dyad 3, T_C was preferred over T_A because of its *functional efficiency* in lifting both rimmed and rimless utensils.

5.5.2 Design decisions during redesigning of artefacts

This analysis was relevant to the ball-point pen task in WS2 and the tongs task in Activity Trial. In both these cases students were either asked to suggest redesign ideas in writings or depict the redesigned artefacts.

5.5.2.1 Redesign of ball-point pen

In the WS2 with ball-point task, students were asked to consider the criteria that they would take while redesigning the retractable ball-point pen. Students came up with several design decisions that they would make for the smooth functioning of the pen. Table 5.13 indicates the design decisions made by each dyad while redesigning the pen.

Table 5.13: Redesign suggestions for ball-point pen by dyads in WS2

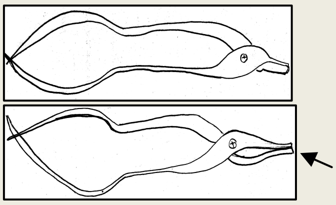
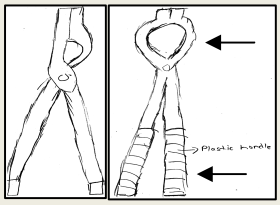
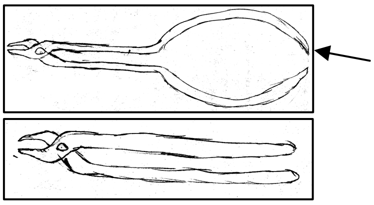
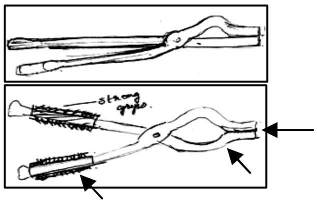
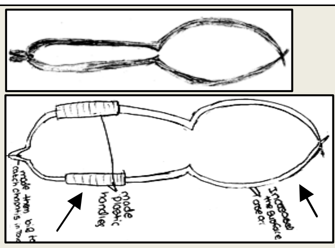
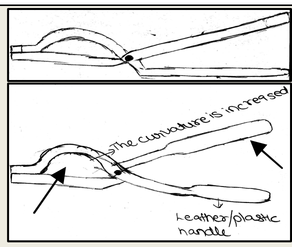
Design decisions	*Specific improvements suggested*	*No. of dyads*
Ergonomics	Better/softer grip	5
	Better body	2
Functional	Durable body	3
	Long lasting ink	3
	Free flow ink	1
	Good quality/water proof ink	3
	Add light at one end	2
	Add eraser/whitener at one end	1
	Smoother nib	1
	Multicolour nib	1
	No leakage at high altitudes	1
Marketing	Better advertised	1
	Have label ‘not for children below 3 years’	1
Safety	Smoother edges	1
Environmental	Made of disposable/recyclable plastic	2

As seen from Table 5.13, students suggested redesign proposals from a user’s point of view. Most decisions were made to improve the grip of the pen for better holding. Students also made ergonomics decisions to improve the overall body of the pen for better holding of the pen. The next key decisions taken to improve the quality of pen were related to the functioning of the pen for better writing. In functioning students mostly emphasized on the durability and resilience of the pen body and the provision of long-lasting ink. Interesting additions such as light and whitener or eraser were also suggested by a few dyads.

5.5.2.2 Redesign of pairs of tongs

In the Activity trial with pairs of tongs, students were given the option to redesign any tongs that they thought needed improvement. Unlike the pen task where students were just asked to suggest redesign proposal ideas, in the tongs tasks, students were asked to sketch both the original and redesigned versions of the tongs. All the dyads chose to redesign T_A and T_B. Redesigning was done independently by each student. However, each student integrated the ideas generated during the evaluation phase. As improvements, students either suggested *addition of a new component* or *modification* in their redesigns.

Table 5.14: Redesign suggestions for pairs of tongs by each dyad in AT

<u>Dyad 1</u> D1a  The smaller gripping part be made bigger (*)	**<u>Dyad 1</u>** D1b  • Should have a plastic handle for insulation(+)
<u>Dyad 2</u> D2a  • Priority to be given to the smaller gripping part, round part to be removed (-) • Pointed tips on the round side to be removed (*)	<u>Dyad 2</u> D2b  • Gap between the gripping parts to be made curved (*) • Serrations to be in the gripping part (+) • Should have a plastic handle (+)
<u>Dyad 3</u> D3a  • Curvature (of the bigger gripping part) to be increased to lift bigger utensils. (*) • Curvature's size to be controlled by a clip at the base of the curvature. **(**+) • Handle to have plastic/leather cover. (+) • The small gripping part to be made bigger to hold *chapattis*. (*)	**<u>Dyad 3</u>** D3b  • Curvature (gap between the gripping parts) to be increased. (*) • Should have a plastic or leather handle (+)

[Original (left/top) and Redesigned sketches (right/bottom) (changes shown by arrows) {parts: added (+); removed (-); modified (*)}]

Using their experience and insights gained through the testing of the tongs, students redesigned their selected pairs of tongs by assuming the user's point of view. In case of the tongs students mainly focused on achieving *functional efficiency* and providing better *ergonomics* to users while using the tongs. Besides, students who were redesigning T_B

tended to adopt a *linear redesign process* (non-iterative) by proposing their redesign ideas around their selected best design, i.e. T_D. Hence T_B in the redesigned version actually became T_D. Dyads 1 and 2 redesigned T_A by making it similar to T_D (Table 5.14). Dyad 3 (girl dyad) suggested changes, one of which was a radical change while the other was a change similar to what others had suggested. The radical change suggested was with respect to the redesigning of T_A such as, *modifications* in the size of the gripping part for lifting/carrying heavier utensils and *addition of* an adjustable clamp or clip to adjust the size of the gripping part (not shown graphically but suggested in writing). The other change suggested by this dyad was the *addition* of a plastic or leather cover on the handles. They also suggested increasing the gap between the gripping parts of T_B to enable lifting of heavier and bigger utensils (Table 5.14).

An important distinction found between redesign strategies in the ball-point pen and the pairs of tongs tasks were that more varied redesign proposals were suggested for ball-point pens than for the tongs. This could perhaps be due to two probable reasons. The first obvious reason could be perhaps due to the extent of familiarity with the two kinds of artefacts. Using them in their daily life, students are more familiar with pen than with the tongs. Hence they could come up with more varied redesign ideas than students who worked with tongs. Another reason could be due to the nature of the task itself. The pen task was not as challenging as the tongs task. In the pen students were merely asked to suggest ideas without representing them through drawings or modelling. However, students in the tongs task were asked to depict the changes or improvements that they desired in their redesigned tongs. The requirement to depict their redesign proposals could have constrained them to suggest fewer ideas in case of tongs.

5.5.3 Students' solution to the design problem: Without make (WS1) and with make (WS2)

According to Schön (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. All people possess the ability to solve real-world problems that are ill-structured, with unclear goals and contain little information. These problems have multiple solutions and several ways of reaching them. Real-world problems 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. By resolving a real problem through designing of artefacts, students in both the workshops got the opportunity to emulate or assume the role of a designer.

5.5.3.1 The design problem given to students in WS1 and WS2

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

Figure 5.11: Students designing solutions in WS1

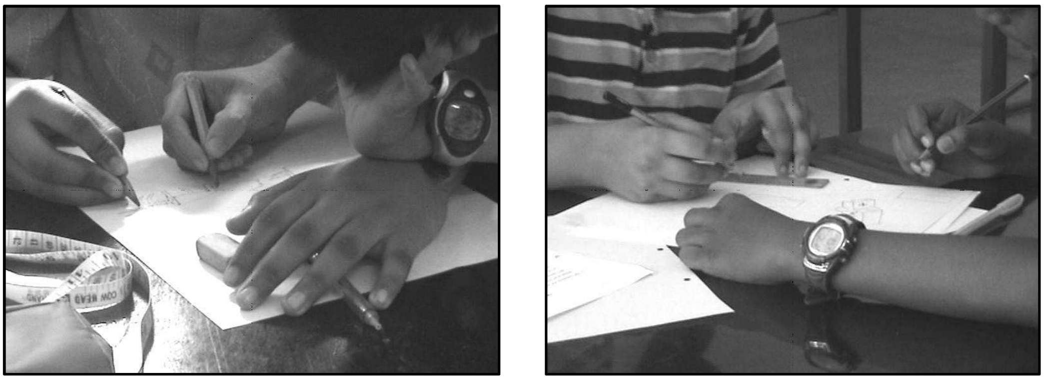
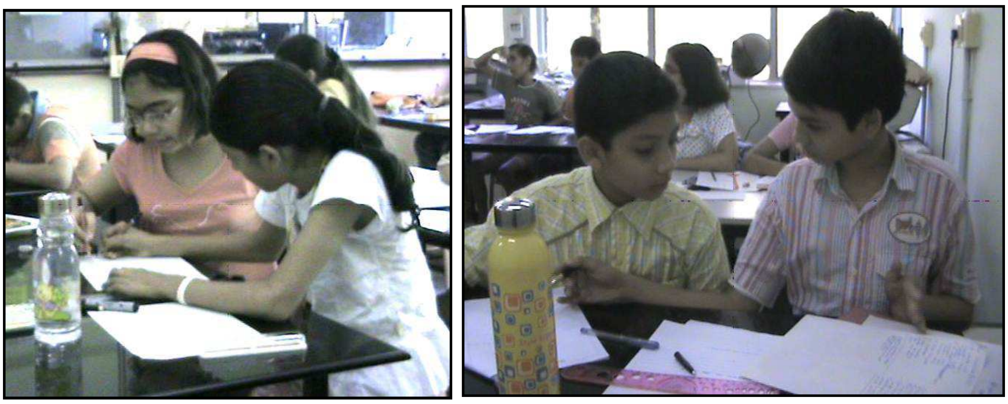


Figure 5.12: Students designing solutions in WS2



In WS1 where students were asked to design but not make, 12 designed solutions were generated by 7 groups (around 2 designs per group). Interestingly when constrained to make what they had designed student dyads in WS2 generated only 7 designs. Students' solutions in the *design-without-make* activity ranged from highly complex to simple designs, while those in the *design-with-make* activity were mostly simple and easy to make in the classroom settings with easily available materials. Figure 5.11 and Figure 5.12 shows the pictures of students designing collaboratively in WS1 and WS2 respectively.

5.5.3.2 Creativity in students' designed solutions

Creativity in students' designed solutions was analyzed using NACCCE (1999) features of creativity. The NACCCE report listed 4 criteria for a work to be considered as creative: using imagination, pursuing purposes, being original, and being of value. Each of these features was used to analyse students design productions.

A. Using imagination

Most of the groups in design-without-make activity in Workshop 1 (except 1 group) clearly drew and wrote about their best designed solution suggesting that they could mentally visualize the images of the product. The imaginative thought was also evident in students' designed solution in design-with-make activity in Workshop 2. However, an important distinction in the designs was that while groups in WS1 imagined their products varying from the most complex to very simple designs, all dyads (except 1) in WS2 made very simple and easy to make designs. The design drawings of WS2 students were clearer (Figure 5.22, Figure 5.23, Figure 5.24, Figure 5.25) compared to those of students in WS1 (Figure 5.15, Figure 5.20, Figure 5.21).

It was also observed that while modelling their ideas, WS2 students made very little deviations 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 WS2 students attempted to depict their designs in at least two views, front and back. Though in some cases, the front and the back were depicted as same, it suggested that their designs were symmetrical about an axis.

B. 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 lift needles from the floor. In *design-without-make* activity, out of 12 designed solution ideas generated by 7 groups, 8 designs considered lifting both metallic/non-metallic needles in their designed solutions. Lifting a metallic needle is easy since it just involves the use of a magnet. However, lifting a knitting needle from the floor was a challenging task, which many of the designed solutions of workshop 1 aimed at. The 4 groups, who made use of magnets in their design and considered lifting only metallic needles, recognized that their designed solution was not appropriate to the requirements of the problem. A girl's group in workshop 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 in the first place by either designing a bangle with a string (Figure 5.16) or a chair with a 'flap' (Figure 5.17). In the case of the chair, a user sits on it and puts on the flap attached to it. If the needle falls, it will remain on the flap and can easily be located. The flap also has a thin magnet around the perimeter for attracting the metallic needles.

Design-with-make activity 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 WS2 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. While evaluating their designs, they however, recognized that their designed solution could not be used to lift knitting needles and that they had designed the device for sewing needles alone.

C. Being original

Since students were unfamiliar with any artefact that can lift fallen needles, the design problem was new to students in both workshops. All groups and dyads in workshops 1 and 2 respectively, generated solutions that could therefore be said to be original An important difference between the designed solutions of workshop 1 and 2 students was that while the solutions of WS1 students varied from simple to complex designs and were unique and different from each other (Figure 5.15, Figure 5.16, Figure 5.17, Figure 5.18, Figure 5.19, Figure 5.20, Figure 5.21), the designs of WS2 students were very similar to each other (Figure 5.22, Figure 5.23, Figure 5.24, Figure 5.26) except the 2 designed solution of two boys' dyad (see 1st and 2nd pictures from the left in (Figure 5.26). Both these dyads also made use of magnets in their designs, but one of them attached a controllable lighting mechanism (switch and LED connected to a battery) into their designs (Figure 5.13) while the other dyad attached a torch and wheels for mobility. These made their design different from the other dyads.

Figure 5.13: A dyad using lighting mechanism in their model in WS2

Figure 5.14: A dyad using elongated rod for their model in WS2

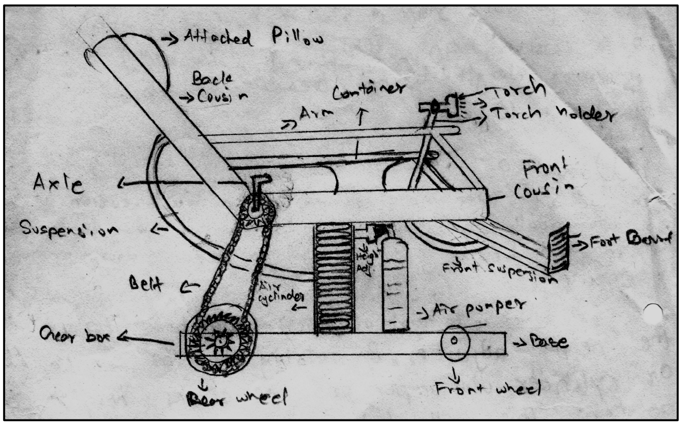
Most designs in WS2 made use of an elongated stick/tube/telescopic rod, at one end of which was attached a powerful magnet (Figure 5.14). A girl dyad made use of a woollen thread instead of a rod, such that their final product swayed to and fro to attract the fallen needle.

D. Being of value

The designs of all the groups aimed to improve people's quality of life. Two groups in the *design-without-make* activity also enhanced the quality of their designs by increasing the possible uses of their artefacts. For example, in Figure 5.16, the design is in the shape of a bangle, which can be worn by the elderly lady while she sews the clothes or knits the sweaters. One end of a string is attached to the bangle while the other end is attached to the needle and prevents it from falling. The design can also be used a bangle after removing the strings. Two dyads in WS2 also enhanced the value of their design by increasing their possible uses. This use was however, common between the dyads and was limited to an aid as a walking stick for old people.

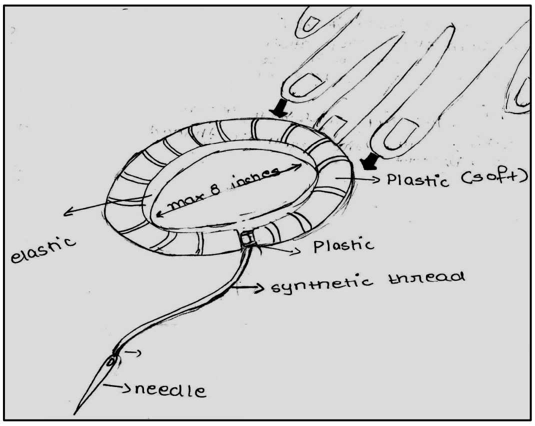
5.5.3.3 Students designs from WS1 (design-without-make activity)

Figure 5.15: Design solution of a boy group ('Adjusting wheel chair')



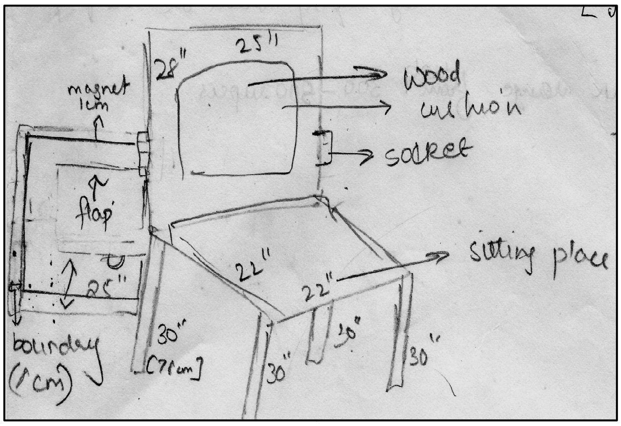
This design uses the principle of air pressure. The user sits on the wheel chair whose height can be adjusted using a pulley mechanism and air pressure.

Figure 5.16: Design solution of a girl group ('The Bangle')



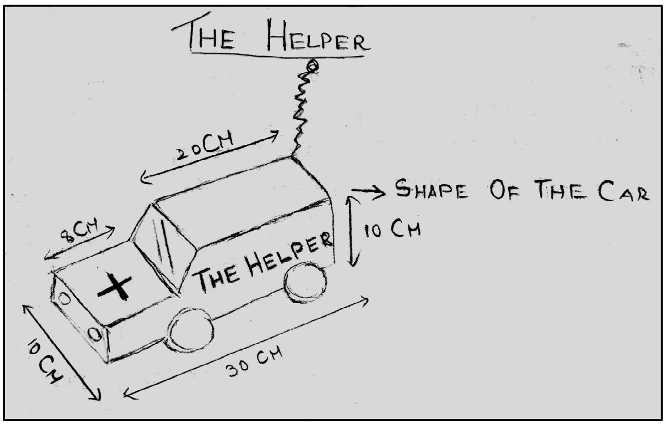
The design is in the shape of a bangle; can be worn in the hand while sewing. A string is attached to the bangle; the other end is attached to a needle and prevents it from falling.

Figure 5.17: Design solution of a girl group ('The Flap chair')



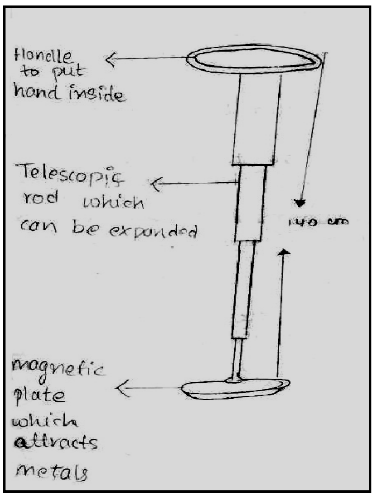
User sits on this 'chair with a flap'. Needle cannot falling on the floor; it remains on the flap which has a rim of magnet

Figure 5.18: Design solution of a boy group ('The Helper')



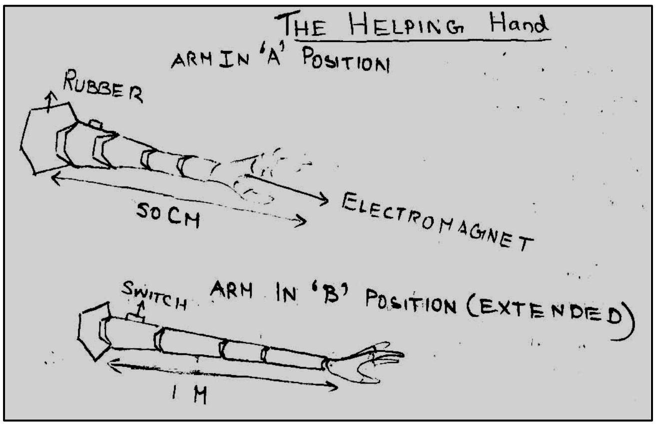
This design makes use of a remote controlled car underneath which is an electro magnet. An alarm rings when needle gets attracted to the magnet.

Figure 5.19: Design solution of a girl group



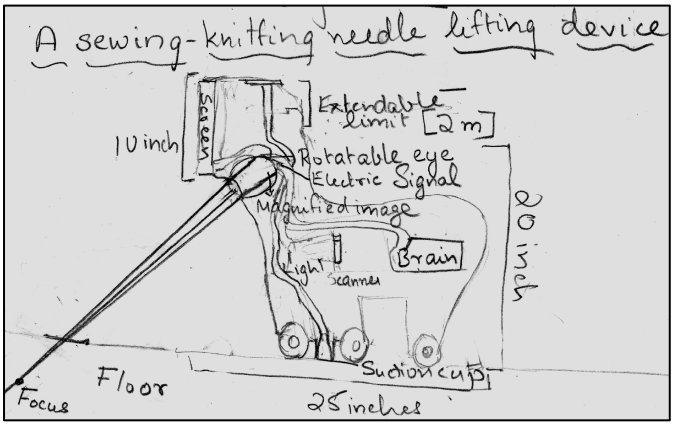
The design includes an aluminium telescopic rod. To one end of the rod is a magnet which attracts the fallen metallic needles and to the other end is a handle for holding the rod.

Figure 5.20: Design solution of a boy group ('The Helping hand')



This design makes use of electro magnet which can be activated via a switch which also enables extension of the hand.

Figure 5.21: Design solution of a boy group ('Sewing-knitting needle lifting device')



This design is very complex and makes use of radio sensors, scanning technology and image processing mechanisms.

5.5.3.4 Students designs from WS2 (design-with-make activity)

Figure 5.22: Dyads' simple design ideas in WS2 using stick, one end of which is attached a magnet.

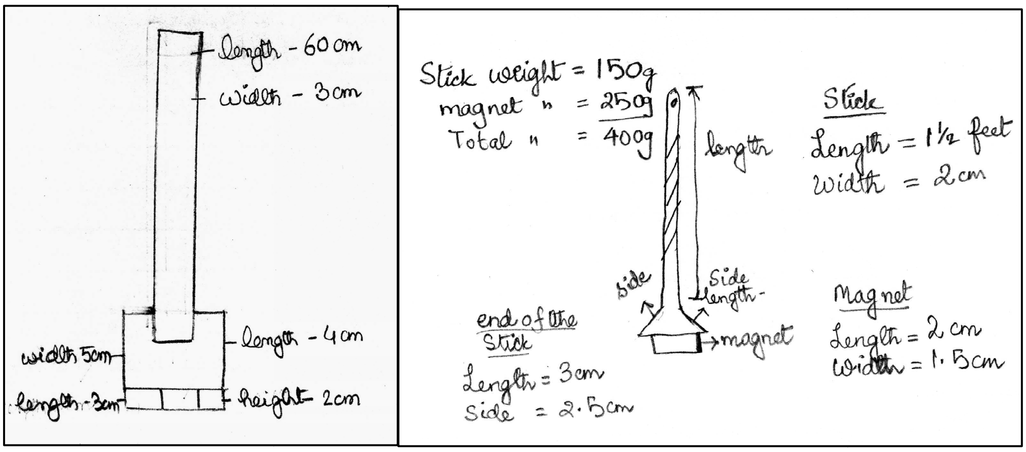


Figure 5.23: Dyad's use of a string, instead of a stick/rod to attach the magnet

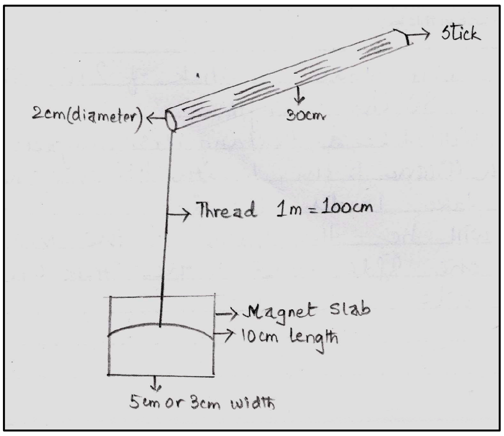


Figure 5.24: A dyad used wheels and integrated lighting mechanism

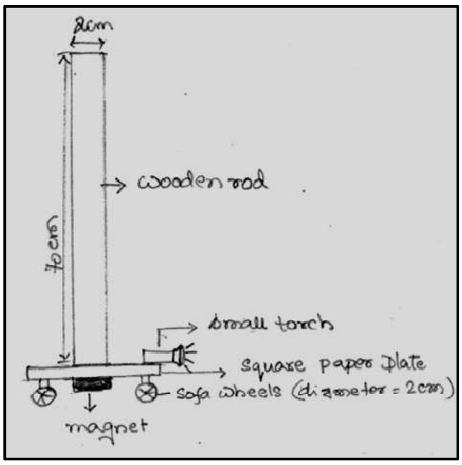


Figure 5.25: A dyad used lighting mechanism inside a short tube

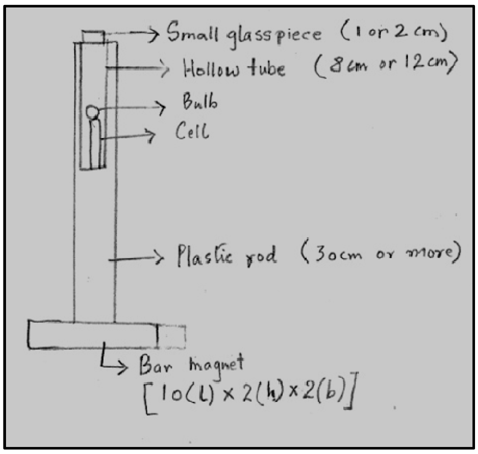


Figure 5.26: The working models of dyads from design-with-make activity in WS 2

5.5.3.5 Students' design decisions in Design-without-make and Design-with-make activities

As mentioned above, Barlex's (2007) framework of design decisions was used to analyze students' designed solutions through 5 design decisions: conceptual, technical, constructional, marketing and aesthetics.

A. Evidence of conceptual decisions

Conceptual decisions are concerned with the overall purpose of the design, that is, what sort of product it will be. While making conceptual decisions, students were required to think about the overall purpose of the design. Although the design problem was already specified to the students, in both the workshops (design-without-make and design-with-make activities) students did take significant conceptual decisions while designing solutions for the given problem. They showed clear evidence of what their designs would do. Lifting a sewing needle is easy since it is usually metallic and thus can be picked up by employing the use of a magnet. However, lifting a knitting needle is a challenge since it is usually made of non-metallic material such as plastic, aluminium or sometimes even wood. The knitting needle is also longer than a sewing needle. Hence this also posed a challenge to students. The analysis of students' designs in WS1 and WS2 suggests that their designs aimed at solving the problems of people having backache and who need to pick fallen needles from the floor. However, there were important distinctions between the conceptual decisions made by students when they were not required to make and when they were required to make their designs. In the design-without-make activity, of the 12 designed solutions generated by 7 groups, 8 groups considered lifting of both sewing and knitting needles in their designs. This is in striking contrast to the design-with-make activity where all the dyads designed solutions attempted to lift only the metallic sewing needles by employing the use of magnets in their designs. Thus the constraints of making in WS2 influenced students to take certain conceptual decisions such as making a device that could lift only metallic needles. Even while evaluating their designs, students realized that their device was suitable only for metallic needles and not the knitting ones.

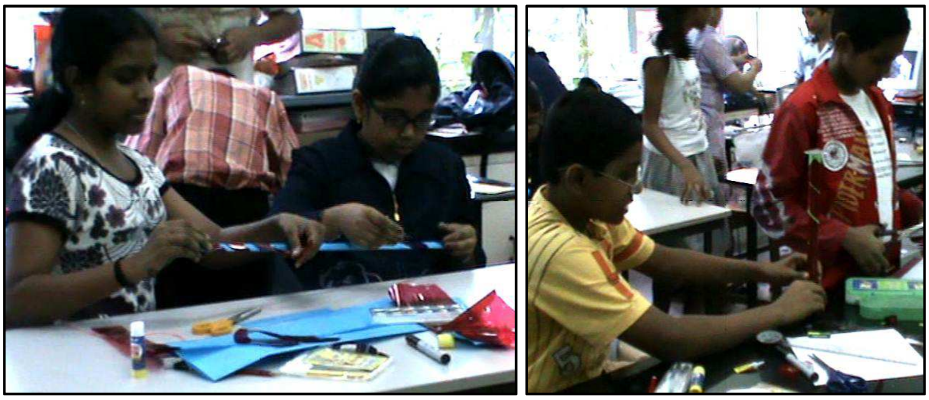
B. Evidence of technical decisions

Technical decisions are concerned with how the design will work. In *design-without-make* activity, of the 7 groups, 5 groups indicated how their design will work. Two groups however could not clearly indicate how their design will lift the needles from the floor. As mentioned earlier, although these students did not explain how the scientific or technological principles worked in their design, they mentioned the overall application of those principles in their designs. In *design-with-make* activity, all the dyads showed evidence of technical decisions taken by them. They clearly explained how their device will work on completion.

C. Evidence of aesthetic decisions

Most groups in the *design-without-make* activity showed little evidence of using aesthetic decisions in their designs. For example, as shown in (Figure 5.16), a girl group made a simple bangle to prevent needles falling and the group decided that the bangle could be used for aesthetic purpose as well that is for wearing. Most groups in WS1 drew their design from one point of view without indicating how their designs would look from other perspectives. In the *design-with-make* activity, however, except 1 dyad, all the dyads took aesthetic decisions. Most of them showed their designs from at least two perspectives. The aesthetic decisions were very much evident in their modelled solutions. For example most dyads used coloured and glazing papers to wrap the stick and the magnets (Figure 5.27). One of the dyads even decorated their models by using beads and decorative flowers.

Figure 5.27: A boy and a girl dyads decorating their models in WS2



D. Evidence of constructional decisions

Constructional decision involves how the design will be put together. Although *design-without-make* students were not required to make their designs, of the 12 designs made, 4 could be constructed with everyday materials. Three groups actually suggested ways of making their designs with easily available materials. In the *design-with-make* sample all the dyads clearly indicated how their designs will be put together by easily available materials. As evident in (Figure 5.26), all the models show use of simple, everyday material such as a plastic stick or rod, magnet, funnels, thread/string, coloured papers, umbrella handles, glue, cello tape etc. Two of the dyads used lighting mechanism in their designs. One of these dyads used a torch while the other used a controllable mechanism with a switch.

E. Evidence of marketing decisions

Although the user was already indicated by the researchers, few groups/dyads in both the activities took marketing decisions regarding the cost of the product or a limited warranty with the product. Based on the materials used in their proposed designs, and the cost of making it, the groups and dyads decided on the price of their designs. Some of them gave realistic prices of the product, while some gave exorbitant prices. For example, in design-without-make activity, the groups which made use of advanced technology in their design (Figure 5.21), proposed the estimated price of the finished product as 80,000-1, 20,000 Indian rupees!

Additional criteria as proposed by Barlex and Trebell (2007) were also made use of to analyse students' design decisions. These criteria included elements of feasibility, use of scientific and technological concepts.

A. Elements of feasibility

Lifting a knitting needle (especially non-metallic) was a challenge to students in both the samples. Four groups in workshop 1 (*design-without-make)* used magnets in their design but the complexity involved differed. Although all the groups kept the user in mind, only 4 of 12 designs were easy to make and feasible. The other designs were either too ambitious (like the wheel chair design; Figure 5.15) or too expensive (80,000-1,20,000 Indian rupees; Figure 5.21) thereby indicating that these students, not constrained by making what they had designed, took more risk compared to the WS2 students *(design-with-make)* who made simple designs that could be modelled with every day and easily available materials.

B. Use of scientific and technological concepts

In Workshop 1 *(design-without-make)* compared to *design-with-make*, students showed evidence 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, wheelchair, alarm and battery. WS2 students *(design-with-make)* did not seem to make use of any scientific or technological concepts besides using magnets. Only 1 dyad in this sample showed clear evidence of utilizing the concept of electricity in their model by incorporating a controllable lighting mechanism (Figure 5.13 and Figure 5.26).

It is to be noted that although students in the *design-without-make* activity mentioned the use of scientific and technological concepts in their designs, hardly a few of them actually explained how these principles would work in their designs. For example in the wheel chair design (Figure 5.15), the group wrote that *'air pressure mechanism will be used to raise and lower the height of the wheel chair'*. How the air pressure would lift and lower the chair was not explained. Similarly for most groups in the *design-without-make* activity, scientific principles and new technological innovations were incorporated without actually mentioning how they worked. In contrast, very few scientific concepts were used by students in *design-with-make* activity, but the dyads explained clearly how the principle was used in their design.

C. Overall comparison of solutions from *design-without-make* and *design-with-make* activities

The comparison of the solutions from *design-without-make* and *design-with-make* activities revealed that students unconstrained with making, showed more evidences of creativity and risk taking than students constrained with making. The design-without-make students also came up with more number of and a variety of design ideas in contrast to the design-with-make students. Risk-taking behaviour was seen in the former students' complex designs where they made use of scientific principles and new technological innovations. When the making of what students have designed was removed, it allowed students to conceive of ideas for products that were not limited by their personal making skills and tools, materials and equipments that are easily available. Although this group of students seemed to be making use of concepts without understanding them completely, they were not restricted by what they knew but had actually broadened their scope of applying new knowledge and had taken the risk of incorporating new technology or scientific concepts that they might have encountered in school or outside of school. This opportunity is generally not provided by other school subjects. Barlex and Trebell (2007) also found students using high technology such as Bluetooth technology in their design-without-make-solutions.

Students in both the activities were unfamiliar with any artefact that could pick needles from the floor. Hence the design problem was new to them. The generated solutions by students from both the samples could therefore, be said to be original and novel to them. But the design decisions made by students in both the workshops varied. Students in the *design-without-make* workshop seemed to make little design decisions in comparison to the students in WS2 *(design-with-make)*. The decisions made by the latter seemed more real, but produced less creative solutions. It did however provide students the opportunity to take important decisions that were technical, constructional, aesthetic and marketing based. Although limited in nature, creativity in *design-with-make* activity was achieved through constructional and technical design decisions. Though students' designs were modest in terms of make-ability, most dyads in *design-with-make* activity struggled while modelling their ideas. For example, while choosing appropriate combination of materials which are readily available and fixing magnets to the rod or stick. Each dyad devised their own ways of attaching the magnets to the stick. One of them used string, one used a funnel, and others stuck the magnets directly onto the stick.

Design-with-make assignments on the other hand, provided opportunities to students to recreate the whole design process, from identification of a need, to creating a brief and a specification, then generating ideas, developing them, modelling them, and finally producing a working product. An important feature about making the design is the amount of uncertainties involved, whether the new design will do what is expected since there may be unexpected problems. Modelling the solutions allows the designer to explore design alternatives, test theories and confirm performance. Multiple iterations of prototypes help designers refine their ideas. Even in the D&T classrooms, students may iteratively model their ideas to make it a workable product. The making of the artefact allowed development of skills in designing. Thus despite the creativity generated in a *design-without-make* activity the development of skills in the *design-with-make* activity makes us suggest that the two activities should be complementary and not substitutes of each other.

5.5.4 Evaluation of students' designs and models

Evaluation and reflection were encouraged in most of the activities in Workshops 1 and 2. In WS1, evaluation was only built in the designing activity. Each group had to present their best designs to the other groups. The other groups gave critical feedback to the presented design solutions. The feedback facilitated each group to reflect upon their designs and iterate their solutions. In WS2, evaluation was built into most of the activities since dyads were required to present their ideas after completing each of the activities. The aim of these post-activity presentations was to provide opportunities to students to reflect upon their responses by being questioned, receiving feedback and suggestions, about their ideas, from other students. Students in WS2 mostly read out their responses aloud to the other dyads, who then responded to the presented ideas by questioning and challenging them and providing constructive feedback whenever possible. The dyads presenting their ideas often defended and explained or clarified their ideas to others. In this thesis, evaluation of students' self and peers' work that occurred during the designing and making activities in WS1 and WS2 has been presented.

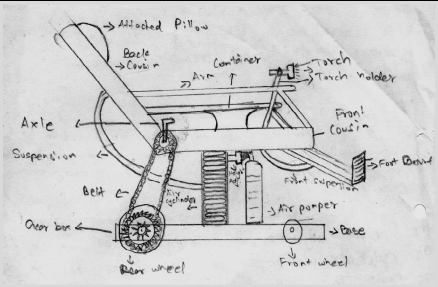
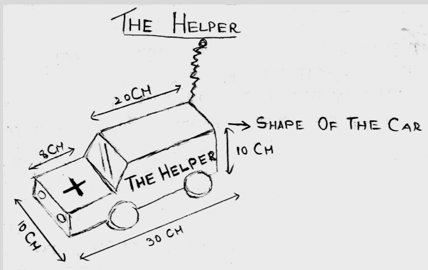
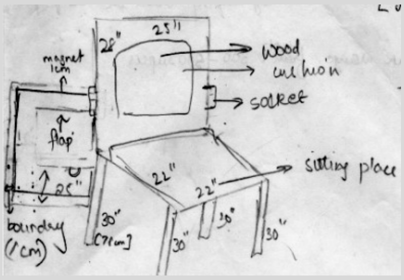
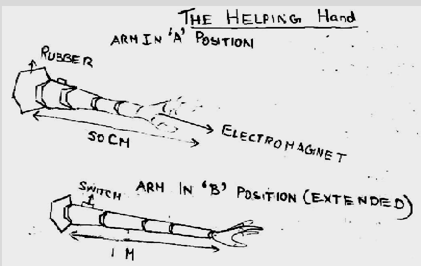
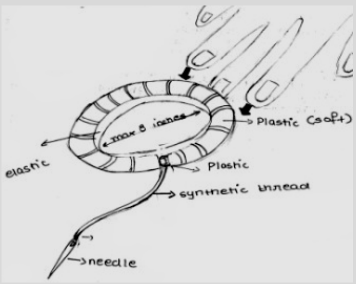
5.5.4.1 Evaluation of self and peers' design ideas in WS1

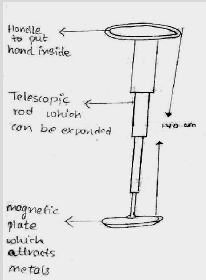
In WS1, each group was asked to generate and sketch how different design solutions for the given design problem. On the second day of the workshop, each group was asked to select their best designs which was scanned on computer and projected on a screen through an LCD. A few groups (a boy and a girl group) insisted on presenting both their designs to their peers. One by one each group was asked to stand before the class and present their designs to the other groups.

While presenting their designs, for most of the boy groups, usually one student presented the design. The other group members intervened only when their presenter was not able to defend their designs. However, for both the girl groups, one of the girls presented their designs and the other girls actively defended and explained their ideas to the others.

In WS1, students were asked to evaluate their own and their peers' ideas based on their own criteria. No criteria were provided by the researcher. However students were asked to evaluate if their own and their peers' design ideas met all the design criteria that were provided in the brief. Hence it was observed that the most commonly used criterion by groups was suitability for the purpose. In other words, students mostly attempted to evaluate the design solutions on the basis of the design criteria given by the researcher in the design brief, that is, whether the design ideas fulfilled the design criteria or not. Some of critical feedbacks offered by groups for their peers' design solutions have been presented in Table 5.15.

Table 5.15: Peers' feedback on some of the presented design solutions in WS1

Design Solutions	***Feedback/Criticisms***
	• Bending becomes necessary since there is a limit to which the chair can be lowered. • Cannot be steered to different directions.
	• Cannot lift non-metallic needles. • User must learn to operate the remote controlled car. • Car might slip from the ramp
	• User is restricted to sitting on the chair • It is difficult to pick it up fallen needles. • Prevents needle from falling but cannot pick fallen needles.
	• Cannot lift non-metallic needles. • The mechanism for movement of the hand is not clear.
	• Can only be used for knitting needles. • Cannot be used to prevent sewing needles from falling.

	• Cannot lift non-metallic needles. • Problem of locating the needle for people with poor vision. • Lots of trials required. • Strong magnet will attract all metallic things on the floor.

Surprisingly, none of the groups used other criteria such as appearance, feasibility of the designs (in terms of make-ability and cost) to evaluate their peers' design solutions. However, the feedback provided by students showed evidence of logical reasoning and critical thinking.

5.5.4.2 Evaluation of self and peers' designs and models in WS2

In WS2 structured evaluation procedures were adopted through researcher-developed evaluation criteria. Opportunities for evaluation were provided to students both after designing as well as after making their models. After their completion of their designs, each dyad was supposed to present their designs to their peers. For this purpose, each dyad's design was scanned on the computer and then projected on a screen. Both students in each dyad also received 2 evaluation sheets on which they had to rate their own as well the others design on researcher generated criteria (*Appendix V*). The criteria used for evaluating self and peers' design ideas were: *suitability for the purpose, clarity for the design ideas, safety, portability, use and make-ability.* While evaluating each of the design ideas on each of the above criteria, students had to rate their own and their peers' design ideas on a three point rating scale of yes, not sure and no.

Table 5.16 presents the evaluation of design ideas of students by their peers. A rating of 2.5 and above on any criterion indicates that the model was rated high for that criterion. A rating less than 2 on any criterion indicates that the model was rated low for that criterion. As seen from the table, except the design ideas of Dyad 1, most dyads have received higher ratings from their peers. It is to be noted that Dyad 1 was the only one who decided to put an automatic lighting mechanism in their model. As evident from Table 5.16, their design ideas have been rated low by their peers on most criteria. For example they have been rated low on issues of safety, portability, usability and make-ability. It is interesting to note that those dyads who have tried to integrate any sort of lighting mechanism, whether automatic (Dyad 1) or manual (Dyads 3 and 7), in their designs, were rated low on make-ability. Perhaps students perceived it difficult to make or introduce any lighting mechanism in their designs.

It can also be seen that most dyads have been rated high on suitability of purpose (first criterion). Dyad 1 has received highest rating on this criterion perhaps due to the integration of controllable lighting mechanism with switch and indicators to indicate to the needle getting attracted to the magnet. Since none of the dyads incorporated any mechanism to lift non-metallic needles, they all mentioned in writing that their design was best suited for a metallic needle. It thus seems that even while evaluating their designs, they tended to ignore this aspect and considered evaluation of their ideas only with respect to metallic needles.

Students were also required to rate their own ideas on the same criteria in the same evaluation sheet. Students' rating of their own ideas has been presented in Table 5.17. When students' ratings of their peers' design ideas (Table 5.16) is compared to the ratings of their own ideas (Table 5.17), it becomes evident that all the dyads rated their own designs high on all the criteria. Even dyads who introduced lights in their designs considered it easy to make their own designs. Only Dyads 1 and 7 were found to rate their designs low on portability. Both the dyads were either unsure or not convinced that their designs would be easy to carry.

Table 5.16: Peer evaluation of design ideas in WS2

Criteria	***Dyad 1 (boys)***	***Dyad 2 (girls)***	***Dyad 3 (boys)***	***Dyad 4 (girls)***	***Dyad 5 (boys)***	***Dyad 6 (girls)***	***Dyad 7 (boys)***
Does it solve Rita's grandmother's problem?	3.0	2.8	2.8	2.8	2.8	2.8	2.8
Is the design clear?	2.3	3.0	2.3	3.0	3.0	2.7	3.0
Is it safe to use?	1.7	2.8	2.2	2.8	2.8	3.0	2.5
Is it easy to carry?	1.8	2.8	2.8	2.3	2.3	2.3	2.2
Is it easy to use?	1.3	2.5	2.5	2.3	2.7	3.0	2.5
Is it easy to make?	1.2	3.0	1.3	3.0	3.0	2.7	1.7

Table 5.17: Self evaluation of design ideas in WS2

Criteria	*Dyad 1 (boys)*	*Dyad 2 (girls)*	*Dyad 3 (boys)*	*Dyad 4 (girls)*	*Dyad 5 (boys)*	*Dyad 6 (girls)*	*Dyad 7 (boys)*
Does it solve Rita's grandmother's problem?	3	3	3	3	3	3	3
Is the design clear?	3	3	3	3	3	3	3
Is it safe to use?	3	3	3	3	3	3	3
Is it easy to carry?	2	3	3	3	3	3	1
Is it easy to use?	3	3	3	3	3	3	3
Is it easy to make?	3	3	3	3	3	3	3

After finishing making their models, each dyad was given opportunities to come before the rest of the class and test their models. Students were provided with a chair and asked to assume themselves as Rita's grandmother and then test their models by lifting a metallic needle fallen on the floor. Students' testing of their models accompanied an evaluation of their models. Each dyad was also asked to test their peers' models if they wanted to. After watching their peers test the models and sometimes themselves testing their peers' models, students rated their own and their peers' models on several criteria provided to them by the researcher. Table 5.18 presents students' ratings of their peers' working model.

Table 5.18: Peer evaluation of the model in WS2

Criteria	*Dyad 1 (boys)*	*Dyad 2 (girls)*	*Dyad 3 (boys)*	*Dyad 4 (girls)*	*Dyad 5 (boys)*	*Dyad 6 (girls)*	*Dyad 7 (boys)*
Does it solve Rita's grandmother's problem?	2.8	2.3	1.8	2.2	1.7	2.3	2.0
Does it look good?	1.5	3.0	2.3	2.7	2.2	2.8	1.8
Is it safe to use?	1.8	2.7	1.7	2.7	2.8	2.2	1.8
Is it cheap?	2.0	2.8	2.3	2.8	2.5	2.3	2.2
Will it last long?	1.7	2.3	1.8	2.0	2.2	2.0	2.0
Is it easy to carry?	2.0	2.7	3.0	2.7	2.3	2.5	2.0
Is it easy to use?	2.3	2.5	1.8	2.8	1.8	2.7	2.2
Does it work well?	2.3	3.0	1.8	2.5	2.7	2.8	2.0
Is it easy to make?	2.2	2.8	3.0	3.0	2.5	2.8	2.5

As seen from Table 5.18, students' rating of their peers' model differed from their ratings of their designs on the same criteria. For example, while most dyads rated their peers' design ideas high on suitability of purpose (1st criterion), their working model was rated lower. This happened since students actually witnessed their peers' and their own models being tested and thus their ratings were based on more real experience of the testing of the models. All the girls received higher ratings on their working models on the criteria of appearance. This was due to the fact that all the girls used colourful papers, beads and other decorating material to decorate their models. Dyads usually covered their models with colourful papers since their models were made of everyday materials and students attempted to conceal this through decoration. Dyad 1 who did not decorate their model or covered it with colourful papers, received the lowest rating on appearance. Interestingly all the dyads who used lights in their models were rated low on safety. This perhaps reflects students' lack of knowledge regarding electricity.

Dyad 1 (boys) which used a lighting mechanism in their model was rated high for the suitability of purpose (first criterion) but it was perceived to be unsafe, since it involved electricity.

Table 5.19: Self evaluation of the model in WS2

Criteria	***Dyad 1 (boys)***	***Dyad 2 (girls)***	***Dyad 3 (boys)***	***Dyad 4 (girls)***	***Dyad 5 (boys)***	***Dyad 6 (girls)***	***Dyad 7 (boys)***
Does it solve Rita's grandmother's problem?	1	3	3	3	1	2	2
Does it look good?	2	3	3	3	3	3	2
Is it safe to use?	3	3	3	3	3	3	3
Is it cheap?	2	3	2	3	3	2	2
Will it last long?	3	3	1	3	2	1	1
Is it easy to carry?	3	3	3	3	3	3	3
Is it easy to use?	3	3	1	3	3	3	3
Does it work well?	3	3	3	3	3	3	1
Is it easy to make?	3	3	3	3	3	3	3

Models in which elongated rods/ tubes were used (Dyad 1) or were bulky (Dyad 7) were rated low on portability while those using short tubes/rods were rated high (Dyads 2, 3 and 4). Except Dyad 1's model which used the principle of electricity in their model, all the models were rated high on make-ability. Students thus considered making other dyads' models easily but not of Dyad 1. All the dyads rated their peers' model low on durability and high on cost.

In the self evaluation of models, it was observed that students rated their own models higher than the others (Table 5.19). This was mostly true for girl dyads, two of whom rated their models high on all the criteria. Students were found to rate their models low on a few criteria such as suitability of purpose, appearance, cost, durability, ease of use and performance.

5.5.5 Design problems posed by students

According to Kimbell (1994), students should be provided more opportunities for problem finding to engage them in a holistic design process. The investigation process can include the act of problem finding. Lewis et al. (1998) asserts that in D&T education, problem finding has not been given as much prominence as problem-solving. Wertheimer (in Lewis, 2005) claims that problem-finding can be a marker of creativity suggesting that '*Often in great discoveries the most important thing is that a question is found. Envisaging, putting the productive question is often more important, often a greater achievement than solution of a set question….*'

Getzels and Csikszenthmihalyi (1976) through a longitudinal study of young artists claimed that artists who emphasized problem finding over problem-solving in their cognitive approach to their work tend to be the more successful in their creative careers.

In order to solve the problem, design briefs are created that set the parameters of the design problem. A design brief describes an outline of the situation, problem or need and specifications such as constraints and considerations that apply to the design problem. A design brief may serve two main purposes. Firstly by creating the brief, the designer ensures that the client knows exactly what she wants to achieve from the design project. Secondly it acts as a focal point for the designer to pay attention to, as it clarifies the problem that she is trying to solve.

In the final task in WS2 students assumed the role of an observer, user and designer. Through the adoption of these roles they were required to identify real world problems in one's daily life and intend to resolve it by proposing a solution in terms of an artefact, a process or a system. They were asked to write a short design brief and then present their problem and the proposed solution to the other dyads.

Table 5.20: The design problems posed by different dyads in WS2

Dyads	*Design problems*	*Design briefs*	*Criteria*
Dyad 1 (Girls)	Blind children cannot play like the children having eyesight.	Design a toy with which blind children can play like the children with eyesight.	• It should not be costly • It should be safe for blind children • It should be long lasting • It should be easily carried • It should be made of simple materials
Dyad 2 (Girls)	Rahul is a small child who is in third class and who finds difficult in carrying his school bag to school as his bag is very heavy.	Make a device for Rahul so that he can carry his bag easily.	• The device should be able to lift at least 10 kgs. • It should be cheap • It should be attractive • It should be easily carried by children • It is to be used by students
Dyad 3 (Boys)	Many people are charged extra at airport due to heavy luggage. At home, they are not aware about the weight of the luggage.	We design a device which measures the weight of luggage automatically and is situated in the suitcase itself.	• It must be weight sensitive • It must be situated at the base of the luggage • It should have negligible weight • It has a digital display weight • It can be used by all people travelling on flight
Dyad 4 (Boys)	Rohan and many other students get bored with the same pens and throw them away after some time, say one week. This is usually seen in people who are rich.	Design a multi-coloured and light emitting pen which is very interesting to everybody.	• The pen should be able to change the colour whenever one wants • The pen parts should be safe for everybody • It should be attractive • It is to be used by students

Dyad 5 (Boys)	Raghu has a complaint. Ink pens are very leaky. If they are shaken, they throw out huge amounts of ink drops which make the surroundings dirty.	We have created a device which is on the side the pen. It takes in ink from one side and leaves it through the other end. When the pen is shaken, the object detects whether it is safe for ink to flow out. If not, it makes a bubble at the end from where ink leaves it. When shaking is stopped, the bubble breaks and ink flows like before. If the user wants some more ink to drop out, he should shake it lightly. It does not allow waste of ink. The device gets the energy from the finger with which we hold.	• It should be small in size • It should have easy flow of ink • It should be attractive to look at • Can be used by students, teachers or any people who write with fountain pens.
Dyad 6 (Boys)	In some remote village there is a gender distinction. The girls are not allowed to go to schools. They are forced to work in the houses. They are beaten without any reason. They don't get equal rights as boys.	We will design a poster which would be displayed in the village and which would make parent understand that girls should also go to schools.	• It should have the theme of girls' equality • It should be understandable by all people • It should be attractive
Dyad 7 (Boys)	New-born babies are very young. So they crawl on the floor. Sometimes while crawling they get hurt on their knees.	We will design a device for the babies so that they can easily crawl on the floor without getting hurt. This device will be tied on to their knees	• It should be light to lift • It should be attractive • It should be cheap • It should be soft • It should be safe

As indicated in Table 5.20, three of the design briefs focussed on areas that were of personal interest to students (such as those related to problems with pens and carrying heavy bags to school). Two dyads considered issues beyond their own immediate environment (such as the problem related to baby crawling and airport problems). Two dyads also included is/sues relevant to the community at large, such as those related to the gender discrimination and problem encountered by blind children.

A detailed analysis of dyads responses revealed their tendency to come up with at 'closed' design briefs where students had already identified the solution broadly. A closed design brief narrows the likely outcome by suggesting a single solution that a designer has to produce. Although it does not indicate how the final design will look like, it indicates what the solution will be like. For example, some of the closed design brief produced by students were, '*We design a device which measures the weight of luggage automatically and is situated in the suitcase itself'* or *'Design a multicoloured and light emitting pen which is very interesting to everybody'* or '*we will design a poster which would be displayed in the village and which would make parent understand that girls should also go to schools.'*

In contrast an open design brief enables formulation of many possible solutions to the design problem. An open design brief does not indicate what the solution is going to be. Open design briefs were also suggested by students such as *'Design a toy through which blind children can play like the children having eyesight.'*

Analysis also revealed the kind of features considered by students in their briefs. All students considered the functional requirements of their design solutions. Most also identified the user/s in their design briefs. The other criterion regarded by most dyads was aesthetic. Most of them suggested their design to be aesthetically pleasing. The other common criteria suggested by many dyads were safety and economical.

5.5.6 Summary

This chapter provided an overview of the results generated from all the design activities conducted in the workshops and the activity trial with middle school students. The broad objectives for analyzing the design activities were set forth in the form of various research questions and the frameworks for analyzing the activities were described. Aspects such as structure-function relations of artefacts, students' creativity, evaluating strategies and their design-decision-making skills were the main emphasis of the analysis.

Students' handling of the familiar artefacts reveal students' lack of understanding of the functions and importance of several key features of design. Also while they were familiar with the overall function of the artefacts, specifics were absent from their responses. Students presented a superficial understanding of the functions of the different parts of familiar artefacts. Often the obvious function of the familiar artefact was considered, and no further thinking was thought to be necessary. However it is believed that given sufficient time and providing sufficient scaffolding at appropriate places, students can get benefit through these tasks.

Students' activities with the unfamiliar artefacts revealed that few but not all students could make appropriate connections between the structure and functions of artefacts. The accidental functions suggested by students indicate their lack of understanding of the structure and functional relations in a designed artefact. Students related the functions of the unfamiliar artefacts with those that were known to them without acknowledging the immediate structure of the artefacts available before them, thereby coming up with functions which were trivial and inappropriate.

From a designer's point of view, it is important to look at an artefact closely and try to distinguish as many properties and functions as one can. Students thus need to learn about the nature of technical artefacts rather than become familiar with the details of individual artefacts.

When given opportunities to redesign familiar artefacts, students assumed the role of users and suggested functional and ergonomics improvements in their redesign proposals, both in writing and drawings.

The comparison of the solutions from *design-without-make* and *design-with-make* activities revealed that students not constrained with the making of their designs, showed more evidences of creativity and risk taking than students constrained with making their designs. The design-without-make students also came up with more number of and a variety of design ideas in contrast to the design-with-make students. Besides, design-without make activities provided opportunities to students to incorporate latest scientific and technological concepts in their designs.

However, *design-with-make* activities provided opportunities to students to recreate the whole design process, from identification of a need, to creating a brief and a specification, then generating ideas, developing them, modelling them, and finally producing a working product. The making of the artefact allowed development of skills in designing. Thus despite the creativity generated in a *design-without-make* activity the development of skills in the *design-with-make* activity makes us suggest that the two activities should be complementary and not substitutes of each other.

Students' evaluation of the design ideas and models of self and peers reveal that they mostly rated their own ideas and models higher than the others. Moreover, for the same criteria, the design ideas were rated higher than their models by most of the dyads in WS2. This could perhaps be due to the fact that making and implementing their design ideas actually provided opportunities to students to test their designs and see the consequences of their designs in actual.

Students presented many design problems from the real world and even designed their own briefs addressing the challenges posed in the design problem. The problems posed by students were usually posed within their known and familiar contexts. This activity provided them opportunity to look for problems in the real world and resolve them by intervening creatively.

All the activities thus provided opportunities to students to either assume the role of an observer, user, designer or a maker. By engaging in all the activities, students shifted from one perspective to another. At times they were provided opportunities observe everyday artefacts, use them and evaluate them, thus assuming the role of a user. Other activities provided them opportunities to engage in problem solving activities and thus behave as designers. Furthermore they were given opportunities to make what they had design, thus assuming the role of a maker or a producer. A progression in perspectives from an observer to a user to a designer and then finally to a maker facilitated students through experiential learning of design.

The next chapter (Chapter 6) will address some of the changes that occurred in students' understanding of design and designer through this experiential learning.

Chapter 6

ANALYSIS OF PRE AND POST-INTERVENTION SURVEYS

'Tell me and I forget, teach me and I may remember, involve me and I learn.'

Benjamin Franklin

6.1 Introduction

Both Workshop 1 and Workshop 2 involved a one-group pre-post-intervention research having the following three phases: Survey of students' ideas of design and designers, trials of specific design-related activities and studying the impact of design activities on students' understanding of design and designers. The following chapter presents the analysis of the pre and post-intervention survey responses from the students. As mentioned earlier while Workshop 1 (WS1) was a pilot adventure and involved trials of design activities with 25 students of Class 7 working in groups of 3-4 members, Workshop 2 (WS2) was the final study involving 14 students from Class 7 working in dyads. The purpose of the post-intervention surveys was to evaluate the impact of the design activities on students' ideas of and attitude towards design. A comparison between pre and post-intervention surveys enabled assessment of the learning that took place during the intervention or the trials of the activities. The results from the pilot pre and post-intervention surveys are presented first and then the final pre and post-intervention survey results are presented. In both the trials, post surveys used the same questionnaires that were used in the pre-intervention surveys.

6.2 Methodology

6.2.1 Pilot pre and post-intervention surveys (WS1)

The pilot pre and post-intervention surveys were in terms of structured or semi-structured individual responses of students. Following the pre-intervention survey, 8 students (4 boys and 4 girls) were interviewed. The interviews focused on students' responses to some of the questions in the survey, with the aim to explore their ideas in detail and test the consistency of their responses in the questionnaire. The same questionnaire was used for the pre and post-intervention surveys. By having students complete essentially the same questionnaire at the end of the trials of the activities course as they did at the beginning, it is possible to evaluate changes in attitudes and knowledge.The post-intervention questionnaire during the first trial was given to the students at the end of all the activities on the 5^{th} day of the WS1 (Chapter 4). The result of the pilot study was published in a peer reviewed International conference publication (Ara, Chunawala and Natarajan, 2009a).

6.2.2 Final pre and post-intervention surveys (WS2)

The questionnaires used for the WS2 pre and post-intervention surveys were the same as that used in the final survey with middle school students (Chapter 3). The responses of the students in this survey was in terms of individual structured or semi structured, open ended and drawn responses. The same questionnaire was used for the pre and post-intervention surveys. The post-intervention questionnaire in WS2 was given to the students at the end of all the activities on the 8^{th} day of the workshop (Chapter 4). Following the post-intervention survey, 4 (2 boys and 2 girls) students were interviewed in detail. The interviews focused on students' responses to the questions in the survey, with the aim to explore their ideas in detail and test the changes or consistency in their responses in the post-intervention questionnaire.

6.3 Analysis

The analysis of the pilot pre and post-intervention surveys are presented qualitatively while the results of analyses of the final pre and post-intervention surveys are presented both qualitatively and quantitatively.

6.3.1 Pilot pre and post-intervention surveys (WS1)

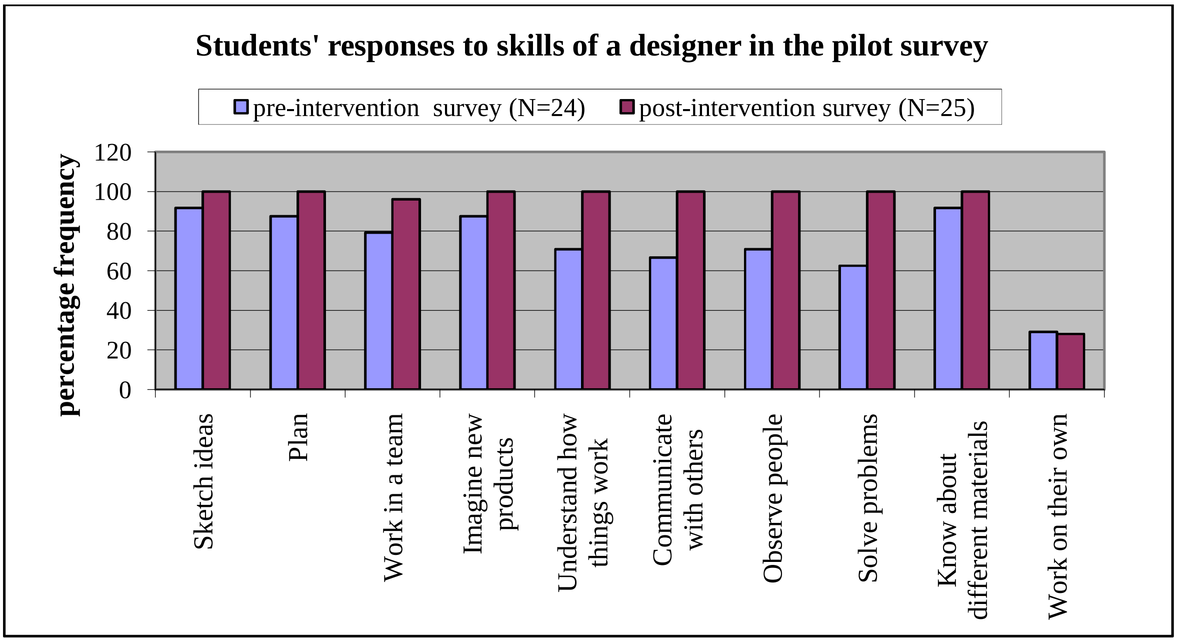
The questionnaires used for WS1 pre and post-intervention surveys were same as that used in the pilot survey done with the middle school students. When asked *'What comes to your mind when you hear the word design?'* most students in the pre-intervention stage (54%) associated design with arts, such as, decorations, drawings, pictures/paintings and patterns. In the post-intervention stage this number came down to 40%.

To the question, *'Designers are people who…,'* students mentioned professions such as, architecture, fashion designing, textile designing and product designing or attributed certain skills to designers such as imagination, creativity, concentration, ability to learn and think (for example, one student wrote, designers *'are always creative and full of imagination'*). A few students recognized that designers in different fields have specific knowledge and skills (for example, one student wrote, *'fashion designers cannot design cars'*). In the post-intervention phase, more students associated designers with two specific skills of imagination and creativity. No other difference was noted in their responses.

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

When asked *'Can animals design?'* there was a little difference in students' responses in the 2 stages. Most students (67% in pre-intervention and 64% in post-intervention) stated that animals design. When asked whether designers solved real world problems nearly half of the students disagreed in the pre-intervention stage. However, after actually solving a real life problem in their design activities, this number reduced to about one-fourth of the original sample.

Graph 6.1: Skills of a designer compared on pre-post-intervention in the pilot survey



As indicated in Graph 6.1, most students, both before and after intervention, perceived working in a team, sketching ideas, planning, imagining new products, knowing about different materials as skills required by a designer. However, post-intervention there was a marked increase in the number of students, who considered observing people and communicating with others as the essential skills of designers. This seems to be influenced from the fact students were provided opportunities to communicate their ideas to others during the trials of the activities.

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

6.3.2 Final pre and post-intervention surveys (WS2)

The questionnaires used for WS2 pre and post-intervention surveys were same as that used in the final survey done with the middle school students. Hence the basic questionnaire had the following sections:

A. Demographic data of the students;
B. *'Draw a designer at work';*
C. This was the largest section and consisted of questions pertaining to students' ideas and attitude towards design. It consisted of open-ended, complete-the-sentences, rating scales, dichotomous questions etc.
D. The last section consisted of several pictures showing certain activities performed by individuals. Students were asked to mark the activities which they considered were designing activities.

As in the main survey as described in Chapter 3, Section D was of 2 types- one with all the activities done by males while the other with one with all the activities done by females. Students had to respond to any one of the types. The analysis thus used the same framework as used in the final survey.

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

Before the activities, the 14 students participating in WS2 came up with 25 ideas (with around 2 ideas per students) while the number of spontaneous ideas generated by them increased to 36 (with about 3 ideas per students) in the post-intervention phase. A comparison of their ideas in the pre and post-intervention surveys has been presented in Table 6.1. As evident from the table, in the pre-intervention phase 36% of students' ideas were related to the meaning of design while 64% were related to the other ideas of design, mostly examples of designed products (56%) such as dresses and cars. In the post-intervention survey, however, most ideas of students were related to the meaning of the word design (61%) while 39% of ideas were related to other aspects of design such as examples of designed products, attitude towards design, skills associated with designers and purpose of design. The examples given in the post-intervention phase were reduced to 22% with students mostly giving examples of cars and buildings. As seen from Table 6.1, in the post-intervention phase, a notable increase of ideas were found in students' association of design with making or modelling things (from none in the pre-intervention phase to 22% in the post-intervention one), planning (from 4% to 11%) and designing for a purpose, especially making useful products for people (from none to 11%).

Table 6.1: Students' spontaneous ideas of design in the pre-post-intervention surveys

The spontaneous ideas of design	*Pre-intervention*	*Post-intervention*
Ideas related to the meaning of Design *Pre-intervention (36%); Post-intervention (61%)*		
Art (painting, decoration, patterns)	5 (20%)	3 (8%)
Drawing (drawing or scientific drawing)	1 (4%)	3 (8%)
Making/transforming/repairing things	0	8 (22%)
Plan/drawing to show how things are made	1 (4%)	4 (11%)
Invention/creating new things	1 (4%)	2 (6%)
Coming up with new idea/ imagination	1 (4%)	2 (6%)
Other ideas associated with Design: *Pre-intervention (64%); Post-intervention (39%)*		
Examples of things/artefacts designed	14 (56%)	8 (22%)
Examples of design professions	1 (4%)	0
Attitude towards design and design learning	1 (4%)	0
Skills associated with design/designers	0	2 (6%)
Design is for a purpose (making useful products)	0	4 (11%)
Total	***25 (100)***	***36 (100)***

A decrease in associating design with art from 20% in the pre-intervention survey to 8% in the post intervention phase suggests that students seemed to associate design less with art. However the examples of designed products suggested by students pertained to cars, buildings and dresses. Thus one cannot be certain whether they now associated design more with technology not.

As seen from Table 6.1, there is also an increase in students' ideas in the post intervention phase of design as associated to making. This perhaps seems to be due to the influence of the designing activities that required students to engage in the process of making what they had designed. The association of design with making, especially testing of ideas through modelling, was also evident in one of the students' responses in the post-intervention interview. For example, a girl student (G1) in response to this question suggested, that '*a designer spontaneously comes up with different ideas and tries out their ideas by making those things.'* Another student in the interview suggested that design was like making patterns and making drawings before beginning to make something.

6.3.2.2 'Designers are people, who…'

When asked to complete the above sentence, somewhat more ideas were generated in the post-intervention phase (25%) than in the pre-intervention phase (19%) (Table 6.2).

Table 6.2: Students' spontaneous ideas of designers in the pre & post-intervention surveys

The spontaneous ideas of designers	***Pre-intervention***	***Post-intervention***
Ideas related to the work of designers (53%): Pre-intervention (47%); Post-intervention (24%)		
Designs	5 (26%)	2 (8%)
Makes art/ decorates, beautifying things	3 (16%)	1 (4%)
Makes (some things/a model)	1 (5%)	2 (8%)
Comes up with ideas/theories	0	1 (4%)
Other ideas associated with designers (47%): Pre-intervention (52%); Post-intervention (76%)		
Skills of designers (c*reativity, imaginative, artistic*)	3 (16%)	4 (16%)
Examples of things that designers design (*clothes, buildings, cars etc*)	4 (21%)	8 (32%)
Designs for a purpose (*make useful things for people)*	0	7 (28%)
Attitude towards design and design learning	1 (5%)	0
Examples of design professionals (*fashion designers)*	2 (11%)	0
Total	***19 (100)***	***25 (100)***

As evident from Table 6.2, compared to the post-intervention phase, more ideas in the pre-intervention phase were also tautological since students completed the sentence by just writing *'design'*. More examples of things designed by designers (such as cars, clothes and buildings) were given in the post-intervention phase.

Here again students in the post-intervention stage suggested that designing was done for a purpose (28% of ideas) while none said so in the pre-intervention survey. Thus students mostly wrote that designers *'designs or makes useful things for people'*, or *'which help people.'* This aspect of students' ideas of design seems to be influenced by the intervention wherein they were required to design and make a product for an elderly person.

The student (B1), who considered design as pattern and drawings on probing in the interview, suggested that designers *created patterns which are continuous*. When probed on why the patterns need to be continuous, he (B1) suggested *'it follows the same rule; so, many patterns can make it continuous.'* According to him, *'a designer also makes plan, designs a building. That's also like making a pattern; which thing should come where, it is like following a rule.'* When probed further on how designers follow rules, he suggested, *'if a designer designs the first floor in the shape of a rectangle, he cannot design the second floor in the shape of a triangle, otherwise how will the rooms come on top of each other.'* This student seemed to have a rule-based approach to design and seemed to believe that although designers create new patterns, they follow some basic rules while creating those patterns. When probed further he also revealed that designers need a pre-requisite of 'knowledge' before designing anything.

6.3.2.3 Can animals design?

When asked whether animals can design, 10 students (71%) in the pre-intervention phase and 8 students in the post-intervention phase (57%) agreed that animals did design (Table 6.3). The number of justifications provided for and against animal designing also did not vary much across the two phases. The only difference noticeable was a slight increase in the post-intervention phase in the number of students recognizing that specific skills like creativity, imagination and drawing were necessary for designing. Thus even despite the intervention, there were no noticeable change in students' consideration of designing by animals.

Table 6.3: Students' justifications for and against animal designing in the pre & post-intervention surveys

Can animals design?	***Pre-intervention***	***Post-intervention***
Justifications for design by animals ***Animals can design:*** Pre-intervention (71%); Post-intervention (57%)		
Make their own shelters	6 (38%)	7 (39%)
Make patterns with paws/footprints	3 (19%)	0
Plan for a living by hunting	1 (6%)	0
Have brains	1 (6%)	1 (6%)
Justifications for why animals cannot design ***Animals cannot design:*** Pre-intervention (29%); Post-intervention (43%)		
Have no thinking ability	0	3 (17%)
Have no hands/ have four legs/ cannot hold tool	2 (13%)	2 (11%)
Have small brains/no brains	2 (13%)	0
Have no creativity/ imagination/ drawing skills	1 (6%)	4 (22%)
Have no materials	0	1 (6%)
Total	***16 (100)***	***18 (100)***

However, the nature of justifications provided by students was important in this regard. Students in the post-intervention survey did not regard paw prints, planning for a living/hunting as designing by animals. Also while providing justification against animal designing, students considered thinking ability as an important faculty lacking in animals. Students even disregarded design by animals on the assumptions that animals lack specific skills such as creativity and imagination which were essential in designing.

In the interview, the student (B2) who agreed with animal designing were probed if there were any difference between animal designing and human designing. He suggested, '*in humans they have particular designers or some small group of people who designs and there are masons or others who make, designers themselves do not make. But in the animals they themselves do the designing and then make it.'* This students' response suggest that he considered designing and making as two distinct processes, wherein the work of designers was mostly involved in conceptualising the product but not essentially make it.

6.3.2.4 Design in different Indian languages

In both the phases of the survey, students mostly generated English words more often than words in Indian languages (Table 6.4). In the pre-intervention phase, 10 students responded to this question and generated 12 words. Most words in the pre-intervention survey were related to art or the work of art such as the English word ‘art’, Hindi or Marathi word, *‘Kala’*. Very few words in the pre-intervention survey were generated for design as planning or making in English or any other Indian languages.

Table 6.4: Students’ produced words for design in the pre & post-intervention surveys

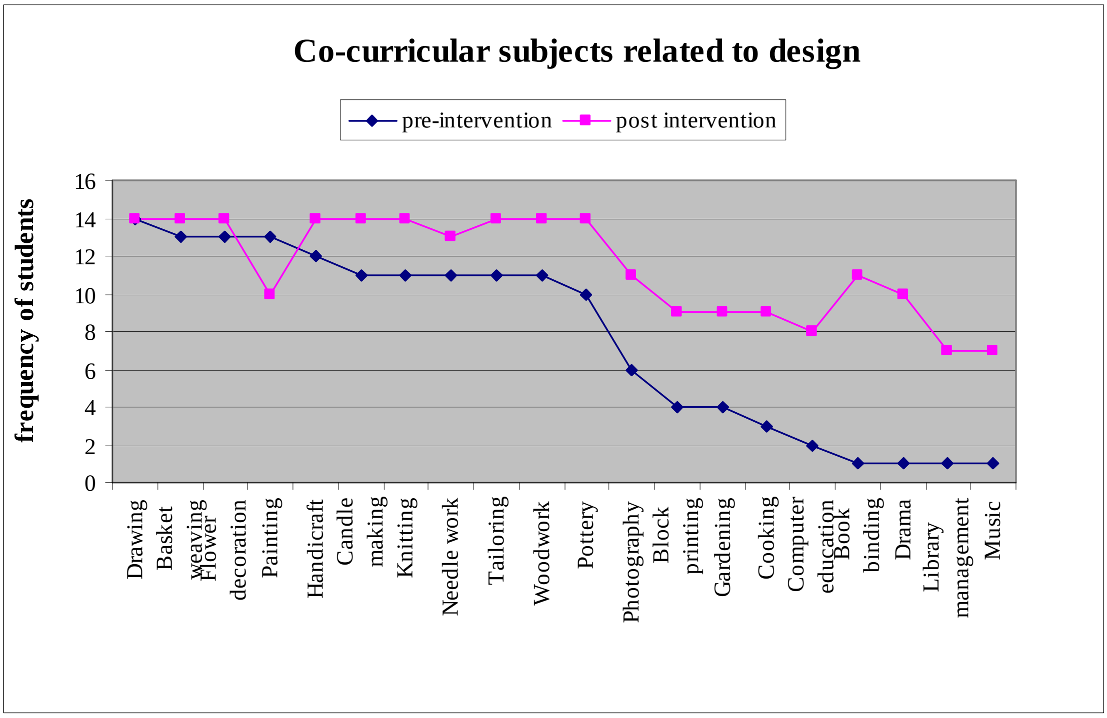
Different words for design	**Pre-intervention**	**Post-intervention**
Work of art/art *(‘Kala’*-Hindi, Marathi, Bengali)	8 (67%)	4 (27%)
Drawings *(‘aanka’)*	1 (8%)	2 (13%)
Skill	2 (17%)	1 (7%)
Plan	1 (8%)	3 (20%)
Making/make *(’banana’, banawat)*	0	2 (13%)
Creation/create *(‘aavishkaar’)*	0	3 (20%)
Total	***12 (100)***	***15 (100)***

In the post-intervention phase, the number of words generated by 13 students was 15. As compared to the pre-intervention phase, more words in the post-intervention phase was related to the English words, ‘plan’ and ‘create’ and Hindi words *‘aavishkar’* (which means invention). A decrease in the number of students’ association of design with art in the post-intervention phase indicates a direct influence of the activities on students’ understanding of design.

6.3.2.5 Schools subjects and design

Graph 6.2 depicts the ratings of the subjects by students in both the pre and post-intervention phases. The ratings were arranged in a descending manner with most designerly subjects ordered on the left hand side of the graph. In both the phases, some subjects were considered designerly more often by students than the other subjects. This pattern seemed to be consistent in the post-intervention phases (Graph 6.2). An overall increase in the ratings of all the subjects as related to design was noted in the post-intervention phase. Special attention, however, needs to be given to the subjects like painting which was rated as designerly by less students in the post-intervention phase than in the pre-intervention phase.

Graph 6.2: Students' association of co-curricular subjects with design in pre& post-intervention surveys



The following transcripts for some of the responses would enable one to observe the reasoning pattern among students in the post-intervention survey. When a student (G2) who had suggested painting as related to design were asked why she marked it, she responded by saying, '*…mixing of colours before painting is important and that is where design comes in*'.

One of the students (G1) who did not mark this subject as designerly replied, *Painting… No. Because, it has an order, but they* (painters) *follow their own wish. There is order when you have to choose the colours but then they paint whatever comes to their mind.'* This response suggests that this student has begun to distinguish between art and design to a certain extent.

The same reasoning pattern was used by her (G1) to indicate why music was not related to design, *'A musician makes music based on his wish, or based on whatever comes to his mind. He is not thinking much.'*

The subject of gardening revealed interesting insights. A student (B1) who had not marked gardening as related to design responded by saying, *'Gardening is not related to design, because in gardening we don't have to invent or modify anything'*. This student perhaps seems to consider design as invention or making of things. Gardening which involves planning was thus not considered a designing activity by this student.

However a student (B2) who marked gardening as related to design showed evidence of a planning approach to design. He suggested, *'A gardener has to first plan; like if he wants to make his garden look more beautiful then he will divide the garden. For example, he will keep the roses in one place. Again while putting the seed or while removing the weeds also he needs to give proper space so that both the plants do not compete with each other.'*

The same reasoning was evident in a girl student's (G2) response when she considered library management as related to designing, *'Library management is somewhat related to design. For example if we have a bundle of 100 books and 10 shelves so we can arrange them by order of alphabets or like bed time stories in one place or historical in another or mythological stories in another place. So it might be related to design because you are ordering things properly.'*

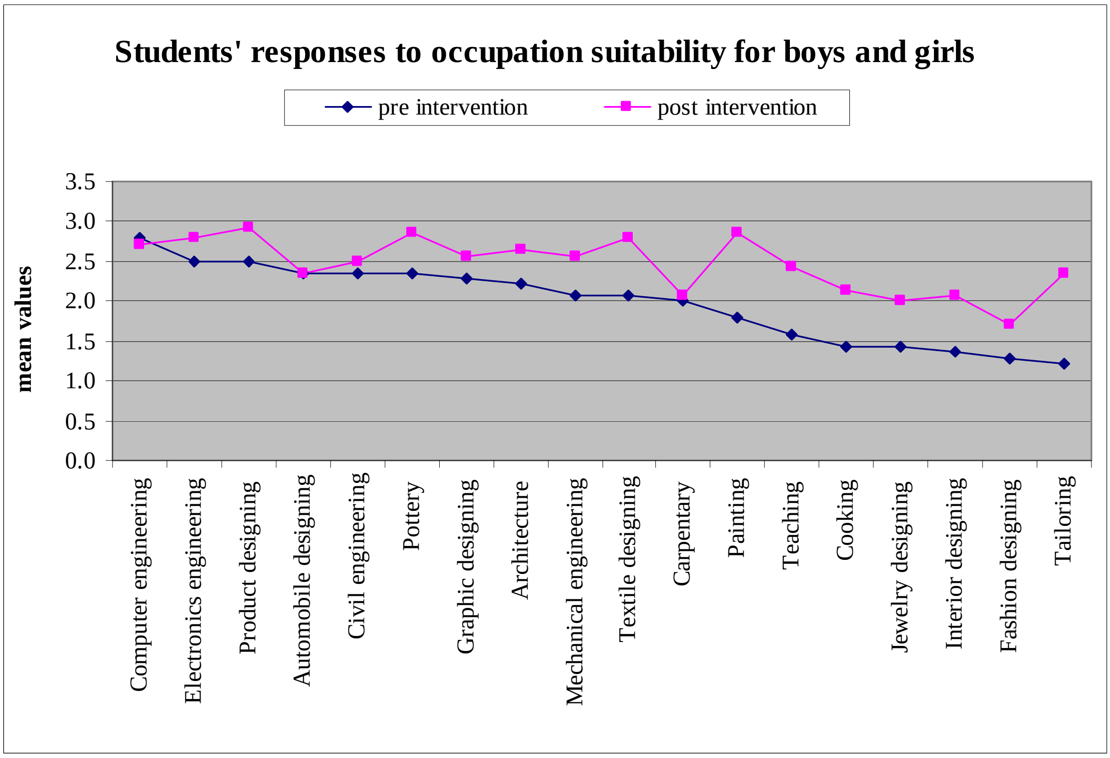
A student (B2) who did not mark drama as related to design but showed evidence of designerly thinking suggested, *'Drama is not designing because in drama a person basically does what has happened in the past. For example whenever there is a school drama; I am not talking about the drama written by Rabindrath Tagor; that I think may be related to design because he wrote the dramas and made the characters. But the drama that we do in the school is not related to design; no teacher writes that drama; most of it is taken from the past which has already occurred.'*

The above response of B2 indicates that he is able to distinguish design from imitation or copying. While he considers a novel drama script as design, he considers the enactment of play on ready-made scripts as non-design. These responses of students indicate that they have begun to distinguish between what might be and what might not be 'design'. The interviews indicate that these students have started to think of design as a planning process entailing a purpose, intention and creativity.

6.3.2.6 Design occupations and gender suitability

In this structured question, a list of 18 occupations were provided and students were supposed to select by circling either one of the three options for each occupation, 'suitable for girls', 'suitable for boys' or 'suitable for both'. For analyzing the responses from the students, each of the response was coded as follows: 'suitable for girl' was coded as 1, 'suitable for boy' was coded as 2 and, 'suitable for both' was coded as 3. Next the mean value for each item was plotted and it reflects the average ratings of the occupation for all the students. The means for the entire sample for the 18 occupations are arranged in the descending order and shown on a plot of means versus occupations. The means for both the pre and post surveys are shown on the same plot area to enable comparison (Graph 6.3).

Graph 6.3: Students' responses to occupation suitability in pre & post intervention surveys

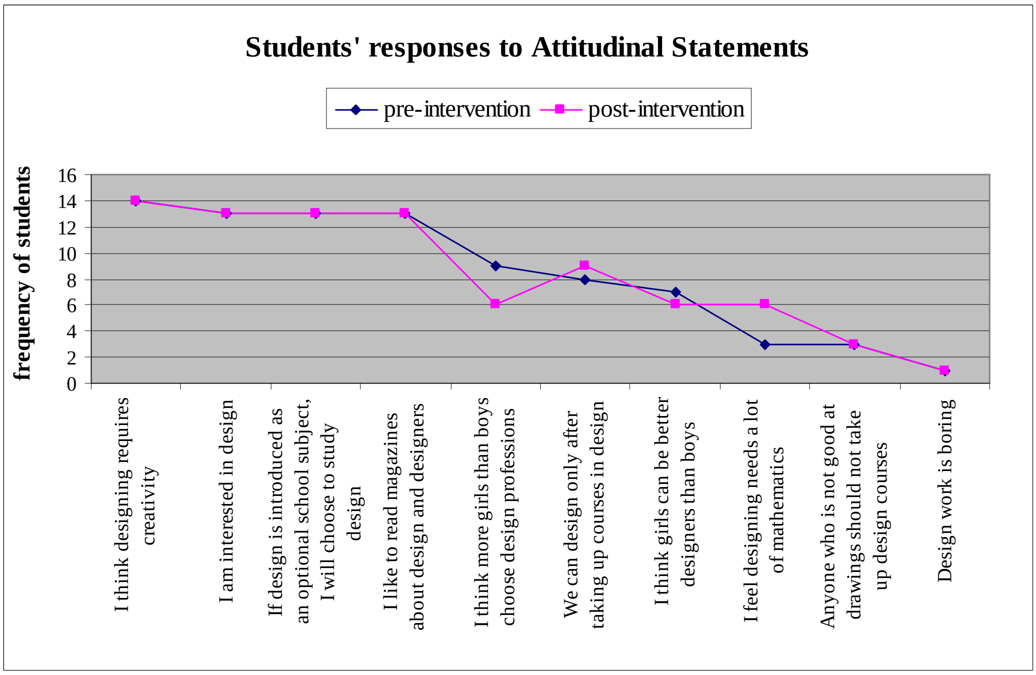


For an occupation, a mean value of 3 indicates that all the students chose ‘suitable for both’ option for that occupation; a value of 2 indicates that all chose the option, ‘suitable for boys’ while a value of 1 indicates that all chose the option, ‘suitable for a girl’ for that occupation. On the basis of the above analysis it was found that while marking the occupations suitability in both the pre and post-intervention, students displayed a certain preference in selecting an occupation suitable for one gender than the other. Although the intervention was not specifically designed to influence students’ perception of occupations, however it was observed that students in the post-intervention survey tended to mark most occupations as suitable to both the genders. However there were certain occupations which were still considered as more suitable to a boy or a girl. For example, automobile designing, civil engineering and carpentry were still selected as more suitable to boys than girls; while occupations such as fashion designing and jewellery designing were still considered as feminine professions in the post-intervention phase.

6.3.2.7 Attitude and interest towards design

A list of 10 statements was used to probe students’ interests and attitude towards design. For each of the statement students were supposed to choose either of the two options, ‘agree’ or ‘disagree’. Graph 6.4 presents students’ agreed responses to the statements. As seen from the graph, students had a positive attitude towards design and design learning even before the intervention. There was a slight change noticed only with respect to the following two statements- ‘*I think more girls than boys choose design profession*’ and *‘I think designing needs a lot of mathematics’*. It was observed that there was a slight decrease in the number of students who agreed that more girls than boys choose design professions in the post intervention. There was also a slight increase in the number of students in the post-intervention phase who believed that designing required mathematics. This perhaps could be due to both boys’ and girls’ active engagements and participation in resolving real world design problems. Both boys and girls contributed and came up with creative solutions in all the activities. This perhaps could have led students to believe that design was not a domain of either only for boys or for girls. The requirements to take measurements, make accurate calculations, visualize different shapes of various sizes and make drawings of the same on paper, perhaps led students to understand that designing required mathematics to an extent.

Graph 6.4: Students' agreed responses to attitudinal statements in pre & post-intervention surveys

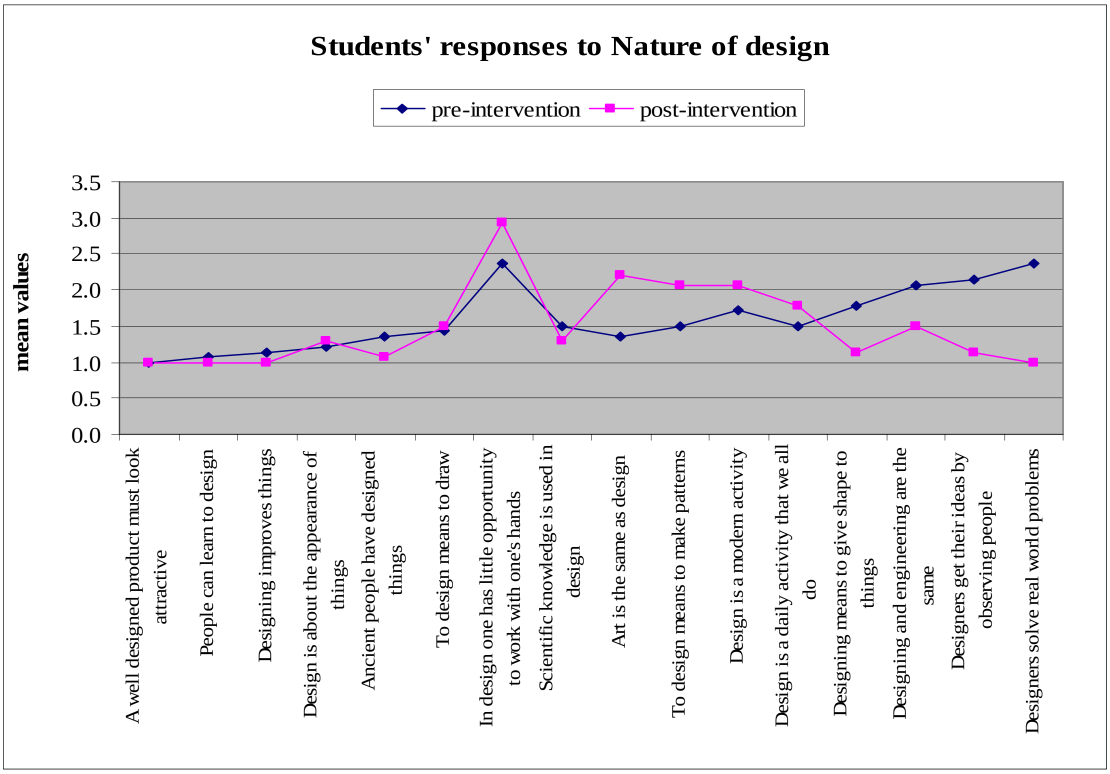


6.3.2.8 Nature of design

A set of 16 statements probed students' understanding of the nature of design. Students had to indicate whether they 'agreed', 'disagreed' or were 'unsure' about each of the statement. For the analysis, students' responses were coded as follows: the option 'agree' was coded as 1, the option 'unsure was coded as 2, while the option 'disagree' was coded as 3. For a statement a mean value of 1 indicates that all the students agree with the statement, a mean value of 2 indicates that all the students choose the option 'unsure' for that statement while a mean value of 3 indicates that all the students disagree with that statement. As in the case of occupation, the means for both the phases for all the statements were plotted on the same graph.

The pre and post-intervention survey analyses of students' responses revealed that there were differences in students' understanding of design for some of the statements (Graph 6.5). For example, an inclination towards a mean value of 3 for the statement *'In design one has little* *opportunity to work with one's hands'* means that more students in the post-intervention survey expressed disagreement regarding this statement. This is attributed to students' engagement in the trials of the activities where students engaged in hands-on exploration for all the activities.

Graph 6.5: Students' responses to nature of design in pre and post-intervention surveys



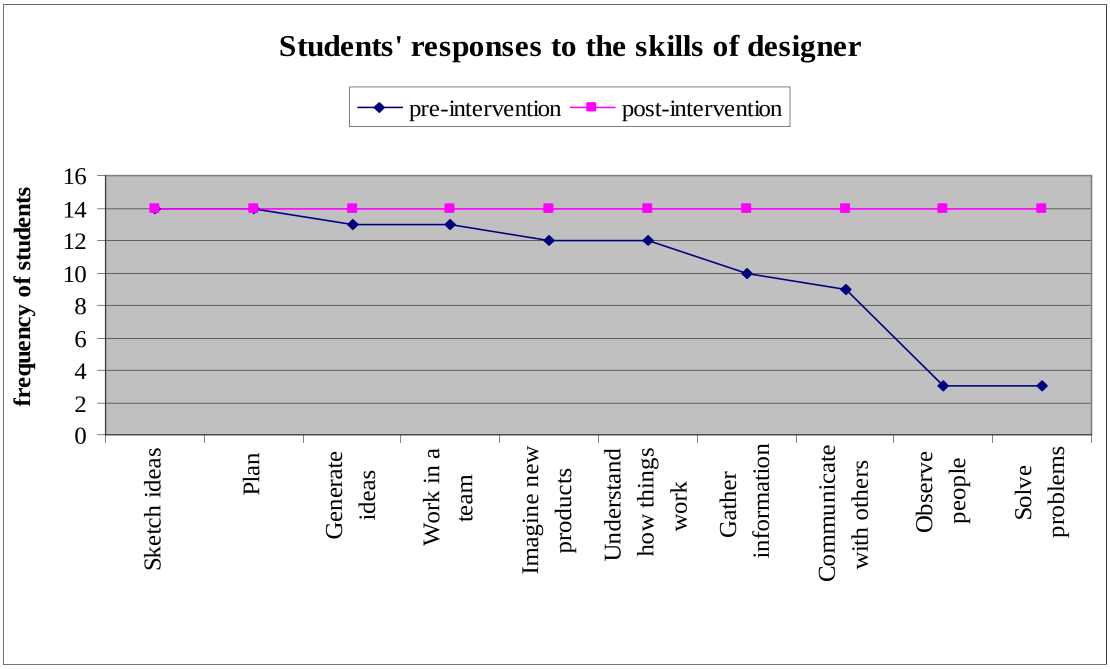
There was also a marked increase in the number of students who were unsure or disagreed about the statements *'Art is the same as design'*, *'To design means to make patterns'* and *'Design is a daily activity that we all do'* indicating that students' engagement in the design activities influenced their ideas of design to a certain extent. More students after the activities disagreed that design and art were same or design is about making patterns. 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. When students were probed for their response in the interview, one student (B1) suggested, *'We don't design daily. We don't make models and devices every day. Only when we need them, then only we make them'*.

There was also a marked increase in the post-intervention survey, in the number of students who agreed that *'Designing means to give shape to things'*, *'Designing and engineering are the same'*, *'Designers get their ideas by observing people'*, *'Designers solve real world problems'*. By actually engaging in real world design issues, handling artefacts, evaluating them, designing solutions, making models and looking for design problems around them, students showed a slightly better understanding of the nature of design.

6.3.2.9 Skills of a designer

In the post-intervention phase, all the skills were marked by all the students as the essential skills of a designer. The skills which were marked less frequently by students in the pre-intervention phase (*Communicate with others, observe people and solve problems*) were also considered as the necessary skills of a designer by all the participants in the post-intervention survey (Graph 6.6) indicating students' increased awareness about the skills associated with design due to experiential understanding of design.

Graph 6.6: Students' responses to skills of designers in pre & post-intervention surveys

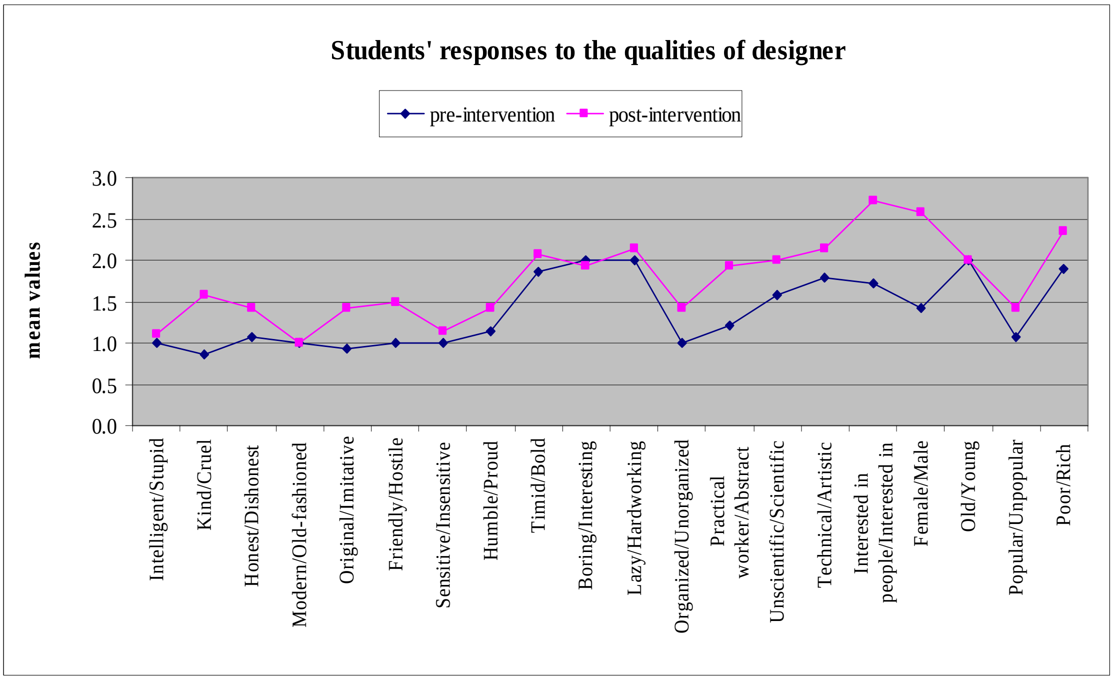


6.3.2.10 Qualities of a designer

A list of 20 contrasting qualities of a designer was presented in this question, wherein students were supposed to circle any one of the qualities. 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.

For the sake of analysis the responses from students were coded as follows: a circle of the option on the left side (qualities presented on the left side of the two qualities) was coded as 1, a circle of the option on the right side (qualities presented on the right side of the two qualities) was coded as 2 and a circle of both the options was coded as 3.

Graph 6.7: Students' responses to the qualities of designers in the pre & post-intervention surveys



While responding to this question, it was observed that there was a tendency for students to select the positive qualities in both the pre and post-intervention phases (Graph 6.7). However, students more frequently selected both the options in the post-intervention phase than in the pre-intervention phase. For most of the skill-based traits such as *‘interested in people/ interested in ideas’,’ technical /artistic’,* and *‘Practical worker/ abstract thinker’* students had a tendency to select both the options in the post-intervention survey in comparison to the pre-intervention survey. Students also most frequently selected both the options for the biological traits *female/ male* in the post-intervention phase.

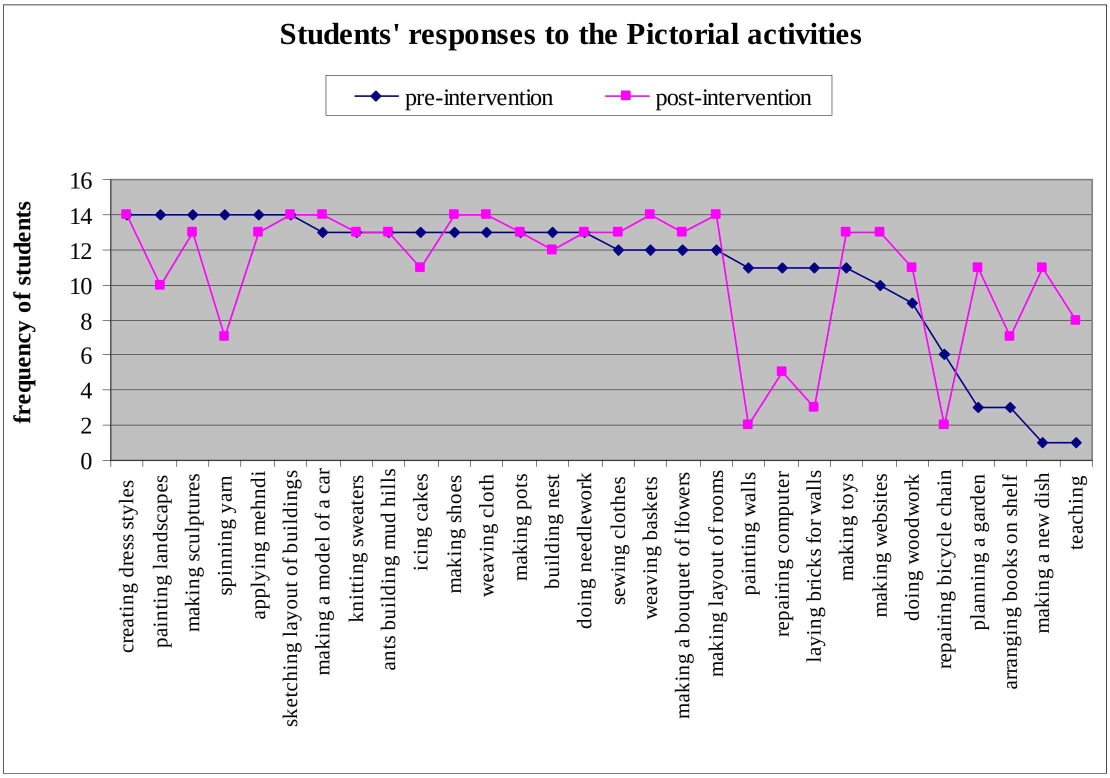
This indicates that students’ participation in the activities influenced their ideas about the skill-based qualities of a designer. Thus a designer could either be a female or a male, he/she could be technical or artistic, interested in people or ideas. Their ideas thus seem to come closer to the ideas of teachers and designers who tended to select both positive and negative qualities for a designer.

6.3.2.11 Section D: Pictorial activities

In response to the pictorial activity, the pre-intervention survey responses indicate that some activities were considered as related to design more often than the other activities (Graph 6.8). For example, the top five activities related to design by most students in the pre-intervention survey were creating dress styles, painting landscape, making sculptures, spinning yarn and applying *mehndi*, while the bottom five activities or those least frequently associated with design, were repairing a bicycle chain, planning a garden, arranging books on shelf, making a new dish and teaching.

In the post-intervention phase, some activities were considered designerly more often than in the pre-intervention phase such as making a model of a car, making shoes, weaving cloth, making pots, sewing clothes, weaving baskets, making a bouquet of flowers, making layout of rooms, making toys, making websites, doing wood work, planning a garden, arranging books on shelf, making a new dish and teaching. For some of the activities there was a marked decrease in the number of students considering them as designing activities in the post-intervention survey. These activities included: painting landscape, spinning yarn, icing cakes, painting walls, repairing computer, laying bricks for walls and repairing bicycle chain.

Graph 6.8: Students' responses to pictorial activities in pre and post-intervention surveys



When probed for their reasons in the post-intervention interview, students revealed the nature of their reasoning in design. For example when asked to a student (B2) why spinning yarn was not a designing activity, he replied, '*In spinning we know how to do it, we are not applying any new ideas.'* This response suggests students' understanding of design as coming up with innovative ways of doing things as opposed to following routine procedures of doing things.

When asked why painting walls is not designing, the same student (B1) replied, *'if in painting walls we make some new patterns, then it is somewhat design, but just painting walls is not designing.'*

When probed for the activity *laying bricks for walls*, a student (B2) who had marked it as a designing activity replied, '*… if we lay bricks in such a way that it is not stable, then the wall will collapse, so we need to think before laying the bricks.*

B1, who had laying bricks as a designing activity replied, '*…in which pattern we lay the* *bricks so that the wall is strong and looks good'*.

A student (G1) who had not marked it as a designing activity reasoned in the following way, '*We are just ordering the bricks in a particular order told by somebody. We are not designing anything new here.'* This student also reveals a better understanding of design wherein she implies a differentiation between implementing or executing and creating something new.

There were still around 50% students who did not consider teaching as a designing activity. B2 gives a clearer picture of why he had not marked teaching as a designing activity but he still acknowledged that it had certain elements of designing involved, '*In teaching we are just telling students what we know, we are not creating anything new, we are just telling what we know. Sometimes teachers use news ways of how to explain things more nicely to students, but it is only sometimes, but that involves designing because the teacher has to think and plan.'* It is thus obvious from the response of B2 that he clearly distinguishes design from non-design. Although he disagreed that teaching involved designing (perhaps being influenced by the didactic method of teaching in most schools), he did acknowledge that creative teaching involving innovative practices of teaching was very much associated with design.

The analysis of pre and post-intervention survey responses indicate that students had an unambiguous picture of what design is about. More students after the intervention considered designing as planning before taking an action, making tangibles or pursuing design for a purpose or a need. Students seemed to distinctly distinguish between design and non-design, indicating that the intervention played an important role in bringing about certain changes in students' ideas of design.

6.3.2.12 Section B: Draw a designer at work

A. Gender of the designers depicted

When asked to draw a designer at work, all the students in the pre and post-intervention surveys drew one human figure all working alone. In the pre-intervention survey all the boys depicted a male designer, while all the girls depicted a female designer, except one girl who depicted a male designer. In the post-intervention survey, all the boys and girls depicted male and female designers respectively. There were thus no difference noted in the depiction of male or female designers by both boys and girls (Table 6.5).

Table 6.5: Gender of designers depicted in the pre and post-intervention surveys

	Male designers	Female designers	Boys drawing male designers	Girls drawing female designers	Girls drawing male designers
Pre-intervention	9	5	8	5	1
Post-intervention	8	6	8	6	0

B. Location of the designers

In the pre-intervention survey all the students depicted their designers working indoors in either their homes (7) or in offices (4) and most working in the city (12) while 2 students suggested their designers were working in a town (Table 6.6). None of the designers were shown to be working outdoors. However, 3 students marked the location of their designers as ‘others’. One of these 3 students, suggested that her designer was participating in a fashion show.

Table 6.6: Location of the designer depicted in the pre and post-intervention surveys

	Indoors	Outdoors	Home	Office	Others (fashion shows, factory)	City	Town
Pre-intervention	14	0	7	4	3	12	2
Post-intervention	11	3	2	9	3	12	2

In the post-intervention phase most of the students also depicted their designers working indoors (11). However, 3 students also showed their designers working outdoors, in park or ‘other’ places. A decrease in the number of students’ depiction of designers working at home was seen in the post-intervention phase, indicating that they now associated design to be mostly a professional activity done in offices. As in the pre-intervention phase, most students also depicted their designers working in city (12) and only two working in towns (in factory). A large number of students depicting designers in a city could be an influence of students’ own urban background.

C. Tools used by the designers

The kind of tools depicted by students influences the nature of activity undertaken. As seen from (Table 6.7), students in both the surveys depicted their designers working with tools, mostly writing tools. The total number of tools depicted in the post-intervention was more than the number of students since one student depicted 2 different kinds of tools. Painting tools were used in the pre-intervention phase when students depicted their designers as painters/artists (Figure 6.1, Figure 6.3). Construction tools were depicted only in the post-intervention phase by 2 students. There were not much differences noticed in the kinds of tools used in the pre and post-intervention surveys.

Table 6.7: Tools of designers depicted by students in the pre and post-intervention surveys

	Writing tools	Painting tools	Construction tools	Stitching tools	No tools	Total tools
Pre-intervention	8	2	0	1	3	14
Post-intervention	9	0	2	1	3	15

D. What the designers were doing?

Students in the pre-intervention phase mostly depicted their designers sketching (8) or painting (2). In the post-intervention phase, however, this number got reduced to only 6 students (Table 6.8).

Table 6.8: Designer's action depicted in the pre and post-intervention surveys

	Sketching / painting	Working with 3D models/ making	Performing/ modelling in shows	Thinking
Pre-intervention	10	2	2	0
Post-intervention	6	6	0	2

In the post-intervention phase a little less than half the students depicted their designers either sketching (Figure 6.4, Figure 6.6) or working with 3D models or making something. An interesting observation was made regarding the designers depicted by two students who depicted their designers seated on a desk and *'thinking'* (Figure 6.2). These two students depicted thinking bubbles in their drawings and also indicated in the bubbles what the designers were thinking. This indicates these students' understanding of design as involving conceptualization of ideas.

Figure 6.1: A female designer depicted by a girl, sketching a floral pattern, in pre-intervention survey

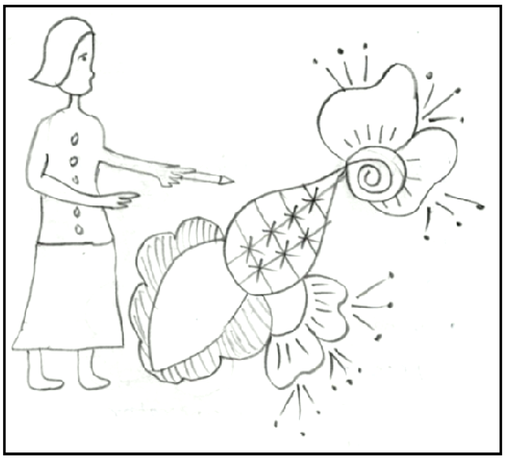


Figure 6.2: The same girl depicted a female textile designer 'thinking' in the post-intervention survey

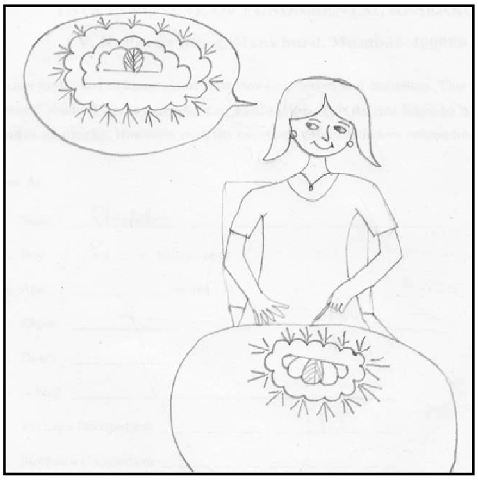


Figure 6.3: A male designer depicted by a boy, painting a landscape in the pre-intervention survey

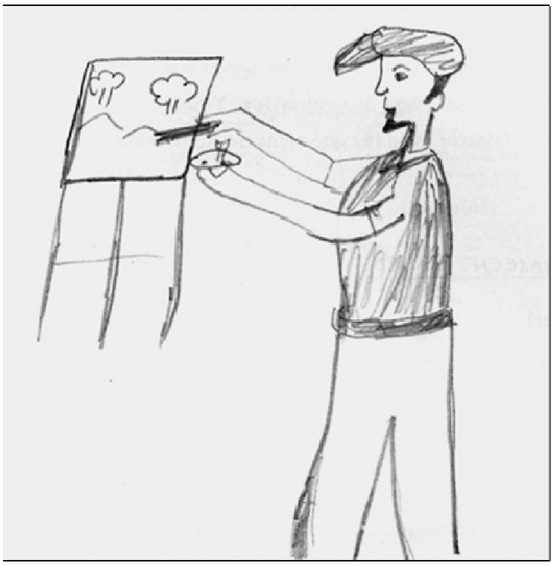
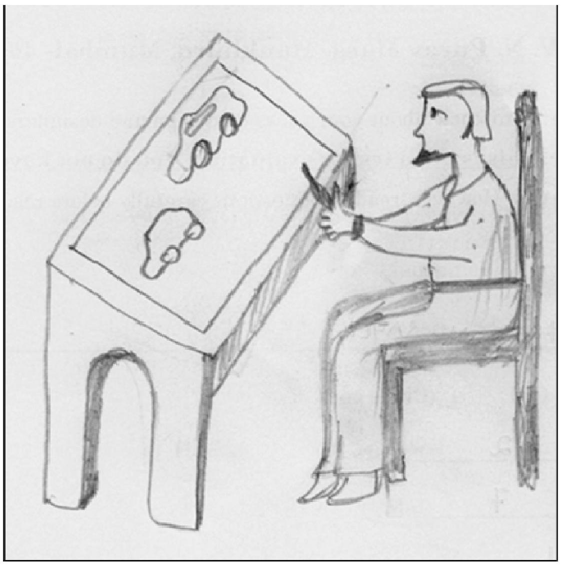


Figure 6.4: The same boy depicted a male designer designing cars in the post-intervention survey



These finding thus reflect the fact students, after the intervention, understood design as both a hands-on and a minds-on activity, in which a designer not only works with hands (as reflected by large number of students depicting their designers working with 3D models) but also gets engaged with the design mentally by generating ideas and planning (as indicated by students depicting their designers as sketching and also thinking).

E. Professions of designers

What professions were mostly depicted in both the phases of the survey?

Table 6.9: Designer's profession depicted in the pre and post-intervention surveys

	Architect	Fashion designer	Performer/ artist/ model	Car/rocket designer	Product designer	Textile designer
Pre-intervention	3	4	5	2	0	0
Post-intervention	6	1	0	4	2	1

As evident from Table 6.9, students in both the phases depicted designers from a variety of professions, such as architecture, fashion designing, automobile designing etc. In the pre-intervention phase 3 students depicted an architect. A little less than half the students in the post-intervention phase (6) depicted architects in their drawings. Only one student in the post-intervention phase depicted a fashion designer (Figure 6.6), as compared to 4 students' depictions of fashion designers in the pre-intervention phase (Figure 6.5). One student was also found to depict a textile designer in her drawing (Figure 6.2).

Figure 6.5: A female dress designer depicted by a girl, 'making a dress' in the pre-intervention survey

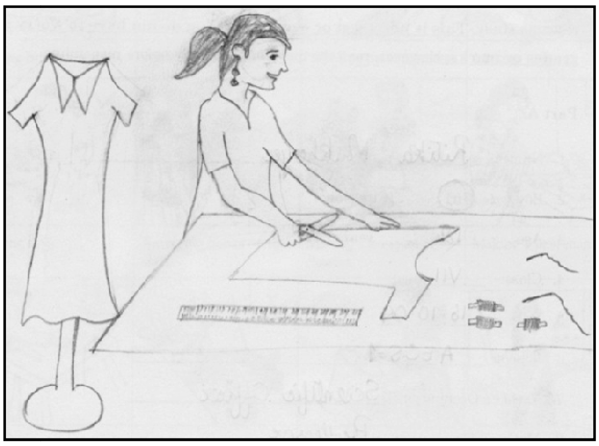


Figure 6.6: The same girl depicted a female dress designer 'designing the dress' in the post-intervention survey

There were also 5 students in the pre-intervention survey, among whom 1 depicted a performer, 2 depicted painters or artists (Figure 6.3) and 2 depicted fashion models. None of these professions were depicted in the post-intervention phase.

6.4 Summary of analysis of pre-post-intervention surveys

The purpose of the comparison of the pre- and post-survey results was to assess the effects of the trials of the design activities. The pre-post-intervention surveys results indicate that students in the post-intervention survey associated design with planning, making or inventing for a cause or a useful purpose and less with artistic endeavour. Students' engagement in the design activities especially the design and make activities seem to have influenced students' perception of design as a goal directed and purposeful activity.

The nature of reasoning in the post-intervention survey as well as the interviews reflected students' improved and better understanding of design. Students' suggestion of the Indian words for design in the post-intervention survey also indicates an increased association of design with words such as creation, plan and making and less so with art and paintings.

Students' responses to the school subjects' association with design in the post-intervention survey as well as the interviews indicate students' association of design also with planning.

Subjects such as music, library management, drama, cooking and gardening which were rated as non-designerly by most students in the pre-intervention survey, were rated as designerly by more than half of them in the post-intervention survey.

Students' responses to the structured questions and their probing in the interviews revealed that students now believed design to be associated with a purpose and the purpose is to either improve things or bring order into something.

Students also recognized sketching and modelling and ideation as important aspects of design (as evident from their drawings of designers). However, some sex-role stereotypes were still found to exist despite the intervention. Students' engagement with the design activities did seem to affect their ideas and associations of design.

The analysis thus revealed that students' ideas in the post intervention survey reflected teachers' and designers ideas on design and suggests that the intervention did lead to some improvements in their ideas of design and designers.

Chapter 7

CONCLUSIONS AND DISCUSSION

'...the only way to change people is to create the conditions for them to change themselves'

Clarke (1999, p. 169)

7.1 Introduction

The aim of the research study described in this thesis is four fold: 1) To study elementary and middle school students', teachers' and designers' ideas about and attitude toward design and designers; 2) To develop design-based activities through trials among urban middle school students; 3) To assess the influence of design-based activities on middle school students' ideas about design and designers and 4) To analyse aspects of structure-function relation of artefacts, creativity and design decision skills in students' responses to the design-based activities. This chapter concludes by presenting the contribution to scholarship resulting from this research. The major conclusions arising from the study are then discussed in line with the research objectives framed. Additionally, limitations of the study are documented and implications are drawn for design in general education based on the findings from this study. The chapter closes by suggesting directions for future research.

7.2 Contribution to scholarship

The following thesis provides two major contributions to the research scholarship: theoretical and methodical. Each of these has been discussed here.

7.2.1 Theoretical contribution

The present study provides theoretical contribution in two broad ways. Firstly, as mentioned in Chapter 1 (Section 2.4) a review of literature indicates a lack of studies in students' and teachers' ideas and perception of technology. Studies on students' and teachers' ideas of design are even rarer. Only a very few studies have explored students' and teachers' ideas of design. The present study, to the best of our knowledge is novel since there have been no research attempts on comparing students', teachers' and designers' ideas of design. This study provides a rich documentation of the commonalities and the points of overlap among students', teachers' and designers' understanding of design. The study thus provides valuable insights into the design education literature.

The second way in which this research makes a theoretical contribution to the body of knowledge is related to the first one. While D&T education is a compulsory school subject in most countries throughout the world, Indian school curriculum neither includes design nor technology education. The present study explores Indian school students' and teachers' spontaneous and unschooled ideas of and attitude towards design and designers. This topic was considered worthy of study given the lack of D&T in Indian schools.While literature provides evidence of a few studies which has explored students' ideas of design, these studies are limited to students and teachers already having D&T education in their curriculum. The present study thus contributes to the existing body of D&T education research by documenting students' and teachers' unschooled ideas of and attitudes towards design.

7.2.2 Methodical contribution

The second major contribution of this research lies in the methods adopted in the study. This research makes use of mixed methods for collecting, analysing and interpreting the data in the study. Students' ideas of design were investigated through the means of written and drawn responses and these were supported by students' responses in the interviews. Teachers' ideas were probed through questionnaire while designers were interviewed in detail, of their ideas of design. The use of mixed methods design provides a depth and breadth of students', teachers' and designers' ideas of design which could not have been possible using quantitative research methods in isolation. The written, drawn and interviewed responses from the students also helped in establishing an internal validity of the study. Also, the use of the similar (but not the same) instrument for gathering students', teachers' and designers' ideas were found to be purposeful since it enabled a comparison of their ideas.

7.3 Summary of major findings

The findings from this research study have been organised keeping in line with the research objectives. Thus the findings are summarised under the following headings:

- Findings from students’, teachers’ and designers’ ideas of design;
- Development and trials of the design activities;
- Insights from the analyses of the cognitive aspects of design activities; and
- Insights from the impact of design activities on students’ ideas about design;

7.3.1 Findings from students’, teachers’ and designers’ ideas of design

The survey provided useful insights into Indian students’, teachers’ and designers’ ideas of design. The study sought to reveal ideas of design among students and teachers who had no experience in formal design or technology education. It is thus presumed that their ideas of design would be spontaneous and influenced by factors, other than schools such as media, peers, parents and colleagues. The rationale for studying students’ ideas of design was based on the constructive perspective of teaching and learning, which acknowledges learners’ prior conceptions before planning a lesson or a curriculum. The basis for studying teachers’ ideas of and attitude towards design rests on the assumption that teachers’ attitude on any subject has great influence on their own thinking and teaching practices. It is the teacher who organise the learning experiences of their students and thus have a direct influence on their concepts, views and attitudes (de Vries, 2005). Designers’ ideas of design served as a yardstick and enabled contextualization of students’ and teachers’ ideas of design and designers.

The survey involved selecting the sample, strategy to draw the sample, development of the questionnaire for each sample, its administration and analysis of the responses. Four different questionnaires were developed, one each for: Elementary class students (Classes 5 and 6); Middle school students (Classes 7-9); Teachers and Designers (Post Doctoral design students). The survey with students was conducted in two phases: pilot and the final. The pilot study was conducted with 25 students from Class 7 while the final survey was conducted with 511 students from classes 5-9. In addition, another sample of 22 students (Classes 7, 8 and 9) were interviewed using the same final questionnaire. A sample of 34 teachers (27 females, 7 males) was drawn from a College of Education in Mumbai while 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.

7.3.1.1 Students’ spontaneous ideas about design and designers

Students’ responses in the survey revealed their strong association of design with art, mostly painting on canvases, decorations or pattern-making. Even the examples of designed products, produced by students seemed to suggest their emphasis on aesthetics and appearances of products. Students also associated design with drawing, making, planning or inventing and few with ideating. Younger students in the sample produced simpler views about design mostly related to painting or making something. On the other hand, older students held a more varied understanding of design, such as design as making, planning or drawing to show how things are made, ideating or shapes of things. Students’ responses also show a portrayal of spontaneous positive attitude towards design and design learning.

The most commonly cited designers by students in their spontaneous responses writing were fashion designers especially by the middle school students. All students provided examples of dresses, buildings and cars as things that are designed by designers. If one compares this study with research studies on students’ perception of technology, the differences are very obvious. Studies on students’ perception of technology indicate that students mostly associate technology with computers, electronic gadgets and electrical appliances ((Jarvis and Rennie, 1998; Khunyakari et al., 2009; Mehrotra et al., 2007; de Klerk Wolters, 1989). However in study reported in this thesis, students did not indicate any ‘technological’ objects such as computers, electrical appliances or machines as examples of designed products anywhere in their spontaneous responses. Instead their examples pertained to dresses and clothing. Thus it can be said that these students did not connect design with technology or engineering but actually seemed to associate design with art or fashion. It further reflects their narrow view of design as only artistic design.

Only a few students invoked two steps of the designing process (i.e., planning and making, or ideation and making in their spontaneous responses. This was evident only in middle school students' responses and not among the younger students.

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 Indian words suggested by designers were closest to the meaning of design in English.

Students did spontaneously suggest certain skills as associated with designers such as creativity, imagination, having ideas, talent in design.

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' responses.

7.3.1.2 Teachers' spontaneous ideas about design

Like students, majority of teachers' ideas were also related to art or artistic expressions, mostly paintings and decorations. The responses of teachers indicate that they strongly associated design with 'planning'. However, by planning, these teachers mostly suggested a more general planning process rather than a plan intended before making an artefact. Thus interestingly, unlike students, none of the teachers mentioned 'planning before making' or 'drawing to make something' as design suggesting their ideas to be more aligned with design of the intangibles and planning in general.

Teachers also suggested skills of designers. However they restricted themselves to suggesting only two skills, creativity and imagination as associated with designers. Most teachers associated design very strongly with their own profession of teaching and mostly cited examples of lesson plans or curriculum and even fate of students as things designed by teachers. Unlike students, none of the teachers cited fashion designers as examples of design professionals, although they did give examples of dress as things that are designed.

Teachers mostly accentuated the ideation phase of designing. Teachers mostly emphasized, 'coming up with different ideas' as an essential feature of design. However none of the teachers attempted to elaborate on how those ideas could be developed through testing and evaluation.

While considering designing by animals most teachers agreed that animals could design and also cited examples of the home-making activities of birds. Interestingly teachers' ideas of designing by animals pertained to their making of tangible homes, but in case of humans teachers emphasized 'coming up with ideas' and planning as essential aspects of designing.

7.3.1.3 Designers' spontaneous ideas about design

Unlike students and teachers who emphasized on the surface features of designed products, designers had a deep and rich understanding of design. Considering design fundamentally as human-centric all the designers believed design was done to serve a purpose. Each designer emphasized on one or the other significant aspects of design. Thus while the user interface designer primarily focused on the environment and suggested a holistic approach to designing products and systems, the product designer emphasized on the relationship between the designed product and its context of use. Designers suggested a repertoire of specific skills very different from what students and teachers suggested, namely, being open to perceptions, skills in observation, multidisciplinary, visualization skill, intuition etc.

7.3.1.4 Students', teachers' and designers' responses to structured questions

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.

A. Schools subjects, activities and design

Students' responses to the association of co-curricular school subjects and specific activities (represented through pictures, the pictorial activity in Section D of the questionnaire) with design revealed that subjects and activities which involved a sketching, making of a tangible product, giving shape to a product, rendering aesthetic appeal to it were considered designerly activities. However, co-curricular subjects and activities which required a planning approach and creation of intangibles were considered non-designerly by students. For example, subjects such as library management, music, drama gardening were considered non-designerly. Again from the pictorial activities in Section D, activities such as arranging books on shelf, teaching and cooking were considered less designerly by students. Teachers did not show any specific association of design with these subjects or activities. They marked most of the subjects and activities as designerly. Designers on the other hand suggested approach to each of the subject or the activities as important for considering them as designerly. According to the designers, any activity can turn into a designing activity once it is set within a context and posed as a problematic situation.

B. Design and stereotypes

Responses to the structured question also revealed students' sex-role stereotypes for certain professions such as cooking, teaching jewellery designing, fashion designing, tailoring and interior designing. Teachers and designers did not reflect any sex-role stereotypes for any occupations.

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.

An understanding of the role of modelling and testing as a part of design practice is fundamental to design thinking. However, this was never emphasized in either of the students' or teachers' responses. Although students did attempt to depict some form of testing or evaluation of design in their drawings, these were all strikingly related to the field of fashion designing. This idea of testing of dresses perhaps stems from the customary practice of trying out an outfit once it is stitched by a tailor. Even teachers were not found to report any ideas on testing or evaluating the lesson plans or activities that they often cited as designed products.

Designing was essentially associated more with art than with engineering by both students and teachers. Designers can be considered as artists to the extent that they bring their sense of aesthetics into their design but designing is much more than mere aesthetics and decoration. According to Owen (2005), design is not art. It also is neither engineering nor science and a student must be made aware of the distinctions among them. The findings of the study reveal that Indian middle school students have a lopsided nature of students' understanding of design since they associated the work of designers more with artistic design than with the technological or engineering ones. Owen (2005) suggests that the perceived similarity between a designer and an artist stems from their common use of the visual media to communicate ideas. However, their fundamental methods, results and goals are quite different.

The survey revealed that designers held a more rich and sophisticated understanding of design. In order that our students and teachers share those views we need to engage students in designerly activities. As suggested by the designers in the survey and also emphasized by educators (Hennessy and McCormick, 2002; Hennessy and McCormick, 1994; McCormick, Hennessy and Murphy, 1993), providing authentic contexts to an activity will provide avenues for problem-solving and designerly behaviours among students.

Both teachers and designers in the survey showed a positive attitude towards inclusion of design education in the general school curriculum. Although teachers emphasized that design would foster creative thinking among students, they were unable to identify what differentiated design education from other subjects in the curriculum and how it could be introduced into the curriculum. Designers on the other hand, holding a generalist view on design, suggested a holistic approach to the design integration in schools.

7.3.1.5 Students' responses to 'Draw a designer at work'

Students' understanding of design as art also gets expressed in their drawings of designers where most students (mostly younger students) depicted artists painting landscapes or engaged in some artistic work. Students' ascription of gender and professional stereotypes to design also gets reflected in their drawing of designers where many older students depicted fashion designers. 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.

Like in their writings, in their drawings too, students primarily conceptualized a designer as a fashion designer or an artist. Other professionals depicted were architects, engineers and a few labourers and scientists. Older students also depicted models as the clients of most fashion designers while more of younger students strongly seemed to conflate artists such as painters with designers.

It is to be noted that in research studies where students are asked to depict engineers, most of them depicted machines, vehicles, engines, buildings or robots (Fralick, Kearn, Thompson and Lyons, 2009; Knight and Cunningham, 2004; Karatas, Micklos and Bodner, 2010; Capobianco, Diefes-Dux, Mena and Weller, 2011; Oware, Capobianco and Diefes-Dux, 2007). However, when asked to depict designers, students mostly depicted things associated to art, fashion and decoration such as dresses, paintings and less buildings and cars. Thus students' writings and drawings both were thus indicatives of their association of design with art and fashion and less so with engineering or technology.

A large number of students depicting dress/ fashion designers could also be the influence of the 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 in a conversation between a customer and tailor in India. Thus it could be an influence of the colloquial use of the word design. It could also have been due to the prevalence of only a few kinds of designers such as fashion or interior designers in the present day commercial media mostly televisions, hoardings and magazines. In these media, there seem to be an association of fashion designers with glamour and the film industry. No wonder adolescent students form a strong link between design and fashion. Even Owen (2005) suggests that there is confusion among the general public about the nature of design due to the extensive use of the word 'design' to mean fashion. While fashion designers are stylists mostly concerned with the aesthetics without much regard to functionality, performance or human factors, other design professionals do not deal with aesthetics exclusively. Perhaps this leads to the strong association of design with beautification or aesthetics among the general public.

Among the designerly activities depicted by students, sketching was the most predominant one shown. However the act of sketching was shown more by older students than the younger ones, suggesting that older students have started to develop ideas of the nature of design. Even though planning was nowhere mentioned in almost all the descriptions of students' drawings (except a few), at least a few older students seem to have an idea of the nature of work that designers engage in; quietly seated at a desk and sketching. Very few students, however, mentioned the work of designers as planning or modelling. Only 4 students depicted signs of thinking such as a bubble to depict a thinking activity in their drawings. The fact that designers work with clients and customers was depicted in some drawings. However, that a designer works with the 'maker' was depicted in only a few of the drawings. Also none of the designers were shown to work in teams. Designing was mostly viewed as a solitary act by most students. Just as in the written responses where very few students invoked more than one step of the designing process, namely ideation and making/modelling, even in their drawings few students showed evidence of more than one step of designing process by depicting both 'process' products (such as blueprints, sketches) and 'designed' products (finished products).

An aspect about designer's work that got revealed only in students' writings but not in their writings was the *location* where a designer worked. It is important to note that while the general perception of the activities of science is usually restricted to the laboratories (Mead and Metraux, 1957; Chambers, 1983; Chunawala and Ladage, 1998; Fralick, Kearn, Thompson and Lyons 2009), those of mathematicians to classrooms (Picker and Berry, 2000) and engineers to factories (Cunningham, Lachapelle and Lindgren-Streicher, 2005), designing seems to be perceived both as a professional and as well as an everyday activity. Students' indication of the designer's location as office indicate that they perceived design to be a professional and 'white-collared' job in contrast to the 'blue-collared' job mostly assigned to engineers in other research studies where engineers are often shown as labourers fixing machines and engines and working outdoors (Fralick, Kearn, Thompson and Lyons, 2009; Karatas, Micklos and Bodner, 2010). Again students' indication of designers' location at home seemed to suggest that many students considered designing as an everyday act that can be pursued even at home. However, the activity depicted as being pursued at home mostly involved artistic work, such as painting, decoration, mostly depicted to be undertaken by females. Designing as students understand, is also reflected in the work of people around them such as a homemaker, a tailor, an artist, and even labourers and construction workers. On the one hand, though this perception is fruitful, since students consider designing activity as something which is accessible and done by all. On the other hand, it restricts their perception about design as something which is trivial, commonplace and rendered superficial.

Again while a scientist is represented as an eccentric male wearing a laboratory coat, designers were shown dressed neatly and often trendily. About 40% students depicted female designers. It seemed that with the increase in students' age, there were fewer stereotypes with respect to the gender of the designer. While we can say that the stereotypes with respect to gender of designer is decreasing with age with increasing number of older students depicting female designers, the students seem to be forming a stereotype that designing is a female profession. The profession of design seemed to be associated with a lucrative, hobby-like soft skilled profession that students assumed are pursued or done mostly be females.

Student's ideas and images of any profession and their practicing professionals are very important since students' perceptions of professions are closely related to the choice of their careers (Knight and Cunningham, 2004) and images of those occupations (Gottfredson in Glick, Wilk and Perreault, 1995). Thus in this stage perceptions about different professions might play an important role in making appropriate decisions. If students believe that most designers are artists or fashion/dress designers or women who should be well dressed/groomed or beautiful to look at, and that designing involves soft skills such as decorating or making things attractive then certain groups of students (those academically and scientifically inclined) are less likely to consider design as important for their career.

The scientifically and technologically advanced world demands citizens who are not only scientifically literate but also technologically sound; citizens who have the ability to look for problems in society and design solutions for them as well as citizens who look beyond the superficial appearance of products that they would purchase and use. If students consider design as something artistic, it would be difficult for them even to evaluate their everyday products on design grounds. They would face difficulty in engaging in authentic design activities, wherein they need to work in teams, recognize problems, identify and implement possible solutions, work within constraints, construct models and evaluate their solutions. Thus understanding the nature of design and the way in which designers work will assist students in participating to future design developments and discussions, as well as make use of designed products and appraisal in a critical way.

7.3.2 Development and trials of the design activities

The development and trials of the design activities for Indian middle school students, described in this study occurred through three separate interventions. A review of literature reveals that pedagogically sound design tasks involve authentic, hands-on tasks; use familiar and easy-to-work materials; possess clearly defined outcomes that allow for multiple solutions; promote student-centred, collaborative work and higher order thinking; allow for multiple design iterations to improve the product; and have clear links to a limited number of science and engineering concepts (Crismond, 2001). Thus based on the review of literature and our own understanding of the Indian middle school students' ideas about design, a number of design activities were developed for the students. The aim of these activities was to provide students opportunity to engage in the design activities thereby facilitating them through an experiential understanding of design as a problem-solving activity.

The design activities were developed keeping the four roles view of Robert's model and also developing our own framework of progressing from the domain of familiarity and maximum certainty to a domain of unfamiliarity and least certainty with an evolution in the understanding of design. The initial exposure to design thus started with handling of familiar artefacts by students (involving maximum familiarity and certainty) followed by handling of unfamiliar artefacts (involving unfamiliarity and uncertainty to an extent) and finally designing and making (involving minimum familiarity and certainty). This model was used as a vehicle for creating appropriate and effective design tasks in the present study.

In the Robert's model, each of the roles was identified with the design activities developed for the students. The role of the User was identified with 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 modelling, respectively. The role of the Observer and Designer was identified with the activity of actually coming up with real world problems that could be resolved by creating artefacts.

Thus the themes and contents of the tasks were selected, formulated and coordinated to meet the learning goals which were embedded in the tasks. The tasks were developed over two trials: a pilot trial and a final trial and an intermediate activity trial consisting of the testing of only one design activity. Both the pilot and the final trials were in the form of workshops continuing for a week and more than a week respectively. The pilot trial consisted of the following sequence of activities:

- Handling and analyzing a few familiar artefacts,
- Reviewing the history of a familiar artefact,
- Handling unfamiliar artefacts, exploring and identifying them, and
- Designing an artefacts

The final trial consisted of the following sequence of the design tasks:

- Handling and analyzing familiar artefacts,
- Reviewing the history of the familiar artefact,
- Handling unfamiliar artefacts, exploring and identifying them
- Designing an artefact based on a given real world design problem
- Making artefacts and lastly
- Problem posing or looking for real world design problems in society

7.3.2.1 Trials of the design activities

The first workshop or Workshop 1 (WS1) was a pilot trial of the design activities with 25 students of Class 7 while the second workshop or Workshop 2 (WS2) was the final trial of activities with 14 students from Class 7. The Activity trial or the intermediate trial was carried out with 6 students of Class 8. The pilot study (WS1) was conducted to provide a preliminary evaluation of the workshop approach, format, activities, and measures. Both WS1 and WS2 involved a 'one-group pre-post-intervention' research design having the following three phases: survey of middle school students' ideas of design and designers, trials of specific design-related activities and studying the impact of design-related activities on students' understanding of design and designers.

The activities were developed around the idea of design as an iterative problem-solving and decision-making process. Gaining insights from the literature, the activities acknowledged students' own understanding of design and provided them opportunities to work collaboratively towards a common goal, reflect on their work through gender-neutral and authentic tasks.

The design activities generated semi-structured and unstructured collective responses to questionnaires, drawings, design proposal drawings, redesign proposal drawings, oral presentations, finished products and researchers' written records of the classroom interactions, audio and video recordings of interview responses classroom interactions and transcribed responses. These were then subjected to analyses using appropriate analytical frameworks.

7.3.3 Insights from the analyses of the cognitive aspects of design activities

The broad objectives for analyzing the design activities were set forth in the form of various research questions and the frameworks for analyzing the activities. Aspects such as structure-function relations of artefacts, students' creativity, evaluating strategies and their design-decision-making skills were the main emphases of the analysis.

7.3.3.1 Framework used for analysing the responses in the activities

Several frameworks were utilized from the literature to analyse students' responses to the design activities. Responses to the handling of artefact tasks were mostly analysed based on the Dual nature of technical artefacts proposed by Kroes and Meijers (2006) and Gibson's theory of affordances and actions. Creativity and design decisions in students' solutions were analyzed using three analytical frameworks from literature. The first one is the NACCCE (1999) features of creativity which defines creativity in terms of four characteristics: using imagination, pursuing purposes, being original and judging value. Students' design decisions skills were analysed using Barlex and Rutland's model of design decision pentagon which suggests that students mainly take at least five kinds of decisions, namely conceptual, technical, aesthetic, constructional and marketing. Additionally a few criteria such as elements of feasibility, use of scientific and technological concepts evident in students' designed solutions , as proposed by Barlex and Trebell (2007) were also used to analyse students' designed solutions.

7.3.4 Analysis of responses to the design activities

7.3.4.1 Structures and functions of artefacts

Students' handling of the familiar artefacts reveal students' lack of understanding of the functions and importance of several key features of design. Also while they were familiar with the overall function of the artefacts, specifics were absent from their responses. Students presented a superficial understanding of the functions of the different parts of familiar artefacts. Often the obvious function of the familiar artefact was considered, and no further thinking was thought to be necessary. However it is believed that given sufficient time and providing sufficient scaffolding at appropriate places, students can get benefit immensely.

Students' activities with the unfamiliar artefacts revealed that students used cognitive and handling strategies while exploring them. Accidental functions for the artefacts were suggested by all. However, successful groups later rejected those accidental functions. The accidental functions listed by students were typically related to their daily activities. Most students often probed the artefacts with whatever was available with them at the time, such as finger, pen, pencil, handkerchief and paper. 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.

However the analysis also revealed that not all students could make appropriate connections between the structure and functions of artefacts. The accidental functions suggested by students indicate their lack of understanding of the structure and functional relations in a designed artefact. Students related the functions of the unfamiliar artefacts with those that were familiar with without acknowledging the immediate structure of the artefacts available before them, thereby coming up with functions which were trivial and inappropriate.

A designer's responsibility does not end with the creation of artefacts alone, but she has to determine the kinds of uses that her designed products might be put to use once it is in the hands of a user. Thus from a designer's perspective it is important to look at an artefact closely and try to distinguish as many structures and functions as one can.

7.3.4.2 Testing and evaluation of artefacts

Students tested their predictions through actions and these were found to be particularly useful for students both in the identification of unfamiliar artefacts and also effectiveness of an artefact for a particular use. While studying students' (ages 5-14 years) ideas about how to test structural strength (in the pictures of two bridges), Gustafson et al. (2000) found at least 5 categories of responses but did not find any sequential stages of understanding 'fair' testing through which children progress. They suggest that children, in fact, may show many unanticipated routes to arriving at a full understanding of 'fair' testing. Students in the present study checked their predictions about the effectiveness of different pairs of tongs in lifting different kinds of utensils and demonstrated a range of strategies varying from the most 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). Students evaluated pairs of tongs using a variety of criteria for evaluation, such as functional efficiency, multi-functionality and ergonomics.

7.3.4.3 Design decision skills of students

Students were provided with several opportunities to make design decisions in several tasks. In the familiar task with ball-point pen in WS2, students suggested redesign proposals from a user's point of view. Most decisions were made to improve functionality of the pen. Students also made ergonomics decisions to improve the quality of the pen. Interesting additions such as light and whitener or eraser were also suggested by a few students.

While redesigning pairs of tongs in the Activity trial, students integrated the ideas generated during the evaluation phase and using their experience and insights gained through the testing of the tongs, they redesigned their selected pairs of tongs by assuming the user's point of view. As improvements, students either suggested *addition of a new component* or *modification* in their redesigns. Like the students in the pen task, these students in the tongs task mainly focused on achieving *functional efficiency* and providing better *ergonomics* to users while using the tongs.

A related finding from this task was that students tended to adopt a *linear redesign process* (non-iterative) by proposing their redesign ideas around their selected best design. Hence while redesigning a pair of tongs, they tried to incorporate in it the components which were present in their selected best tongs, thus making the redesigned tongs very similar to their selected best pair of tongs. Redesign activities however, provided opportunities for students to critically select features in the products that could be improved.

The analysis of the decisions made during the activities of *design-without-make* and *design-with-make* suggest that all students in the latter task showed clear evidence of making conceptual decision by suggesting what their designs will do. An important distinction between the conceptual decisions made in the design-with-make and design-without-make activities was regarding the lifting of a metallic needle. While lifting a metallic needle is easy since it just involves the use of a magnet, lifting a knitting needle from the floor posed challenge to the students. It was observed that none of the designed solutions in design-with-make activity attempted to lift the non-metallic knitting needle. All the students were concerned with lifting the metallic needles and thus made use of magnets in their models. In case of the design-without-make activity, however, many students proposed to pick both the metallic as well as the non-metallic needles from the floor.

Students' technical decisions were concerned with how the design will work. In the design-without-make activity however, students did not indicate clearly how their design would work. Students in the *design-without-make* activity showed little evidence of using aesthetic decisions in their designs. Most of them drew their design from one point of view without indicating how their designs would look from other perspectives. However in contrast, students whose designs were simpler in the *design-with-make* activity showed their designs from different perspectives. The aesthetic decisions were very much evident in their modeled solutions with decorations done using glazing or coloured papers, beads. The evidence of constructional decisions were quite prominent in the design-with-make activity wherein students suggested ways of in which their design will be put together using easily available materials. In contrast, students in the design-without-make activity came up with elaborate and ambitious design ideas and were thus unable to make any constructional decisions in their designs. Based on the materials used in their proposed designs, and the cost of making it, students made marketing decisions and decided on the price of their designs. However, some students in the design-without-make activity used new and sophisticated technologies and since they were not aware of their costs, they came up with exorbitant prices for their designed products.

7.3.4.4 Creativity in students' designs

The comparison of the solutions from *design-without-make* and *design-with-make* activities revealed that students not constrained with the making of their designs, showed more evidences of creativity and risk taking than students constrained with making their designs. The design-without-make students also came up with more number of and a variety of design ideas in contrast to the design-with-make students. Besides, design-without make activities provided opportunities to students to incorporate latest scientific and technological concepts in their designs.

Detailed analysis of students' designs in both the activities and designs and models in design-without activity in terms of NACCCE (1999) report, revealed that although both the activities students showed evidences of using imagination through their design drawings, the design drawings of design-with-make students were clearer compared to those of students in design-without-make activity. The design drawings of students in design-with-make activity were very simple and so students showed their designs from different perspectives suggesting that they could mentally visualize the product. In contrast, the design drawings of the students in design-without-make activity depicted complex design drawings and did not use different perspective while drawing their designs.

Students in both the activities pursued the purpose of lifting needles from the floor. However, as mentioned above in the conceptual decisions taken by students, design-with-make activity students found it challenging to design a product that could lift a non-metallic needles. Thus constrained with the making of their designs, all the students in the design-with-make activity designed their products with an aim to lift only the metallic needles by making use of magnets in their designs. Students in the design-without make activity came up with creative and varied solutions to pursue the purpose of lifting needles and considered both the metallic as well as the non-metallic ones.

Since the design problem posed to the students in both the activities were unique and students were with any artefact that can lift fallen needles, all their designed solutions could therefore be regarded as original. However, an important difference between the designed solutions of design-without-make and design-with-make activities was that while the solutions of students in the former activity varied from simple to complex designs and were unique and different from each other, the designs of students in the latter activity were very similar to each other, since all of them made use of an elongated stick/tube/telescopic rod, at one end of which was attached a powerful magnet.

Students in both the activities aimed to improve people's quality of life and enhanced the quality of their designs by increasing the possible uses of their artefacts.

Risk-taking behavior was thus seen in students' solutions in the *design-without-make* activity wherein they made use of scientific principles and new technological innovations. However, *design-with-make* activity provided opportunities to students to recreate the whole design process, from identification of a need, to creating a brief and a specification, then generating ideas, developing them, modelling them, and finally producing a working product. While making the models of their proposed design students got the opportunities to explore materials and develop skills in designing. This makes us suggest that the two activities should be complementary and not substitutes of each other.

Students evaluated their own and peers' designs by generating their own evaluative criteria (design-without-make activity) or through researcher-provided criteria (design-with-make activity). In a design-without-make activity, groups questioned usually evaluated their peers' design ideas on 'suitability for purpose'. However, none of them evaluated their own and peers' ideas on feasibility and make-ability. In the design-with-make activity, since the criteria were provided by researcher, students evaluated their own designs and their peers' based on those criteria. Students were found to rate their own design and working models more than the others.

Students' creativity were also expressed when they identified real world problem around them and designed their own briefs addressing the challenges posed in the design problem. It was found that the problems posed by students were usually related to their known and familiar contexts.

The activities thus provided students to shift from one perspective to another. At times they were provided opportunities to behave as users and observe, handle and evaluate a given artefact. At another time they assumed the role of designers, where they actually designed products, while still at other times, students were given opportunity to make what they had designed. Thus a progression from a user to a designer to a maker facilitated students through experiential learning of design.

7.3.5 Insights from the impact of design activities on students' ideas about design

Students' responses from the pre- and post-intervention surveys were compared to assess the effects of the trials of the design activities on their ideas of and attitude towards design. The survey results indicate 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 endeavour. A decreasing association of design with art was reflected in a number of spontaneous responses generated by students in the post-intervention surveys. For example students' spontaneous ideas for design showed a marked decrease in design associated words such as art, paintings, decoration and patterns. Students' generated Indian words for design also demonstrated students' increased association of design with planning, creation and making and less with 'kala' or art in Indian terminology.

The analysis of students' drawings of designers in the post-intervention survey, indicates that students recognized sketching and modelling and ideation as important aspects of design.

Students' engagement in the design activities especially the design and make activities seem to have influenced students' perception of design as a goal directed, purposeful, problem seeking and problem-solving activity. This is evident in students' responses to the structured questions. For example, there was a marked increase in the post-intervention survey, in the number of students who agreed that *'Designers get their ideas by observing people'*, *'Designers solve real world problems'*. This finding is confirmed with students' response to the skill associated with designers which showed a marked increase students' selections of the skills 'observe people' and 'solve problems'.

The nature of reasoning in the post-intervention survey as well as the interviews reflected students' improved and better understanding of design. Some sex-role stereotypes were still found to exist despite the intervention. Students' engagement with the design activities did seem to affect their ideas and associations of design.

7.3.6 Limitation

The limitations that were identified in this study were:

- 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.
- 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.
- Only 5 design students were interviewed due to availability issues. Future research may attempt to study a larger sample of designers. Attempt to make a comparison across different design disciplines would also be insightful.
- The design activities were carried out with only 14 students who voluntarily participated in the workshop. 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.

- Another limitation of the study is the choice of artefacts used in the different activity trials. Selecting an appropriate artefact for a design activity is a challenging task. The choice of the artefacts was dependent on several factors such as the learning goals of the design activities, students' familiarity with the artefacts, their availabilities etc. Although a varied gamut of artefacts is available, attempts were made to select the artefacts that would serve the different purposes in hand. An interesting extension of this study could be the trials and exploration of different products other than those used in this study. Repeating this study with other products would be valuable.

7.3.7 Implications and future directions

Design and Technology education has not been a priority within the Indian schooling system. While design or technology education has been introduced as a compulsory subject in many countries across the globe, Indian schools stills lacks this subject. Based on the findings of this study, the following recommendations and implications are suggested. It is believed that the findings of this study have possible implications for researchers, practitioners and curriculum developers.

7.3.7.1 Implications for researchers

As stated earlier, this study is novel in being the first to document Indian students' ideas of attitude to design and makes a comparative analysis of students', teachers and designers' ideas of design. Thus this study holds possible implications for researchers interested in exploring students', teachers and designers ideas and perception of design and designers. This study was conducted with students from urban schools, who had access to enriched learning experiences and resources available at school. Future researchers might want to consider conducting this study with students with similar or different demography. The study with student from similar demography as in the present study may aim to see if the same or similar results are found, while a study with a different demography could explore whether there are any differences between students ideas about design and designers.

The data from the study did not rely only on students' written responses, but devised various methods of exploring students' ideas of design and designers. The Draw-an Engineer- Test (DAET) was adapted to the Draw-a- Designer-Test in the present study. It proved to be a useful tool in understanding students' perceptions of designers at work. Besides, the study also relied on students' responses from the interviews. The interviews served at least three purposes. Firstly it provided opportunities to learn about students' understanding of design in detail through their justifications and reasons for their responses. It thus provided a holistic picture of students' ideas about design and designers. Secondly, it served to compensate for the limitations and biases if any, in the questionnaire. Thirdly it helped in triangulating the data thereby facilitating validation of the data. Using drawing or written responses alone can be limiting, as it only seeks to obtain information through either writing or drawings. Enabling students to have a voice through interviews in this research study provided depth and breadth to the information provided by students. Future research may want to employ a similar approach.

7.3.7.2 Implications for practitioners and curriculum developers

This study revealed some interesting findings about students' ideas of design and designers that could be of interest to those associated with the development and implementation of curriculum materials and policy documents. Majority of the students at the study school expressed a positive attitude towards design and designers but associated design more with decorative practices. Students in this study demonstrated a gender and professional stereotypes in their drawings as well as in their writings, by depicting more number of female dress designers. These stereotypes seem to grow progressively with age with older students depicting more female dress designers. This state is alarming and raises some important issues for curriculum developers. The findings of the study indicate that many students held stereotypes that designers were mostly artists, dress or fashion designers and mostly women. They tended to underscore and trivialises the activity of designing to a hobby-like, effortless and perhaps a mindless activity that can be pursued without any formal training or practice.

This perception about design and designers might drift academically-inclined students away from design since they might perceive it as not being worthy enough to be pursued. Educating these students that designing is not just about decoration or a mindless activity, may lead more students to consider design as an option of study for their careers. This can only happen if design is integrated at the school level. However, one should be cautious while implementing design in schools. The aim of design education thus, 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 (Heskett, 2002).

An important finding from this study and other studies on image perception reveal that students form stereotypes of professions quite early in their lives. Chambers (1983) noted that by the end of elementary schooling, children have already formed a stereotypic image of a scientist while Newton and Newton (1998) observed that these perceptions remain constant and resistant to change even despite changes in the curriculum. Even in the present study it was found that younger students have just begun to form a stereotypic image of a designer as a female fashion designer. Thus it implies that intervention needs to begin quite early in students’ lives if we do not desire our students to develop stereotypes about design and designers. This has also been echoed by Stables (1997) who suggests that educators need to take control over the experiences of children and attempt to provide equity in opportuinities as early as possible. Wright (1999) also emphasizes that understanding technological environment and its social and environmental impacts and consequences should start as soon as students begin attending school.

Curriculum developers may also find this study relevant while designing technology or design curriculum for Indian students. In the light of this study they can try to organise the curriculum materials around the prior ideas of students and teachers about design and designers. The study also attempted to develop appropriate design based activities for Indian middle school students. They can thus emulate the studies and plan activities or workshops which have the potential for broadening students' concepts of design.

Curriculum developers can also get insight into teachers’ ideas of design and their attitude towards it, thereby leading to teachers’ professional development in design and technology education. Teachers or practitioners willing to pursue teaching design and technology education in schools can get insight into students' ideas of design and their creative potentials. They can organise their lesson plans based in the light of this study. An important finding of this study was teachers' willingness to both teach and learn design. Teachers recognized the importance of design as a process in their own planning of lessons and activities for students. This finding should be accounted for in the professional development of teachers. Small workshops, short terms courses or even projects on design can be incorporated in the teachers' professional development which might offer them insights into their own teaching practices and thereby facilitate a growth in their profession. Also this might provide an avenue for Indian teachers to develop as design and technology teachers, who anyway are required in the present education system.

The range of design activities developed for middle school students has implications in general education as well. All education systems have their own problems. The Indian system of education also has several problems. Firstly the lessons taught in schools seem to be detached from real life issues and concerns (Menon, 2005). Students find these lessons meaningless as they do not find any purpose in doing them. The consequence is that students memorise the content to meet the needs of the examinations. Based on the insights from this study it is recommended that school classroom activities be more concerned with real life situations. Both hands-on and minds-on activities should be set in real life contexts which would enable students to gain an ownership on the activities and make learning more meaningful and effective. Design problems which match the real world problems sustain the interests of students and allow for authentic learning since students manipulate or work with real data and thus make personal meaning of the entire situations.

Besides, the education system in India emphasizes compartmentalization of disciplines with each subject being taught in a respective 'period'. No attempt is made to bridge the gap among them. Design by its very nature is multi and interdisciplinary. This aspect of design provides students opportunities to integrate knowledge, skills and values from several disciplines such as mathematics, sciences, fine art, humanities to bring about a holistic understanding and perspective. Roth (2001) argued that designing activities 'inherently makes available activity structures recommended by constructivist educators' (p. 781). According to him when students develop design ideas, 'the lessons automatically start at developmentally appropriate points for each student' (p. 781). This is very different from what happens in a traditional classroom where the teacher finds it difficult to assess the level of students and thus find out whether a student is ready to learn a new science concept in the classroom. Roth argued that designing activities influenced students' learning of science concepts in many ways. One way was by making their ideas 'inspectable and arguable' (p. 776) by designing and making technologies. The design drawings facilitated communication of students' ideas to their peers and thus open for healthy and constructive criticism which eventually served in making students accountable for their ideas.

Besides a school subject in its own right, design as a process can be integrated in the school curriculum in a holistic way. The aim of this integration is to introduce both teachers and children to purposeful creative activities based on real life experience, thereby making learning meaningful and interesting to students. Barger, Glibert, Poth, and Little (2006) provide an example of such integration. With respect to engineering education, it is not taught as a separate subject in their school, but is instead utilized as an important tool to connect the different subjects taught in school. They believe that this kind of integration works because of the multidisciplinary nature of engineering. Since design itself is multi and interdisciplinary in nature, this approach to design education can also prove beneficial to Indian schools where subjects are taught in isolated manner.

In the Indian school systems, collaborative and group work are mostly discouraged and considered irrelevant. Based on the findings from this study as well as several other studies, it is recommended that Indian schools should encourage collaboration and group work. Students should be given assignments and tasks to work collaboratively in small groups (not more than three or four members). This entails a change not only in the activities designed for collaboration but also in the actual layout of the classroom settings which mostly encourage individualised working arrangement.

Another important implication that entails from this study is that collaboration among students needs to be fostered. As evident from our research, while doing the design activities, students at times were forced to collaborate. This is not surprising since students rarely find opportunities to collaborate in their classrooms. Thus even if the researcher made explicit that students should discuss among themselves before responding, students were not able to make use of this opportunity effectively. The researcher had to intervene to encourage participation by each individual in a group activity. This suggests that students need to be taught how to talk and discuss. This has been echoed by several researchers such as Mercer, Dawes, Wegerif and Sams (2004), Mercer, Wegerif and Dawes (1999), Welch and Barlex (2009). This aspect of effective collaboration in turn has important implications for teacher professional development since it is teachers who need to adopt efficient pedagogy that will enhance the effectiveness of such classroom discussions. According to Mercer et al. (2004) this is especially true for learning and practising science where students are expected to describe observations clearly, reason about causes and effects, pose precise questions, formulate hypotheses, critically examine competing explanations, summarise results etc. Thus in order to advance students' conceptual understanding in science or technology, students' group work should be assisted with proper guidance from teachers.

This thesis has revealed naive ideas held by Indian students and teachers. This thesis also explored the possibilities of changing the naive ideas of students through engagement in appropriate design activities. While the survey of students' ideas revealed that they held stereotypical views of design and designers and considered it to be trivial and relegated it to a status of decoration, students' engagement in the activities provided them opportunities to understand and do design. Students not only got the opportunities to understand and practice design but also got exposed to the flavour of their own creative abilities. The thesis proposes strongly to introduce design or design and technology education in the school curriculum through which a progressive design experience can be developed for students wherein they widen their views of design and use those experiences in responding to ever more design challenges both in their schools and real lives.

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APPENDICES

(All the appendices have been made concise by removing the spaces that were provided in the original questionnaire, where respondents were required to write)

Appendix A

Pilot Survey Questionnaire for Students

Homi Bhabha Centre for Science Education
Tata Institute of Fundamental Research
V. N. Purav Marg, Mankhurd, Mumbai-400088

Note: This is a part of a research study. This is not a test or evaluation. No marks or grades will be given.

Please fill in the details below:

Name: ______________________________

Tick on whichever is applicable for you:

Girl: ☐
Boy: ☐

Class: ________________________________
School: ________________________________
Date: ________________________________

Read the following statements carefully and answer as required

1. **What comes to your mind when you hear the word 'design?' Write as many phrases as you can think of in the following space.**

   ____

____

2. Complete the following sentences.

a. Designing means

____

____

b. A 'designer' is a person who

____

____

3. a. Can animals (besides human) design Yes / No (Circle any one)

b. Gives reasons for your answers

____

____

4. Choose one option which you feel is appropriate.

a. Who among the following do you think can design

i. People who have inborn ability to design
ii. People who have learnt to design
iii. Both of the above
iv. All people can design

b. A well designed product is

i. Attractive to look at
ii. New and innovative
iii. Fit for the purpose for which it was made
iv. Made by suing scientific knowledge

5. State whether you agree or disagree with the following statements. Circle one- either 'agree' or disagree'

a. All artists are designers.	Agree / Disagree
b. Drawing skill is useful in designing.	Agree / Disagree
c. Designing means to draw.	Agree / Disagree
d. Ancient people have designed things.	Agree / Disagree
e. Designers are only found in urban areas.	Agree / Disagree

f. Designers do not solve real world problems.	Agree / Disagree
g. Women are better designers than men.	Agree / Disagree
h. Designers know about materials and their properties.	Agree / Disagree

6. Some people earn a living by designing things. Some jobs are listed below. Tick (✓) those which you think are jobs done by designers.

	Tick here
a. Make new toys	
b. Repair computers	
c. Change layout of rooms	
d. Develop videogames	
e. Create clothing style	
f. Create recipes	
g. Repair furniture	
h. Plan a kitchen garden	
i. Grow and sell crops	
j. Bakes cakes/ breads	

7. There are some things that designers need to be good at. Tick all those items which you think designers need to be good at.

	Tick here
a. Work in a team	
b. Observe people	
c. Sketch ideas	
d. Understand how things work	
e. Work on their own	
f. Plan	
g. Solve problems	

h. Imagine new products	
i. Know about different materials	
j. Communicate with others	

Appendix B

Final Survey Questionnaire for elementary school students

HOMI BHABHA CENTRE FOR SCIENCE EDUCATION
TATA INSTITUTE OF FUNDAMENTAL RESEARCH
V. N. Purav Marg, Mankhurd, Mumbai- 400088

Instruction

We are interested to know about your views on design and designers. This is part of a research study. **This is not a test or evaluation. You do not have to worry about grades or marks.** However, read the questions carefully before responding.

Section A:

1. Name: ____
2. Boy / Girl (Circle one)
3. Age: ____________ years
4. Class: ____________
5. Date: ____________
6. School ____
7. Father's Occupation: ______________________________
8. Mother's Occupation: ______________________________
9. After completing school education, what would you like to become? Mention your future occupation.

   ____

Section B:

1. What is the name of the designers you have drawn? ______________________________
2. The designers in your drawing is Male / female (circle one)
3. Where is the designer working?
   a. Indoor / outdoor (circle one)
   b. Home /office/ other __________ (circle one)
   c. Village / town / city (circle one)
4. What is the designer in your drawing doing?

Section C

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

II. Complete the following sentence:

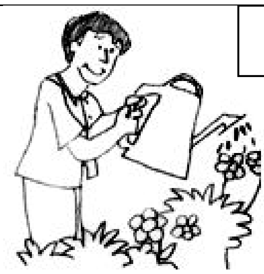
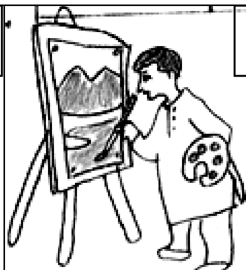
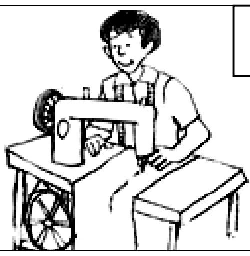
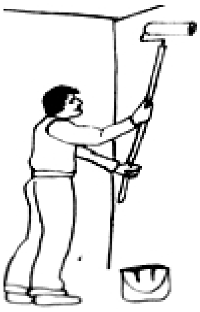
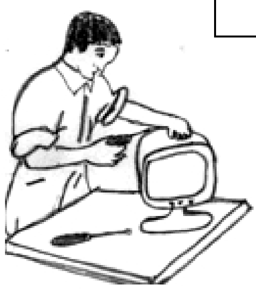
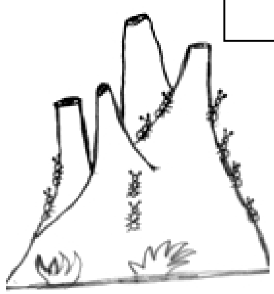
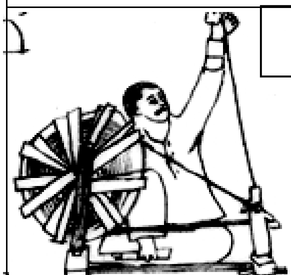
1. A Designer is a person who...

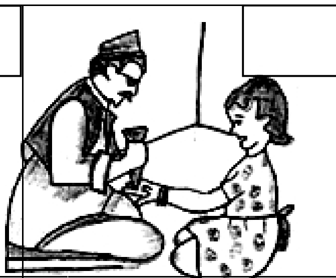
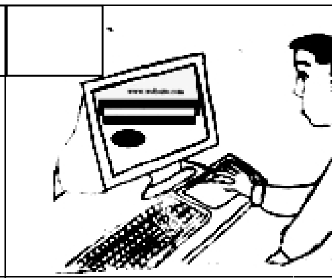
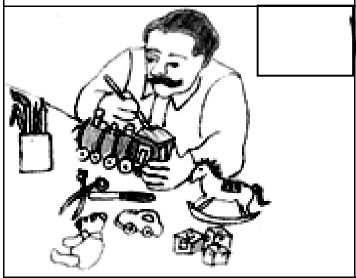
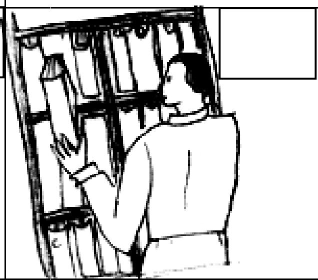
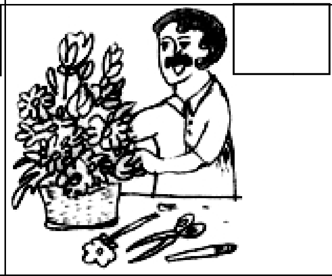
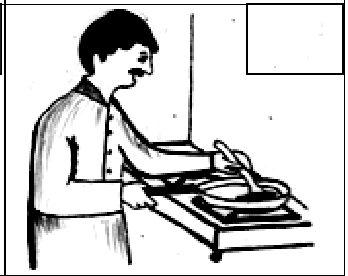
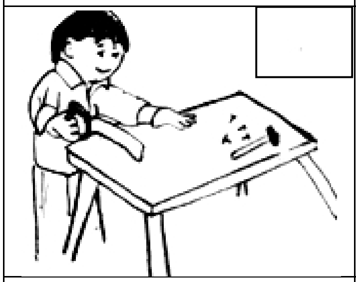
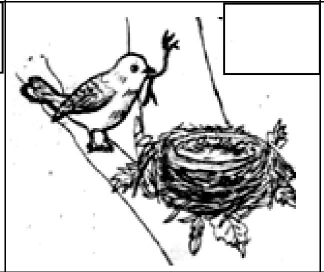
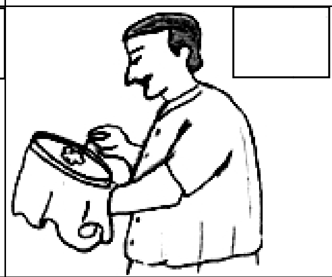
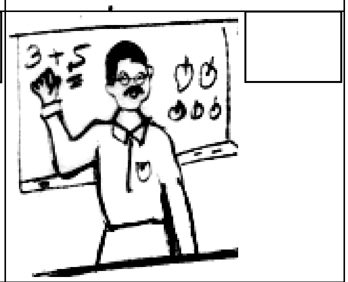
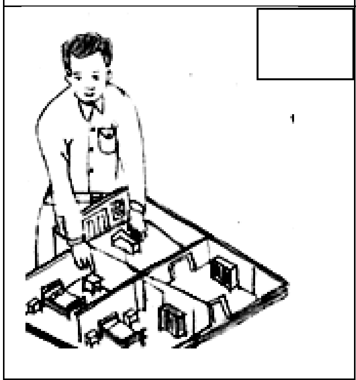
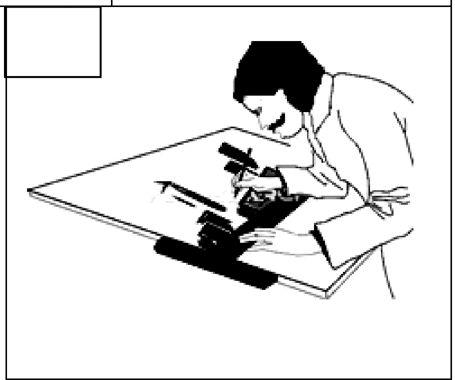
III. 1. Can animals (besides humans) design? Yes / No (Circle one)

2. Give reason for your answer

Section D (Male version) (common for all students, teachers and designers)

In the pictures given below, some activities are shown. In the box provided below, make a tick (✓) if you think that the activity is related to design.

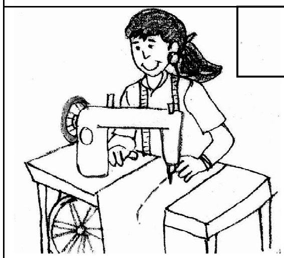
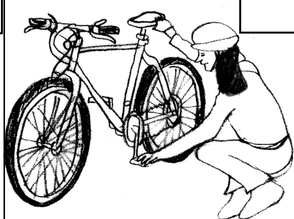
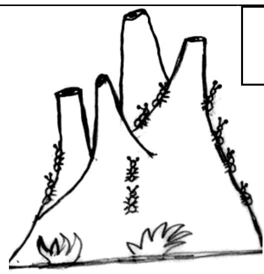
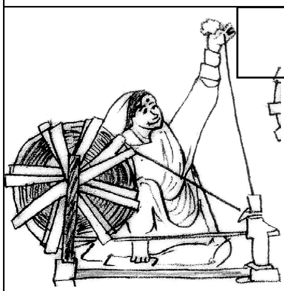
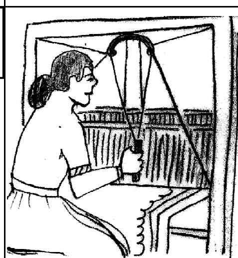
			
Planning a garden	Creating dress styles	Painting landscape	Making sculptures
			
Sewing clothes	Repairing bicycle	Making a model of a	Knitting sweaters
			
Painting walls	Repairing computer	Ants building mud hills	Weaving baskets
			
Spinning yarn	Icing cakes	Making shoes	Weaving cloth

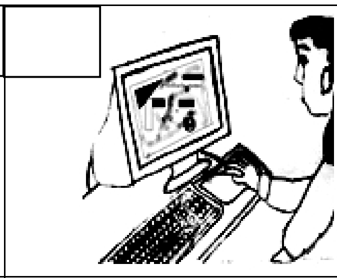
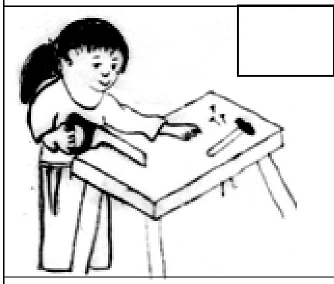
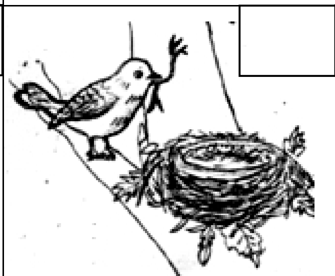
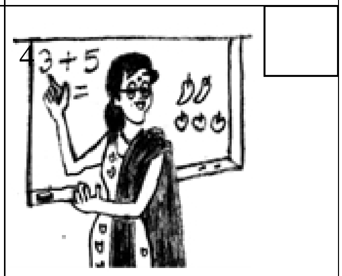
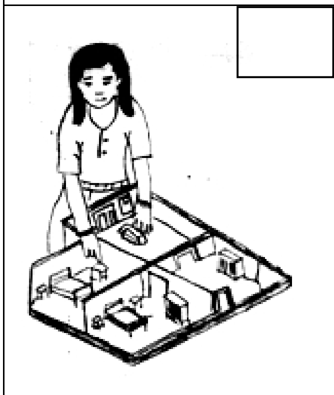
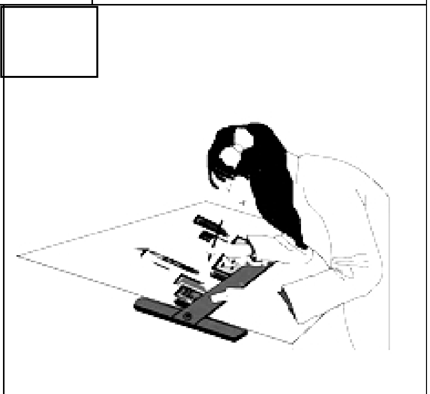
			
Laying bricks for walls	Applying mehndi	Making websites	Making pots
			
Making toys	Arranging books on shelf	Making a bouquet of flowers	Making a new dish
			
Doing woodwork	Building a nest	Doing needlework	Teaching
			
Making layout of rooms			Sketching layout of buildings

APPENDIX B

Section D (Female version) (common for all students, teachers and designers)

In the pictures given below, some activities are shown. In the box provided below, make a tick (✓) if you think that the activity is related to design.

			
Planning a garden	Creating dress styles	Painting landscape	Making sculptures
			
Sewing clothes	Repairing bicycle chain	Making a model of a car	Knitting sweaters
			
Painting walls	Repairing computer	Ants building mud hills	Weaving baskets
			
Spinning yarn	Icing cakes	Making shoes	Weaving cloth

			
Laying bricks for walls	Applying mehndi	Making websites	Making pots
			
Making toys	Arranging books on the shelf	Making a bouquet of flowers	Making a new dish
			
Doing woodwork	Building nest	Doing needlework	Teaching
			
Making layout of rooms			Sketching layout of buildings

Appendix C

Final Survey Questionnaire for Middle school students

HOMI BHABHA CENTRE FOR SCIENCE EDUCATION
TATA INSTITUTE OF FUNDAMENTAL RESEARCH
V. N. Purav Marg, Mankhurd, Mumbai- 400088

Instruction

We are interested to know about your views on design and designers. This is part of a research study. **This is not a test or evaluation. You do not have to worry about grades or marks.** However, read the questions carefully before responding.

Section A:

10. Name: ____
11. Boy / Girl (Circle one)
12. Age: ______________ years
13. Class: ______________
14. Date: ______________
15. School ____
16. Father's Occupation: ___________________________________
17. Mother's Occupation: ___________________________________
18. After completing school education, what would you like to become? Mention your future occupation.

    ____

Section B:

1. What is the name of the designers you have drawn?
   ____
2. The designers in your drawing is Male / female (circle one)
3. Where is the designer working?
   a. Indoor / outdoor (circle one)
   b. Home /office/ other __________ (circle one)
   c. Village / town / city (circle one)
4. What is the designer in your drawing doing?

Section C

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

V. Complete the following sentence:

1. A Designer is a person who...

VI. For the word 'design', give as many words as you can in different Indian languages. Mention the language of each word.

Word/s	**Language**
________________________	__________________

VII. 1. Can animals (besides humans) design? Yes / No (Circle one)

2. Justify your answer

VIII. List your school subjects which you think might be related to design.

IX. A list of 20 school subjects is given below. If these subjects are going to be taught in your schools, which three would you prefer to learn.

1. ______________________________
2. ______________________________
3. ______________________________

Now tick the subjects which you feel are related to design

	Subjects	**Tick (✓) those subjects which you feel are related to design**
1	Basket weaving	
2	Block printing	
3	Book binding	
4	Candle making	
5	Computer education	
6	Cooking	
7	Drama	
8	Drawing	
9	Flower decoration	
10	Gardening	

11	Handicraft	
12	Knitting	
13	Library management	
14	Music	
15	Needlework	
16	Painting	
17	Photography	
18	Pottery	
19	Tailoring	
20	Woodwork	

X. Some occupations are listed below. For each occupation circle one option that you feel is appropriate.

	Occupations	**Suitable for**	**Suitable for**	**Suitable for**
1.	Architecture	girls	boys	both
2.	Automobile designing	girls	boys	both
3.	Carpentry	girls	boys	both
4.	Civil engineering	girls	boys	both
5.	Computer engineering	girls	boys	both
6.	Cooking	girls	boys	both
7.	Electronics engineering	girls	boys	both
8.	Fashion designing	girls	boys	both
9.	Graphic designing	girls	boys	both
10.	Interior designing	girls	boys	both
11.	Jewellery designing	girls	boys	both
12.	Mechanical engineering	girls	boys	both
13.	Painting	girls	boys	both
14.	Pottery	girls	boys	both
15.	Product designing	girls	boys	both

16.	Tailoring	girls	boys	both
17.	Teaching	girls	boys	both
18.	Textile designing	girls	boys	both

XI. Do you agree with the following statements? Tick any one- 'agree', or 'disagree.'

	Statements	Agree	Disagree
1.	I think girls can be better designers than boys		
2.	We can design only after taking up courses in design.		
3.	I am interested in design.		
4.	Anyone who is not good at drawings should not take up design courses.		
5.	I think more girls than boys choose design professions.		
6.	I like to read magazines about design and designers.		
7.	If design is introduced as an optional school subject, I will choose to study it.		
8.	I think designing requires creativity.		
9.	I feel designing needs a lot of mathematics.		
10.	Design work is boring.		

XII. Do you agree with the following statements? Tick any one- 'agree', 'unsure' or 'disagree.'

	Statements	Agree	Unsure	Disagree
1.	To design means to make patterns.			
2.	Design is about the appearances of things.			
3.	To design means to draw.			
4.	Scientific knowledge is used in design.			
5.	Art is the same as design.			
6.	Design is a modern activity.			
7.	Designing means to give shape to things.			

	Statements	Agree	Unsure	Disagree
8.	In design one has little opportunity to work with one's hands.			
9.	A well designed product must look attractive.			
10.	Designing improves things.			
11.	Design and engineering are the same things.			
12.	Design is a daily activity that we all do.			
13.	Designers get their ideas by observing people.			
14.	Ancient people have designed things.			
15.	Designers solve real world problems.			
16.	People can learn to design.			

XIII. There are some skills that designers have. Tick all the items that you think designers need to be good at.

	Skills	Tick
1.	Work in a team	
2.	Sketch ideas	
3.	Understand how things work	
4.	Plan	
5.	Generate ideas	
6.	Imagine new products/services	
7.	Communicate with others	
8.	Work with different tools	
9.	Gather information	
10.	Solve problems	

XIV. Some qualities of people are listed below. Circle on the one which you feel is associated with a designer. Circle any one

A designer is usually…

1.	Lazy	/	Hardworking
2.	Intelligent	/	Stupid
3.	Interested in people	/	Interested in ideas
4.	Popular	/	Unpopular
5.	Kind	/	Cruel
6.	Poor	/	Rich
7.	Humble	/	Proud
8.	Female	/	Male
9.	Old	/	Young
10.	Timid	/	Bold
11.	Technical	/	Artistic
12.	Friendly	/	Hostile
13.	Boring	/	Interesting
14.	Original	/	Imitative
15.	Sensitive	/	Insensitive
16.	Honest	/	Dishonest
17.	Organized	/	Unorganized
18.	Practical worker	/	Abstract thinker
19.	Modern	/	Old-fashioned
20.	Unscientific	/	Scientific

Appendix D

Survey Questionnaire for Teachers

HOMI BHABHA CENTRE FOR SCIENCE EDUCATION
TATA INSTITUTE OF FUNDAMENTAL RESEARCH
V. N. Purav Marg, Mankhurd, Mumbai- 400088

Instruction

We are interested to know about your views on design and designers. This is part of a research study. Please read the questions carefully before responding. Your identity will be kept confidential and all your responses will be kept anonymous.

Section A: Background Information

1. Name: ____
2. Male / Female (Circle one)
3. Age: ____________ years
4. Classes / Grades that you teach:______________________________
5. Subject/s that you teach:__________________________________
6. Highest academic qualification:______________________________
7. Highest teacher qualification:_______________________________
8. Number of years that you have been teaching (Give details):______________
9. Date: ____________________

Section B (mentioned as Section C in the analysis)

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

II. Complete the following sentence:

a. A Designer is a person who...

III. For the word ‘design’, give as many words as you can in different Indian languages. Mention the language for each word.

Word/s	**Language**
____________________	____________________

IV. 1. Can animals (besides humans) design? Yes / No (Circle one)

2. Why do you think so?

V. List all the school subjects which you think might be related to design.

VI. 1. Do you think design education should be a part of the school curriculum?

Yes / No (Circle any one)

2. Why do you think so?

VII.		Very Much	Somewhat	Not at all
1	According to you, how much is the teaching profession related to design?			
2	Why do you think so?			

VIII. Look at the table given below. A list of 20 school subjects is given in the table. If these subjects are going to be introduced in your institution, which three would you prefer to teach/learn.

1. ______________________________
2. ______________________________
3. ______________________________

Now tick the subjects which you feel are related to design

	Subjects	**Tick (✓) all those subjects which you feel are related to design**
1	Basket weaving	
2	Block printing	
3	Book binding	
4	Candle making	
5	Computer education	
6	Cooking	
7	Drama	
8	Drawing	
9	Flower decoration	
10	Gardening	
11	Handicraft	
12	Knitting	
13	Library management	

14	Music	
15	Needlework	
16	Painting	
17	Photography	
18	Pottery	
19	Tailoring	
20	Woodwork	

IX. Some occupations are listed below. Three options are provided- 'suitable for women,' 'suitable for men' and 'suitable for both.' For each occupation circle one.

	Occupations	**Suitable for**	**Suitable for**	**Suitable for**
1.	Architecture	Women	Men	both
2.	Automobile designing	Women	Men	both
3.	Carpentry	Women	Men	both
4.	Civil engineering	Women	Men	both
5.	Computer engineering	Women	Men	both
6.	Cooking	Women	Men	both
7.	Electronics engineering	Women	Men	both
8.	Fashion designing	Women	Men	both
9.	Graphic designing	Women	Men	both
10.	Interior designing	Women	Men	both
11.	Jewellery designing	Women	Men	both
12.	Mechanical engineering	Women	Men	both
13.	Painting	Women	Men	both
14.	Pottery	Women	Men	both
15.	Product designing	Women	Men	both
16.	Tailoring	Women	Men	both
17.	Teaching	Women	Men	both
18.	Textile designing	Women	Men	both

X. Do you agree with the following statements? Tick (✓) on either one- 'Agree', or 'Disagree.'

	Statements	**Agree**	**Disagree**
1	I think women can be better designers than men.		
2	We can design only after taking up courses in design.		
3	I am interested in design.		
4	Anyone who is not good at drawing should not take up design courses.		
5	I think more women than men choose design professions.		
6	I like to read magazines about design and designers.		
7	If design is introduced as an optional school subject, I will choose to teach it.		
8	I think designing requires creativity.		
9	I feel designing needs a lot of mathematics.		
10	Design work is boring.		

XI. Read the following statements and circle any one option. Give reasons for your answer.

1. Design is the same as drawing. Agree / Disagree (Circle one)

Reason:

____

____

____

Designers solve real world problems Agree / Disagree (Circle one)

Reason:

____

____

____

XII. Do you agree with the following statements? Tick (✓) any one - 'agree', 'unsure' or 'disagree.'

	Statements	Agree	Unsure	Disagree
1.	To design means to make patterns			
2.	Design is about the appearance of things			
3.	To design means to draw			
4.	Designing means to give shapes to things			
5.	Designing improves things			
6.	A well designed product must look attractive			
7.	In design one has little opportunity to work with one's hands			
8.	Scientific knowledge is used in design			
9.	Designers solve real world problems			
10.	Designers get their ideas by observing people			
11.	Design is a modern activity			
12.	Ancient people have designed things			
13.	Art is the same as design			
14.	Designing and engineering are the same			
15.	Design is an activity that we all do			
16.	People can learn to design			

XIII. There are some skills that designers have. Tick all the items that you think designers need to be good at.

	Skills	Tick
1.	Work in a team	
2.	Sketch ideas	
3.	Understand how things work	
4.	Plan	
5.	Generate ideas	
6.	Imagine new products/services	
7.	Communicate with others	

	Skills	Tick
8.	Work with different tools	
9.	Gather information	
10.	Solve problems	

XIV. Some qualities of people are listed below. For each pair circle on the one which you feel is associated with a designer. Circle any one

A designer is usually…

1.	Lazy	/	Hardworking
2.	Intelligent	/	Stupid
3.	Interested in people	/	Interested in ideas
4.	Popular	/	Unpopular
5.	Kind	/	Cruel
6.	Poor	/	Rich
7.	Humble	/	Proud
8.	Female	/	Male
9.	Old	/	Young
10.	Timid	/	Bold
11.	Technical	/	Artistic
12.	Friendly	/	Hostile
13.	Boring	/	Interesting
14.	Original	/	Imitative
15.	Sensitive	/	Insensitive
16.	Honest	/	Dishonest
17.	Organized	/	Unorganized
18.	Practical worker	/	Abstract thinker
19.	Modern	/	Old-fashioned
20.	Unscientific	/	Scientific

Appendix E

Interview Schedule for Designers

HOMI BHABHA CENTRE FOR SCIENCE EDUCATION
TATA INSTITUTE OF FUNDAMENTAL RESEARCH
V. N. Purav Marg, Mankhurd, Mumbai- 400088

Instruction

We are interested to know about your views on design and designers. This is part of a research study. Please read the questions carefully before responding. Your identity will be kept confidential and all your responses will be kept anonymous.

Section A: Background Information

1. Name: ____
2. Male / Female (Circle one)
3. Age: ______________ years
4. Year of graduation:____________________________
5. Subject of graduation: __________________________
6. Date: ______________________

Section B (mentioned as Section C in the analysis)

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

II. Complete the following sentence:

a. A Designer is a person who...

III. For the word 'design', give as many words as you can in different Indian languages. Mention the language for each word.

Word/s	**Language**

IV. 1. Can animals (besides humans) design? Yes / No (Circle one)

2. Why do you think so?

V. List all the school subjects which you think might be related to design.

VI. 1. Do you think design education should be a part of the school curriculum?

Yes / No (Circle any one)

2. Why do you think so?

VII. Look at the table given below. A list of 20 school subjects is given in the table. If these subjects are going to be introduced in your institution, which three would you prefer to teach/learn.

1. ______________________________
2. ______________________________
3. ______________________________

VIII. Now tick the subjects which you feel are related to design

	Subjects	**Tick (✓) all those subjects which you feel are related to design**
1	Basket weaving	
2	Block printing	
3	Book binding	
4	Candle making	
5	Computer education	
6	Cooking	
7	Drama	
8	Drawing	
9	Flower decoration	
10	Gardening	
11	Handicraft	
12	Knitting	
13	Library management	
14	Music	
15	Needlework	
16	Painting	
17	Photography	
18	Pottery	
19	Tailoring	
20	Woodwork	

IX. Some occupations are listed below. Three options are provided- 'suitable for women,' 'suitable for men' and 'suitable for both.' For each occupation circle one.

	Occupations	Suitable for	Suitable for	Suitable for
1.	Architecture	Women	Men	both
2.	Automobile designing	Women	Men	both
3.	Carpentry	Women	Men	both
4.	Civil engineering	Women	Men	both
5.	Computer engineering	Women	Men	both
6.	Cooking	Women	Men	both
7.	Electronics engineering	Women	Men	both
8.	Fashion designing	Women	Men	both
9.	Graphic designing	Women	Men	both
10.	Interior designing	Women	Men	both
11.	Jewellery designing	Women	Men	both
12.	Mechanical engineering	Women	Men	both
13.	Painting	Women	Men	both
14.	Pottery	Women	Men	both
15.	Product designing	Women	Men	both
16.	Tailoring	Women	Men	both
17.	Teaching	Women	Men	both
18.	Textile designing	Women	Men	both

X. Do you agree with the following statements? Tick (✓) on either one- 'Agree', or 'Disagree.'

	Statements	Agree	Disagree
1	I think women can be better designers than men.		
2	We can design only after taking up courses in design.		
3	I am interested in design.		
4	Anyone who is not good at drawing should not take up design courses.		
5	I think more women than men choose design professions.		
6	I like to read magazines about design and designers.		

7	If design is introduced as an optional school subject, I will choose to teach it.		
8	I think designing requires creativity.		
9	I feel designing needs a lot of mathematics.		
10	Design work is boring.		

XI. Read the following statements and circle any one option. Give reasons for your answer.

1. Design is the same as drawing. Agree / Disagree (Circle one)

Reason:____
____

2. Designers solve real world problems Agree / Disagree (Circle one)

Reason:____
____

XII. Do you agree with the following statements? Tick (✓) any one - 'agree', 'unsure' or 'disagree.'

	Statements	Agree	Unsure	Disagree
1.	To design means to make patterns			
2.	Design is about the appearance of things			
3.	To design means to draw			
4.	Designing means to give shapes to things			
5.	Designing improves things			
6.	A well designed product must look attractive			
7.	In design one has little opportunity to work with one's hands			
8.	Scientific knowledge is used in design			
9.	Designers solve real world problems			
10.	Designers get their ideas by observing people			
11.	Design is a modern activity			
12.	Ancient people have designed things			

13.	Art is the same as design			
14.	Designing and engineering are the same			
15.	Design is an activity that we all do			
16.	People can learn to design			

XIII. There are some skills that designers have. Tick all the items that you think designers need to be good at.

	Skills	**Tick**
1.	Work in a team	
2.	Sketch ideas	
3.	Understand how things work	
4.	Plan	
5.	Generate ideas	
6.	Imagine new products/services	
7.	Communicate with others	
8.	Work with different tools	
9.	Gather information	
10.	Solve problems	

XIV. Some qualities of people are listed below. For each pair circle on the one which you feel is associated with a designer. Circle any one

A designer is usually…

1	Lazy	/	Hardworking
2	Intelligent	/	Stupid
3	Interested in people	/	Interested in ideas
4	Popular	/	Unpopular
5	Kind	/	Cruel
6	Poor	/	Rich
7	Humble	/	Proud

8	Female	/	Male
9	Old	/	Young
10	Timid	/	Bold
11	Technical	/	Artistic
12	Friendly	/	Hostile
13	Boring	/	Interesting
14	Original	/	Imitative
15	Sensitive	/	Insensitive
16	Honest	/	Dishonest
17	Organized	/	Unorganized
18	Practical worker	/	Abstract thinker
19	Modern	/	Old-fashioned
20	Unscientific	/	Scientific

Appendix F

Letter to the Principal of school for the final survey of students

To,
The Principal
Atomic Energy Central School-II
Anushaktinagar,
Mankhurd, Mumbai 400 088

Dear Sir,

Sub: Request for conducting a survey on design with students of Classes V to X studying in AECS-II

Homi Bhabha Centre for Science Education (HBCSE), TIFR, Mumbai, is a National Centre for research and development in science and mathematics education. It conducts a variety of field programmes for students and teachers from primary school to introductory college levels. It also conducts research in education and on student's ideas about science and design and technology.

HBCSE has undertaken a recent project to study students' understanding of design and designers. As part of the project, we need to conduct a survey with students of classes V to X. The survey will be conducted by me and I would be assisted by two of my colleagues under the guidance of Prof. Sugra Chunawala. The survey is expected to be carried out at your school for about 50 minutes. We would be grateful if you could kindly allow the students to participate in the survey.

HBCSE has a long history of collaborating with Atomic Energy Education Society. We hope to continue this association through this project. Thank you very much for your co-operation in this regard and look forward to interacting with you and your students.

Thank you,
Yours truly,

Farhat Ara
Research Scholar

Appendix G

Letter to the Principal of school for Workshop 1

To
The Principal
Atomic Energy Central School-1
Anushaktinagar,
Mankhurd, Mumbai 400 088

Sub: Request for about 30 students of Class VII studying in AECS for activity-based learning session at HBCSE.

Dear Sir,

Homi Bhabha Centre for Science Education (HBCSE), TIFR, Mumbai, is a National Centre for research and development in science and mathematics education. It conducts a variety of field programmes for students and teachers from primary school to introductory college levels. It also conducts research in education and on student's ideas about science and technology.

HBCSE has undertaken a recent project to study students' design thinking. As part of the project, we need to interact with about 30 students, say, one division of Standard VII, with about equal numbers of boys and girls. The activities will be conducted by me and my colleagues and under the guidance of Prof. Sugra Chunawala. They are expected to be carried out at HBCSE in 5 sessions, each of about 2 hours. We would be grateful if you could kindly allow the students to come to HBCSE after school hours and participate in the activity sessions at HBCSE. Adequate copies of a note seeking parents’ consent will be given. The activities will be audio and video recorded for the purpose of research.

HBCSE has a long history of collaborating with Atomic Energy Education Society. We hope to continue this association through this project. Thank you very much for your co-operation in this regard and look forward to interacting with you and your students.

Thank you,
Yours truly,

Farhat Ara
Research Scholar

Appendix H

Letter to the Principal of school for Workshop 2

To
The Principal
Atomic Energy Central School-1
Anushaktinagar,
Mankhurd, Mumbai 400 088

Dear Sir,

Sub: Request for about 15-16 students of Class VII studying in AECS for activity-based learning sessions at HBCSE.

Homi Bhabha Centre for Science Education (HBCSE), TIFR, Mumbai, is a National Centre for research and development in science and mathematics education. It conducts a variety of field programmes for students and teachers from primary school to introductory college levels. It also conducts research in education and on student's ideas about science and technology.

We are interested in studying middle school students' design thinking. As part of the project, we need to interact with about 15-16 students of Standard VII (equal numbers of boys and girls). The activities will be conducted by me and my colleagues at HBCSE under the guidance of Prof. Sugra Chunawala. The activities will be carried out at HBCSE in 8 sessions, each of about 3 hours from 10th October-17th October, 2009. We would be grateful if you could kindly allow the students to come to HBCSE during their school vacation period from 10th October-17th October, 2009 and participate in the activity sessions at HBCSE. Adequate copies of a note seeking parents' consent will be given to the students. The activities will be audio and video recorded for the purpose of research.

HBCSE has a long history of collaborating with Atomic Energy Education Society. We hope to continue this association through this project. Thank you very much for your co-operation in this regard and look forward to interacting with you and your students.

Thank you,
Yours truly,

Farhat Ara

Appendix I

Consent letter to parents for conducting the Workshop 2 with their wards

Sub: Request for conducting an activity-based sessions with your ward in AECS-I from 10th October, 2009 – 17th October, 2009

Dear Parent,

Homi Bhabha Centre for Science Education (HBCSE), TIFR, Mumbai, is a National Centre for research and development in science and mathematics education. It conducts a variety of field programmes for students and teachers from primary school to introductory college levels. HBCSE has undertaken a project to study students' understanding of technology and design. As part of the project, we need to conduct activities with students of Class VII. The activities will be conducted by me, under the guidance of Prof. Sugra Chunawala at HBCSE for three hours during the school vacation period from 10th October to 16th October. The activities would be audio and video recorded and the video and audio data would be used for the purpose of research.

Where and when?
Venue: Main building, Homi Bhabha Centre for Science Education,
Dates: Saturday, 10th October to Saturday, 17th October 2009
Time: 10.30 am to 1.30 pm (Snacks would be provided at around 12.00 noon)

Interested students of Class VII should submit to their teacher the form given below after getting it signed by one of their parents/ guardians.

Farhat Ara,
Researcher (Phone:__________) Signature

…………………………………………………………………………………………
(Tear on the dotted line above)

Application for **Activity Sessions at HBCSE, 10th -17th October, 2009**

1. Student's Name: ……………………………………
2. Class and Section: ……………………………………
3. School: ……………………………………
4. Contact Phone Number: ……………………………………
5. Parent's/ Guardian's signature: ……………………………………
6. Parent's/Guardian's Name: ……………………………………

Appendix J

Activity sheet in Workshop 1 (Familiar artefacts- Fountain pen)

Question Set A

Name of your group____________________________

An object is given to you. Examine the object very carefully. You can take it apart that is, open its different parts and then answer the following questions.

a) Name the object _______________________
b) Have you used this object before? Yes / No (Circle one)
c) Draw the object and its parts in the space provided
d) Label its different parts
e) List the materials from which those parts are made

f) What is this object used for?

____

g) Which is/are the most important part/s without which the object will not work? Why?

____

h) Who uses this object?

____

i) What other objects can be used instead of this object for the same purpose?

____

Appendix K

Activity sheet in Workshop 1 (Familiar artefacts- Electric iron)

Question Set B

Name of your group____________________________

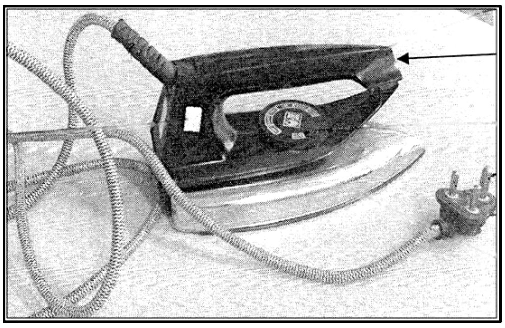
An object is given to you. Examine the object given to you and shown in the picture, very carefully. Answer the following questions.

a) Name the object ________________________

b) Have you used this object before? Yes / No (Circle one)

c) Identify and label its different parts of the object on the picture

d) List the materials from which those parts are made



e) What is this object used for?

____

f) What different materials can be used to mark the parts marked with an arrow?

____

j) Who uses this object?

____

k) What other objects can be used instead of this object for the same purpose?

____

Appendix L

Activity sheet in Workshop 1 (Familiar artefacts-Hurricane lantern)

Question Set C

Name of your group_____________________________

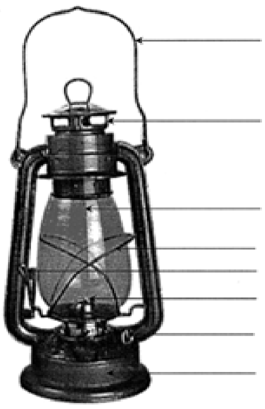
Examine the object given to you and shown in the picture. Answer the following questions.

a) Name the object ________________________

b) Have you used this object before? Yes / No (Circle one)

c) Label its different parts in the space provided

d) List the materials from which those parts are made



Label	Material
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________

e) What is this object used for?

____

f) When is it used?

____

g) List the steps that one needs to do to use this object?

____

h) Who uses this object?

____

i) What other objects can be used instead of this object for the same purpose?

____

Appendix M

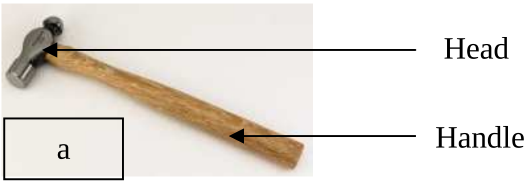
Activity sheet in Workshop 1 (Familiar artefacts-Hammers)

Question Set D

Name of your group______________________________

Two hammers are shown below with parts labelled. Two of them are kept on the table. Observe the pictures, handle the two hammers and answer the following question.

a) Have you seen object 'a' before Yes / No (Circle one)
b) Have you seen object 'b' before Yes / No (Circle one)



c) What are the similarity/ies between 'a' and 'b'?

____

d) What are the differences between 'a' and 'b'?

____

e) Suppose the handles of both are changed to metal.

i. Will 'a' work better with a metal handle? Yes / No (circle one)

ii. Explain how?

____

iii. Will 'b' work better with a metal handle? Yes / No (circle one)

iv. Explain how?

____

Appendix N

Activity sheet in Workshop 1 (Unfamiliar artefacts- 3 Pictures)

Question Set E1

Name of your group____________________________

Watch the picture shown to you carefully. Answer the following questions.

a) Have you seen object before Yes / No (Circle one)

b) List what materials are used to make this object:

____

____

c) Some possible uses of this object are given below. Choose the one which you feel is most appropriate. (Tick any one).

1. This object is used for hanging clothes. You loosen the rope and hang the clothes in between the two planks.
2. This object is a musical instrument. You can hit the two planks with each other to make a musical sound.
3. This object is used for carrying books. You loosen the rope, place the books in between the two planks and hold the handle.'

Question Set E2

Name of your group____________________________

Watch the picture shown to you carefully. Answer the following questions.

This object is hollow inside and is about 8 inches long, 4 inches wide and 6 inches high

a) Have you seen object before Yes / No (Circle one)

b) List what materials are used to make this object:

____

____

c) Some possible uses of this object are given below. Choose the one which you feel is most appropriate. (Tick any one).

1. This object is a jewellery box. You lift the handle, open the box and keep the jewellery inside.
2. This object is a mouse trap. You keep the box open and as soon as the mouse enters it, the box closes.
3. This object is a box for keeping shoes. You keep the shoes in the box so that they remain polished.

Question Set E3

Name of your group___________________________

Watch the picture shown to you carefully. Answer the following questions.

The object is about 8 inches long

a) Have you seen object before Yes / No (Circle one)
b) List what materials are used to make this object:

____

____

c) Some possible uses of this object are given below. Choose the one which you feel is most appropriate. (Tick any one).

1. This object is a bottle cap opener. You fix the rod into the cap of the bottle and pull the cap to open it.
2. This object is a water heater with the missing electric wire and cord. It is used to heat water in a bucket.
3. This object is used for retrieving eggs from boiling water. You slide the rod under the egg and lift the egg.

Appendix O

Activity sheet in Workshop 1 (Unfamiliar artefacts- Knife sharpeners)

Question Set F

Name of your group____________________________

Look carefully at objects A, B and C which are given to you and answer the following questions:

1. **What materials are these objects made of?**
   a. Object A:
   ____
   b. Object B:
   ____
   c. Object C:
   ____
2. **What are these objects used for?**
   a. Object A:
   ____
   b. Object B:
   ____
   c. Object C:
   ____
3. **Are there any similarities:**
   a. Between Object A and Object B? Yes / No (Circle one)
   b. What is/are the similarities?
   ____
   c. Between Object B and Object C? Yes/ No (Circle one)
   d. What is/are the similarities?
   ____
   e. Between Object C and Object A? Yes/ No (Circle one)
   f. What is/are the similarities?
   ____

Appendix P

Activity sheet in Workshop 1 (Designing a device)

Question Set G

Name of your group____________________________

The design problem:

On reaching old age some people have difficulty in bending to pick up fallen things from the floor. Rita's grandmother is very old and also has a problem with her vision. She cannot sit on the floor because of her backache. So she usually sits on a chair or on sofa and sews clothes or knits sweaters. Sometimes she drops the sewing or knitting needle on the floor but she cannot bend to pick it up because of backache.

The design brief:

Design at least two possible solutions for this problem, that is, design a device for Rita's grandmother so that she can easily lift the sewing or knitting needle from the floor without bending. Prepare a plan by drawing out your ideas on a sheet of paper.

Read the problem and observe the situation carefully. Before designing, think of the problem first by discussing with your group members.

Design criteria

The device should be

1. *Able to lift both sewing and knitting needle*
2. *Able to lift needle of weight 50 grams*
3. *Small enough or retractable such that it can easily be carried*
4. *Cheap*
5. *Attractive*

- Make your design with appropriate measurements on the following sheets.
- Also indicate how your design will work.
- Your design will be judged against the above given criteria.

Appendix Q

Activity sheet in Workshop 2 (Card Sorting)

Activity I

Classification activity

Name of your group____________________________

1. Look at all the pictures provided to you and think of the ways in which you could classify the pictures into different groups.
2. Give a title to each of the groups. Write the title on the line below the words group title.
3. List all the objects in the group along the bullets given.
4. Give reason/s for placing the pictures in different groups.

Group 1 title:
____

- ___________________
- ___________________
- ___________________

Reasons for placing these pictures in this group:

Group 2 title:
____

- ___________________
- ___________________
- ___________________

Reasons for placing these pictures in this group:

Group 3 title:
____

- ___________________
- ___________________
- ___________________

Reasons for placing these pictures in this group:

Group 4 title:
____

- ___________________
- ___________________
- ___________________

Reasons for placing these pictures in this group:

Group 5 title:
____

- ___________________
- ___________________
- ___________________

Reasons for placing these pictures in this group:

Group 6 title:

____

- ____________________
- ____________________
- ____________________

Reasons for placing these pictures in this group:

Group 7 title:

____

- ____________________
- ____________________
- ____________________

Reasons for placing these pictures in this group:

Group 8 title:

____

- ____________________
- ____________________
- ____________________

Reasons for placing these pictures in this group:

Group 9 title:

____

- ____________________
- ____________________
- ____________________

Reasons for placing these pictures in this group:

Group 10 title:

____

- ____________________
- ____________________
- ____________________

Reasons for placing these pictures in this group:

Group 11 title:

____

- ____________________
- ____________________
- ____________________

Reasons for placing these pictures in this group:

Group 12 title:

____

- ____________________
- ____________________
- ____________________

Reasons for placing these pictures in this group:

Appendix R

Activity sheet in Workshop 2 (Familiar artefact- Ball-point pen)

Activity II

Name of your group___________________________

Look at the object provided to you. Handle it and observe it carefully. You can take it apart to see its different parts.

a) Are you familiar with it? Yes / No (Circle one)
b) Have you used it? Yes / No (Circle one)
c) What is/are the functions of this object?

____

d) In the table provided below, write the different parts of the object in the left column and the functions of those parts in the middle column. In the right column, write what will happen if the respective parts are lost/not working.

Part of the object	*Functions of each part*	*How will the loss of this part affect the function of the object*

e) Suppose somehow, this object gets into the hands of a tribal person living in a remote village, what do you think he/she would use it for?

____

____

f) Suppose you have designed this object. What are the things that you considered while designing it?

____

____

g) Can you think of alternate ways/objects by which you can perform the same function that this object does?

____

____

Appendix S

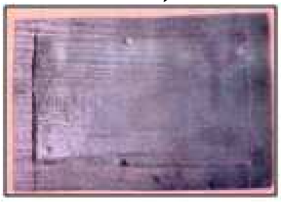
Activity sheet in Workshop 2 (History of writing instruments)

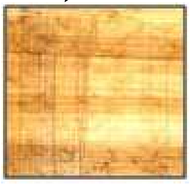
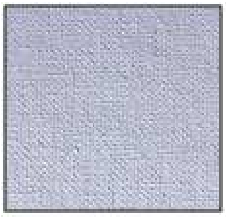
Activity III

Name of your group____________________________

People have been writing since ancient times. For writing, one needs two things: a writing surface and a writing tool to write on it. Following is a list of writing surfaces ranging from the very ancient to the recent.

For each of the writing surface, mention the writing tool that would have been or is possibly used by people.
Give reasons for selecting the writing tools.

Writing surfaces	*Writing tools*	*Justify*
Stone Slab 		
***Clay Slab* (made from mud and clay)** 		
***Wax tablet* (wooden slab coated with wax)** 		

Writing surfaces	*Writing tools*	*Justify*
***Parchment** (made from animal skin)* 		
***Papyrus** (made from the stem of papyrus plant)* 		
Paper 		
Cloth 		

Appendix T

Activity sheet in Workshop 2 (Unfamiliar artefacts- 8 artefacts)

Activity IVA through IVH (separate sheet for the 8 artefacts)

Name of your group______________________________

Look at the objects provided to you carefully and respond to the followings.

a) Are you familiar with **Object 'A'**? Yes / No (Circle one)

b) Have you used **Object 'A'** Yes / No (Circle one)

c) What are the different ways in which object 'A' can be used?

____

____

____

____

____

d) What gave you indication/s about the function/s of object 'A'?

____

____

____

____

____

Activity sheet in Workshop 2 (Unfamiliar artefacts- 8 artefacts)

Activity IVB

Name of your group____________________________

Look at the objects provided to you carefully and respond to the followings.

a) Are you familiar with **Object 'B'**? Yes / No (Circle one)

b) Have you used **Object 'B'** Yes / No (Circle one)

c) What are the different ways in which object 'B' can be used?

____

____

____

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____

d) What gave you indication/s about the function/s of object 'B'?

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Activity sheet in Workshop 2 (Unfamiliar artefacts- 8 artefacts)

Activity IVC

Name of your group______________________________

Look at the objects provided to you carefully and respond to the followings.

a) Are you familiar with **Object 'C'**? Yes / No (Circle one)

b) Have you used **Object 'C'** Yes / No (Circle one)

c) What are the different ways in which object 'C' can be used?

____

____

____

____

____

d) What gave you indication/s about the function/s of object 'C'?

____

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____

Activity sheet in Workshop 2 (Unfamiliar artefacts- 8 artefacts)

Activity IVD

Name of your group____________________________

Look at the objects provided to you carefully and respond to the followings.

a) Are you familiar with **Object 'D'**? Yes / No (Circle one)

b) Have you used **Object 'D'** Yes / No (Circle one)

c) What are the different ways in which object 'D' can be used?

____

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____

d) What gave you indication/s about the function/s of object 'D'?

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Activity sheet in Workshop 2 (Unfamiliar artefacts- 8 artefacts)

Activity IVE

Name of your group______________________________

Look at the objects provided to you carefully and respond to the followings.

a) Are you familiar with **Object 'E'**? Yes / No (Circle one)

b) Have you used **Object 'E'** Yes / No (Circle one)

c) What are the different ways in which object 'E' can be used?

____

____

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____

d) What gave you indication/s about the function/s of object 'E'?

____

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Activity sheet in Workshop 2 (Unfamiliar artefacts- 8 artefacts)

Activity IVF

Name of your group____________________________

Look at the objects provided to you carefully and respond to the followings.

a) Are you familiar with **Object 'F'**? Yes / No (Circle one)

b) Have you used **Object 'F'** Yes / No (Circle one)

c) What are the different ways in which object 'F' can be used?

____

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____

d) What gave you indication/s about the function/s of object 'F'?

____

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Activity sheet in Workshop 2 (Unfamiliar artefacts- 8 artefacts)

Activity IVG

Look at the objects provided to you carefully and respond to the followings.

a) Are you familiar with **Object 'G'**? Yes / No (Circle one)

b) Have you used **Object 'G'** Yes / No (Circle one)

c) What are the different ways in which object 'G' can be used?

____

____

____

____

____

____

d) What gave you indication/s about the function/s of object 'G'?

____

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Activity sheet in Workshop 2 (Unfamiliar artefacts- 8 artefacts)

Activity IVH

Look at the objects provided to you carefully and respond to the followings.

a) Are you familiar with **Object 'H'**? Yes / No (Circle one)

b) Have you used **Object 'H'** Yes / No (Circle one)

c) What are the different ways in which object 'H' can be used?

____

____

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____

d) What gave you indication/s about the function/s of object 'H'?

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Appendix U

Activity sheet in Workshop 2 (Design and make a device)

Activity V

Name of your group____________________________

The design problem:

On reaching old age some people have difficulty in bending to pick up fallen things from the floor. Rita's grandmother is very old and also has a problem with her vision. She cannot sit on the floor because of her backache. So she usually sits on a chair or on sofa and sews clothes or knits sweaters. Sometimes she drops the sewing or knitting needle on the floor but she cannot bend to pick it up because of backache.

The design brief:

Design and make a device for Rita's grandmother so that she can easily lift the sewing or knitting needle from the floor without bending.

Design criteria

The device should be

1. *Able to lift both sewing and knitting needle*
2. *Able to lift needle of weight 50 grams*
3. *Small enough or retractable such that it can easily be carried*
4. *Made from easy available materials*
5. *Cheap*
6. *Attractive*

- Make your design with appropriate measurements on the following sheets.
- Then make a model of your device by using everyday materials. You can suggest your own materials. We will procure it for you and let you know their costs.
- Your design and model will be judged against the above given criteria.

Our model looks like this from the front
Our model looks like this from the side
Our model looks like this from the top

a) Our model is made in this way…

b) Our model will work in this way…

c) The materials that we used to make our working model are…

Appendix V

Design evaluation sheet

Name of your group____________________________

Place a tock mark against each of the criteria in the table below to indicate your option. Do this for every group.

Design of Group 1___________________________

Evaluation of design	Yes	Not sure	No
Does it solve Rita's grandmother's problem?			
Is the design clear?			
Is it safe to use?			
Is it easy to carry?			
Is it easy to use?			
Is it easy to make?			

Design of Group 2___________________________

Evaluation of design	Yes	Not sure	No
Does it solve Rita's grandmother's problem?			
Is the design clear?			
Is it safe to use?			
Is it easy to carry?			
Is it easy to use?			
Is it easy to make?			

Design of Group 3___________________________

Evaluation of design	Yes	Not sure	No
Does it solve Rita's grandmother's problem?			
Is the design clear?			
Is it safe to use?			
Is it easy to carry?			

Is it easy to use?			
Is it easy to make?			

Design of Group 4____________________________

Evaluation of design	Yes	Not sure	No
Does it solve Rita's grandmother's problem?			
Is the design clear?			
Is it safe to use?			
Is it easy to carry?			
Is it easy to use?			
Is it easy to make?			

Design of Group 5____________________________

Evaluation of design	Yes	Not sure	No
Does it solve Rita's grandmother's problem?			
Is the design clear?			
Is it safe to use?			
Is it easy to carry?			
Is it easy to use?			
Is it easy to make?			

Design of Group 6____________________________

Evaluation of design	Yes	Not sure	No
Does it solve Rita's grandmother's problem?			
Is the design clear?			
Is it safe to use?			
Is it easy to carry?			
Is it easy to use?			

Is it easy to make?			

Design of Group 7___________________________

Evaluation of design	Yes	Not sure	No
Does it solve Rita's grandmother's problem?			
Is the design clear?			
Is it safe to use?			
Is it easy to carry?			
Is it easy to use?			
Is it easy to make?			

Appendix W

Product evaluation sheet

Name of your group___________________________________

Place a tick mark against each of the criteria in the table below to indicate your option. Do this for every group.

Product of Group 1___________________________

Evaluation of product	Yes	Not sure	No
Does it solve Rita's grandmother's problem?			
Does it look good?			
Is it safe to use?			
Is it cheap?			
Will it last long?			
Is it easy to carry?			
Is it easy to use?			
Does it work well?			

Product of Group 2___________________________

Evaluation of product	Yes	Not sure	No
Does it solve Rita's grandmother's problem?			
Does it look good?			
Is it safe to use?			
Is it cheap?			
Will it last long?			
Is it easy to carry?			
Is it easy to use?			
Does it work well?			

Product of Group 3____________________________

Evaluation of product	Yes	Not sure	No
Does it solve Rita's grandmother's problem?			
Does it look good?			
Is it safe to use?			
Is it cheap?			
Will it last long?			
Is it easy to carry?			
Is it easy to use?			
Does it work well?			

Product of Group 4____________________________

Evaluation of product	Yes	Not sure	No
Does it solve Rita's grandmother's problem?			
Does it look good?			
Is it safe to use?			
Is it cheap?			
Will it last long?			
Is it easy to carry?			
Is it easy to use?			
Does it work well?			

Product of Group 5____________________________

Evaluation of product	Yes	Not sure	No
Does it solve Rita's grandmother's problem?			
Does it look good?			
Is it safe to use?			
Is it cheap?			
Will it last long?			
Is it easy to carry?			
Is it easy to use?			
Does it work well?			

Product of Group 6____________________________

Evaluation of product	Yes	Not sure	No
Does it solve Rita's grandmother's problem?			
Does it look good?			
Is it safe to use?			
Is it cheap?			
Will it last long?			
Is it easy to carry?			
Is it easy to use?			
Does it work well?			

Product of Group 7____________________________

Evaluation of product	Yes	Not sure	No
Does it solve Rita's grandmother's problem?			
Does it look good?			
Is it safe to use?			
Is it cheap?			
Will it last long?			
Is it easy to carry?			
Is it easy to use?			
Does it work well?			

1. The best thing that we liked about our model is…
   ____
2. The worst thing that we disliked about our model is…
   ____
3. We could have made our model better by…
   ____
4. I have learnt...
   ____

Appendix X

Tongs Task in Activity Trial

1. What do you think the following objects are used for?

Object A	***Object B***	***Object C***	***Object D***

2. Who generally uses these objects?

Object A	***Object B***	***Object C***	***Object D***

3. Where are these objects used?

Object A	***Object B***	***Object C***	***Object D***

4. What materials are used to make these objects?

Object A	***Object B***	***Object C***	***Object D***

5. What do you think is the cost of each of these objects?

Object A	***Object B***	***Object C***	***Object D***

6. Look for ways in which some objects are similar and some are different. Now sort the given objects into groups (2 or 3 groups) by placing all the similar objects together. Write down the number of groups you have formed _____________

7. (a) For each group that you have formed, list in the table below the objects under the group.
(b) Give a title to each group that you have formed.

Group 1	***Group 2***	***Group 3***
Group 1 title___________	***Group 2 title___________***	***Group 3 title___________***

8. Explain below how the objects in each group are alike (why they were put in the same group).

Group 1 title___________
Explanation:
Group 1 title___________
Explanation:
Group 1 title___________
Explanation:

9. Now compare the objects in each of the groups that you have formed. Which object in each group do you think is better? Why?

Group 1: ***Name of the better object:***	*Object ___ is better because...*
Group 2: ***Name of the better object:***	*Object ___ is better because...*
Group 3: ***Name of the better object:***	*Object ___ is better because...*

10. Rate all the objects by circling one of the given 5 options

		Write in this column the criteria you have used to rate these objects
Object A	Very bad/ Bad/ Okay/ Good/ Best	
Object B	Very bad/ Bad/ Okay/ Good/ Best	
Object C	Very bad/ Bad/ Okay/ Good/ Best	
Object D	Very bad/ Bad/ Okay/ Good/ Best	

11. For each of the objects can you suggest other ways in which the objects can be used?

Object A	***Object B***	***Object C***	***Object D***

12. How would people manage if these objects did not exist? Give your ideas and suggestions. ____

13. For each quality, circle any one of the 3 options given under each object.
Yes= 1; Not sure= 2; No= 3

Qualities	***Object A***	***Object B***	***Object C***	***Object D***
Easy to maintain	1 2 3	1 2 3	1 2 3	1 2 3
Safe to use	1 2 3	1 2 3	1 2 3	1 2 3
Reduces physical effort	1 2 3	1 2 3	1 2 3	1 2 3
Costly	1 2 3	1 2 3	1 2 3	1 2 3
Looks good	1 2 3	1 2 3	1 2 3	1 2 3
Innovative/ novel	1 2 3	1 2 3	1 2 3	1 2 3
Eco-friendly	1 2 3	1 2 3	1 2 3	1 2 3
Can be improved/ made better	1 2 3	1 2 3	1 2 3	1 2 3
Easy to learn how to use	1 2 3	1 2 3	1 2 3	1 2 3
Modern	1 2 3	1 2 3	1 2 3	1 2 3
Durable/ will last longer	1 2 3	1 2 3	1 2 3	1 2 3

14. Can you think of any way/s in which any of the given objects can be improved?
Yes/ No

15. Which objects? ____

16. What changes would you like to make in the object/s?
____
____

17. Select one object of your choice and suggest ways to improve it by redesigning and drawing it.

Object _____ Original	***Object _____Redesigned***

Appendix Y

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 2008; 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:

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

- To develop design-based activities through trials among urban middle school students;
- To assess the influence of design-based activities on middle school students' ideas about design and designers and
- 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:

- What are students', teachers' and designers' ideas of and attitude towards design and designers?
- What specific activities can be developed for Indian middle school students to engage them in designerly thinking?
- What is the relation between students' design activities and their understanding of design?
- 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.

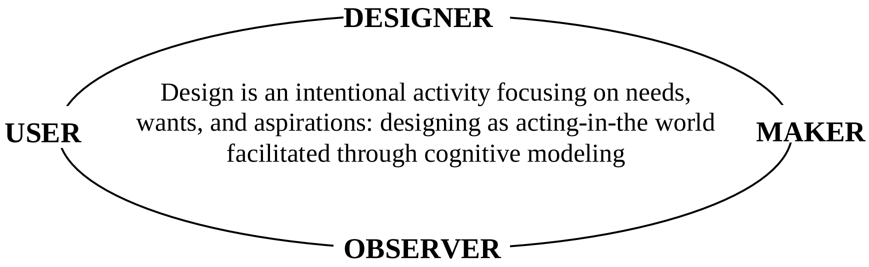


Fig.1.1 Four roles of students in a design classroom offering complementary perspectives on learning-through-designing (Roberts, 2005)

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.

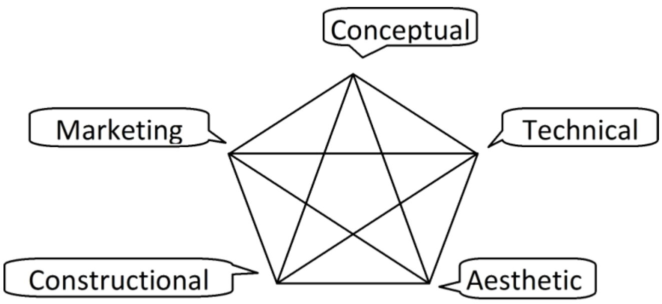


Fig. 1.2 The Design decision pentagon (Barlex, 2007)

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).

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

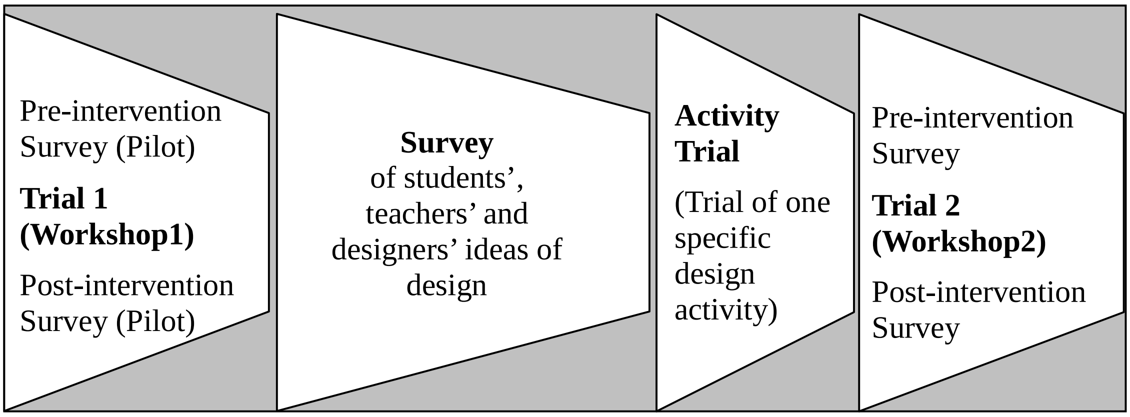


Figure 1.3 Progression of the research study

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*' (Archer in Eggleston, 1994: 26). 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 (2008), 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-

- resolve ill-defined problems
- adopt solution-focusing strategies
- employ abductive/productive/appositional thinking and
- 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 (2005), Schön (1983), Simon (1996), Lawson (1980) and Cross (2001, 2006, 2011). Studies in design thinking have explored how designers frame or structure the problems (Cross 2004), design ability in novices and experts (Cross and Lawson, 2005; Cross 2004; Dorst and 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 and Trebell, 2007 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’ (Barlex, 1998). 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., 2009a; 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 and Initiatives for Sustainable Technologies and 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 and 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:

- 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.
- 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.
- 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..

- 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.

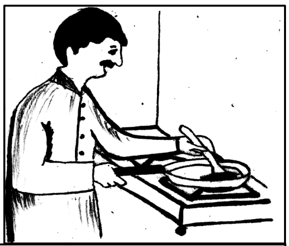


Fig. 3.1 'Making a new dish'
Male version of Section D

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., 2009a). 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

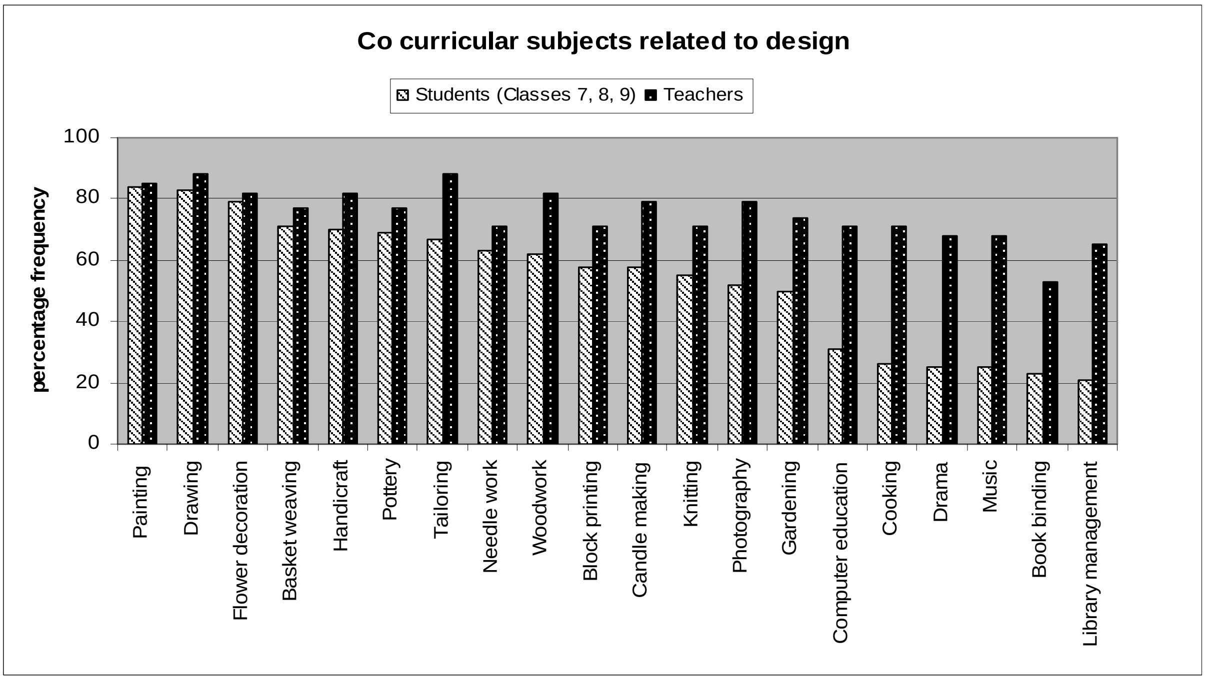
When asked to give Indian words for design, 74% middle school students and 88% teachers wrote different Indian words for the word ‘design’. Most words were in Hindi and Marathi and some were in English as well. About 77% and 51% of the words generated by students and teachers respectively, were related 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.



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

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.

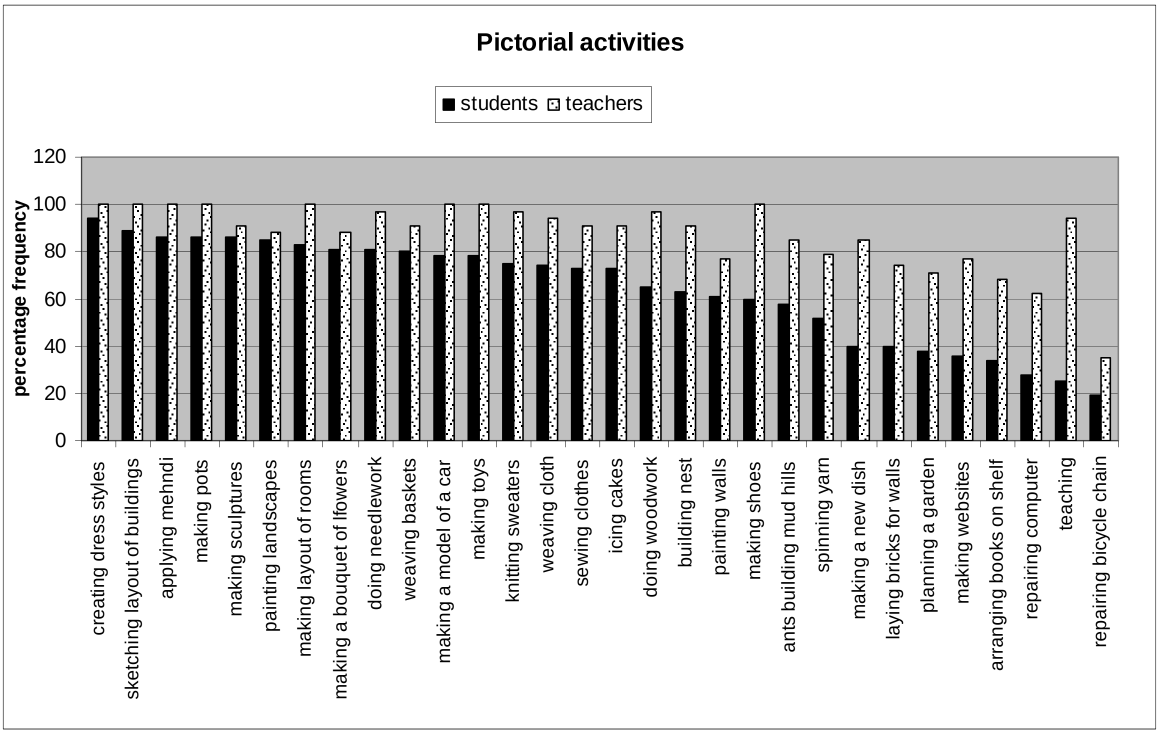
Regarding the skill-based traits, it was observed that both students and teachers considered designers to be mostly organized (87%), interested in ideas (84%), artistic (78%), and scientific (71%). About 57% of the sample considered that designers were practical worker.

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).

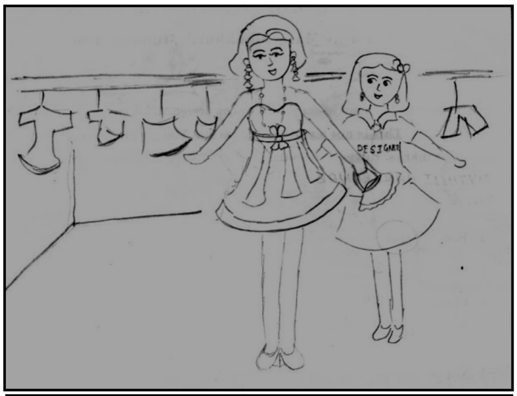


Fig 3.3: A female designer dressing up a female model, (a girl of Class 8)

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 and 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 and 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.

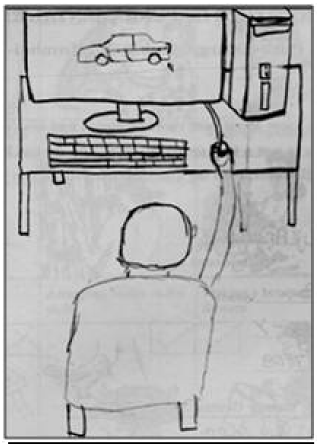


Fig. 3.5 A car designer designing on computers (a boy from Class 8)

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.

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

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.

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

- Handling and analyzing a few familiar artefacts,
- Reviewing the history of a familiar artefact,
- Handling unfamiliar artefacts, exploring and identifying them,
- Designing an artefact (without making in the 1st trial; with making in the 2nd trial)
- 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.

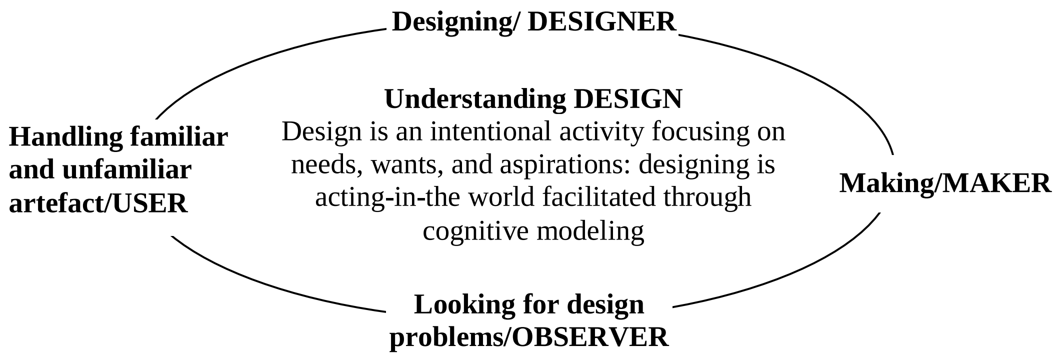


Fig 4.1: Four Roles of students in a design classroom. Adapted from Phil Roberts (2005)

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	• Introduce students to the structure and function relationships of artefacts;	*User*

Activity	Aim of the Activities	Role of students
artefact	• 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;	
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*
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 and 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 and 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., 2009b).

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.

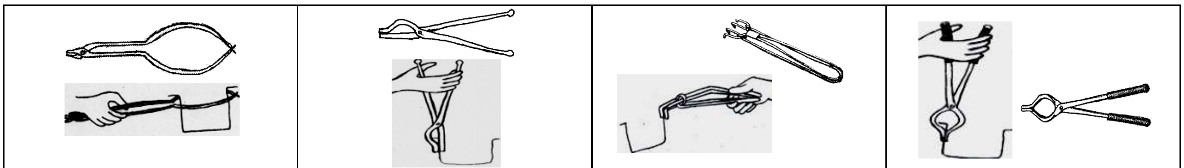
While handling the sharpener, students often probed them with whatever was available with them at the time, such as finger, pen, pencil, handkerchief and paper.

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., 2011a). 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).

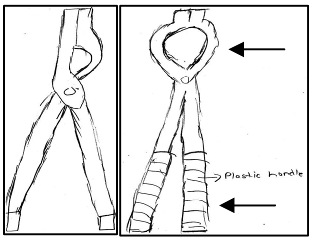
All dyads used the data obtained during testing in generating both the categorising and evaluative criteria. The 3 dyads sorted tongs into groups based on one or more than one of these different qualifying criteria such as *appearance*, *function* and *materials* and *ergonomics*. The criteria employed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



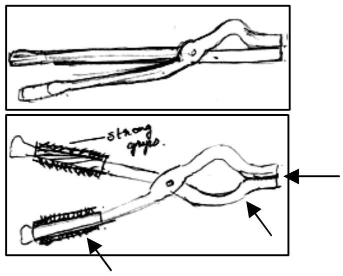
Tongs A	Tongs B	Tongs C	Tongs D

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

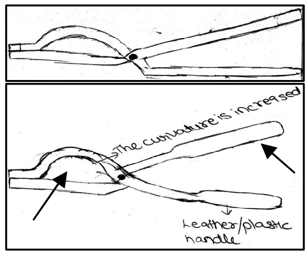
As improvements, student either suggested addition of a new component in their redesign or suggested modification. All the 3 dyads seemed to have assumed the perspectives of users and mainly focused on achieving functional efficiency and providing better ergonomics to users while using the tongs.



Dyad 1



Dyad 2



Dyad 3

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 Schön (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.

On reaching old age some people have difficulty in bending to pick up fallen things from the floor. Rita's grandmother is very old and also has a problem with her vision. She cannot sit on the floor because of her backache. So she usually sits on a chair or on sofa and sews clothes or knits sweaters. Sometimes she drops the sewing or knitting needle on the floor but she cannot bend to pick it up because of backache.

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

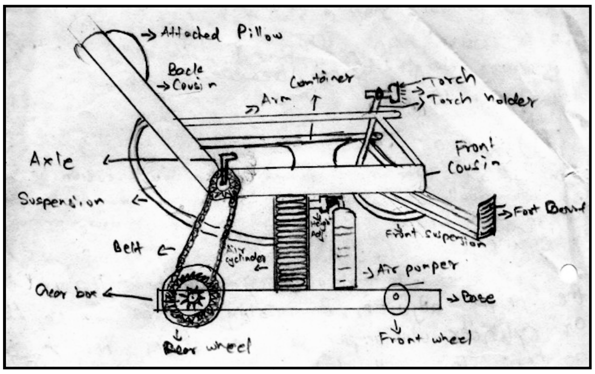
Creativity in students' design was observed with respect to the following features as mentioned in section 5.1, i.e. using imagination, pursuing purposes, being original, and being of value.

(i) Using imagination

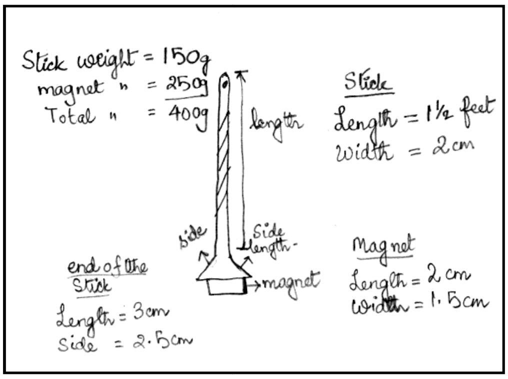
All the groups in Trial 1 (except 1 group) clearly drew and wrote about their best designed solution suggesting that they could mentally visualize the images of the product (Fig. 5.4).

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.

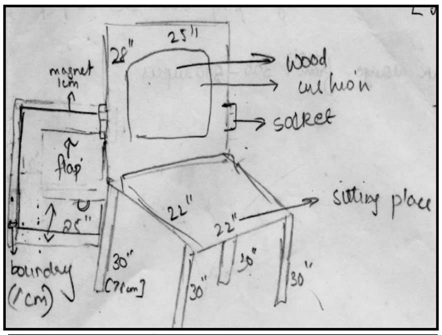


Fig, 5.4 A designed solution by a boys group in Trial 1



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

(ii) Pursuing purpose



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

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).

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.

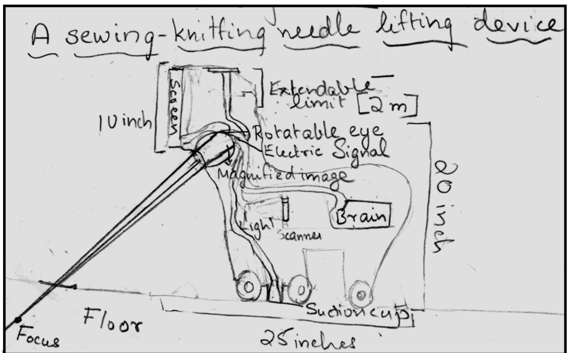


Fig 5.7: A boy dyad in Trial 1, using radio sensors and scanning technology

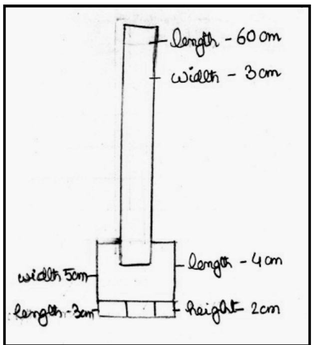


Fig 5.8: A girl dyad in Trial 2 using magnet

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. However it was observed that students did make conceptual decisions by suggesting what would be purpose of their overall design. For example, they decided whether their designs will be used to lift metallic or non-metallic needles.

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.

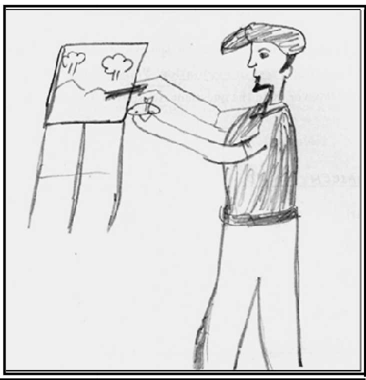


Fig. 6.1: A pre intervention drawing of a designer by a student

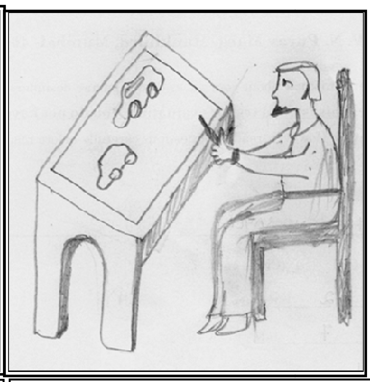


Fig. 6.2: A post intervention drawing of a designer by the same student

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:

- 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.
- 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.

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

  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.