Conjecture - Analysis Model for Integrating Sustainability in Design Pedagogy

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Doctor of Philosophy

by

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Approval Sheet

Thesis entitled **'Conjecture - Analysis Model for Sustainability in Design Pedagogy'** is approved for the degree of Doctor of Philosophy.

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Place: IDC, IIT Bombay

Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or falsified any ideas/data/fact/source in my submission. I understand that my violation of the above will cause for disciplinary action by the Institute and can also evoke penal action from the sources, which have thus been cited, or from whom proper permission has not been taken when needed.

Rupa N. Agarwal

Abstract

Design will do well to have sustainability as the meta-objective of every design project. But concerns expressed in design discourse show that this is not so. Even though there are many approaches, techniques, metrics and indices for sustainability, it is not effectively integrated into design. It is the quest of this study to find the reasons why effective integration of sustainability into design does not happen. One of the major gaps found, was that designerly ways of dealing with sustainability was missing. Adopting sustainability measures developed in other domains do not have great success in design. The premise therefore is that design is not responding to sustainability with its true nature. The larger purpose of this enquiry is therefore to align the ontological nature of design with the epistemology of sustainability. This alignment can be achieved through conjectures. Further, it is proposed that sustainability can be addressed effectively in the domain of design through Conjecture Analysis Model for Sustainability (CAMS).

Conjectures are whole or partial design solutions, which have been implemented in previous instances. These solutions may come from the personal experience of the designer or from an external source. The conjectures further find application in new design situations. A pragmatic view has therefore been taken to integrate sustainability conjectures in the C/A model. It was found that this model could be leveraged as a pedagogic tool to integrate sustainability conjectures in student design projects.

Use of conjectures is not new in design pedagogy, in fact the Conjecture/Analysis model, it has been argued, is more suitable for design. But the fact is that Conjecture analysis is not being used in a structured or usable form nor has been represented in a visual form as a model. Limited efforts are made in the direction of articulating C/A model, and its application in sustainability pedagogy is lacking. The overarching methodology is action research. The main purpose of action research is to improve practice through developing reliable procedures to guide students towards sustainability. This methodology has guided this study in two ways.

1. To develop the model progressively along the action research stages.
2. To use action research as theory in action by demonstrating that conjectures are the link between the theoretical constructs of design ontology and sustainability epistemology.

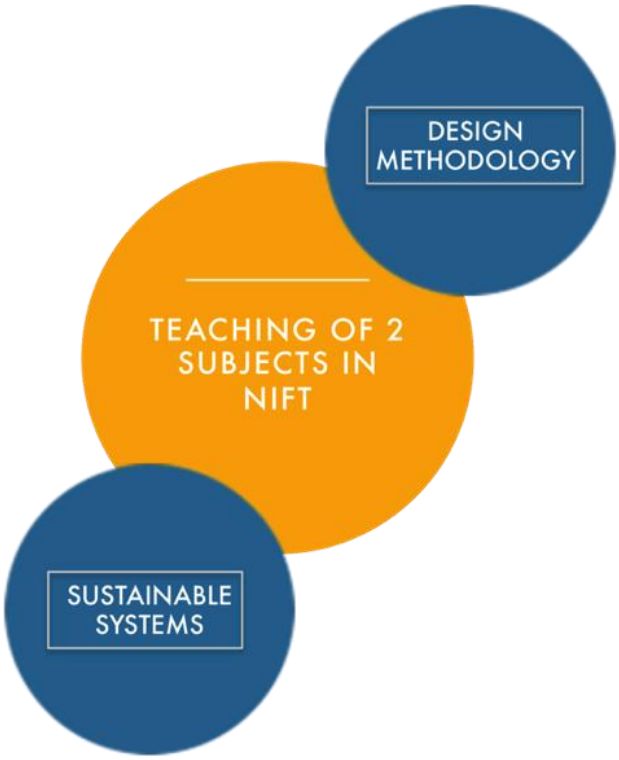
The research contributions are

1. Developing a model representation for pedagogy of Conjecture/Analysis for Sustainability (CAMS). It is essentially a model for converting unsustainability consequences into sustainability conjectures. It is proposed that this model should be used as a teaching-learning aid for sustainability.
2. To expand the vocabulary of conjectures by identifying typologies used in design process.

One of the main challenges facing the development of the model is to address not only environmental sustainability issues but include other aspects of sustainability such as social, cultural and lifestyle and consumption patterns. By doing this, the generalizability of the model increases to a wider range of design problems and has relevance to different design disciplines.

Organization of Chapters

Chapter 1: Introduction

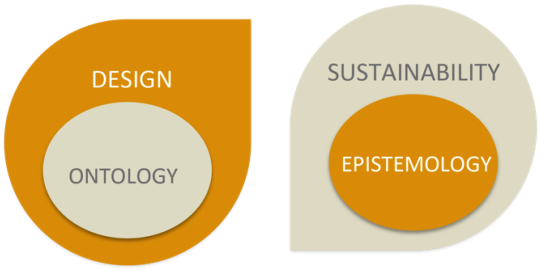


The motivation for this research comes from the teaching experience of the author which gives rise to a fundamental question. The question is whether the method of teaching sustainability is entirely different from the way design is taught? The answer to the question is in the negative. This answer guides the research, to articulate the barriers to integration of design and sustainability in pedagogy and find ways to deal with them.

The thesis postulates that design and sustainability can find a common ground to address the unsustainability that surrounds us. The common ground is where the basic defining features of design (ontology) and knowledge of sustainability (epistemology), come together. The larger purpose of this enquiry is therefore to align the ontological features of design with the epistemology of sustainability discourse. This alignment will be looked at with a lens of design pedagogy where the aim is to find a suitable design pedagogic method for sustainability. An overview of the two large domains of design and sustainability is gained to understand the historical development and some main concerns with regards to the two domains.

The thesis takes the stance of theory building where existing theories are questioned and thereby understood. Through this approach a new theoretical understanding is gained.

Chapter 2: Conceptual, Theoretical and Methodological frameworks



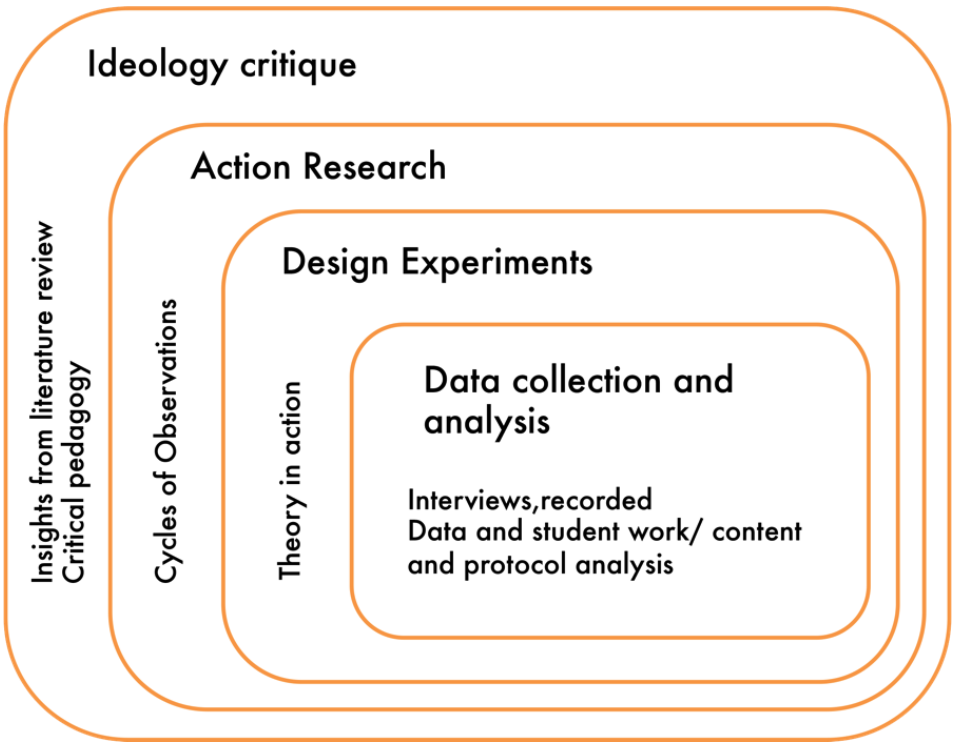
This chapter will present a more focused view within the two domains of design and sustainability, so that an explicit link between them can be established. The entire chapter has been divided into three sections: theoretical, conceptual and methodological.

The theoretical framework is based on broad research problems and questions. The problems identified deal with how 'designerly' ways and means of integrating sustainability into design process is not adopted in design pedagogy; and that sustainability pedagogy for design either gets too specific in teaching particular techniques to certain problems or sidelining the issue completely. The research questions, which emerge from mulling over the aforementioned problems are: (1) What are the defining features of design and what is the epistemology of sustainability where design can contribute? (2) How can sustainability approaches be imparted through design process in design pedagogy? These problems need to be thought about and these questions need to be raised because if ontological features of design integrate sustainability epistemology, there are greater chances of sustainability becoming the meta-objective of design process. The proposition of the theoretical framework section is to find a suitable method to incorporate sustainability knowledge into design process.

The conceptual framework section picks the thread from theoretical framework and identifies conjecture/analysis as a suitable approach to fulfill the above proposition. It sets out a matrix of clarifying the research objectives, hypothesis, data sources, collection methods and analysis methods. The advantages and disadvantages of the conjecture/analysis approach are discussed through supporting literature.

The methodological framework discusses the overall top-down and bottom-up approach followed to answer the research questions. Top-down approach is a theoretical approach through literature. The bottom-up approach is the empirical work conducted with students through action research.

Chapter 3: Methodology and Research design

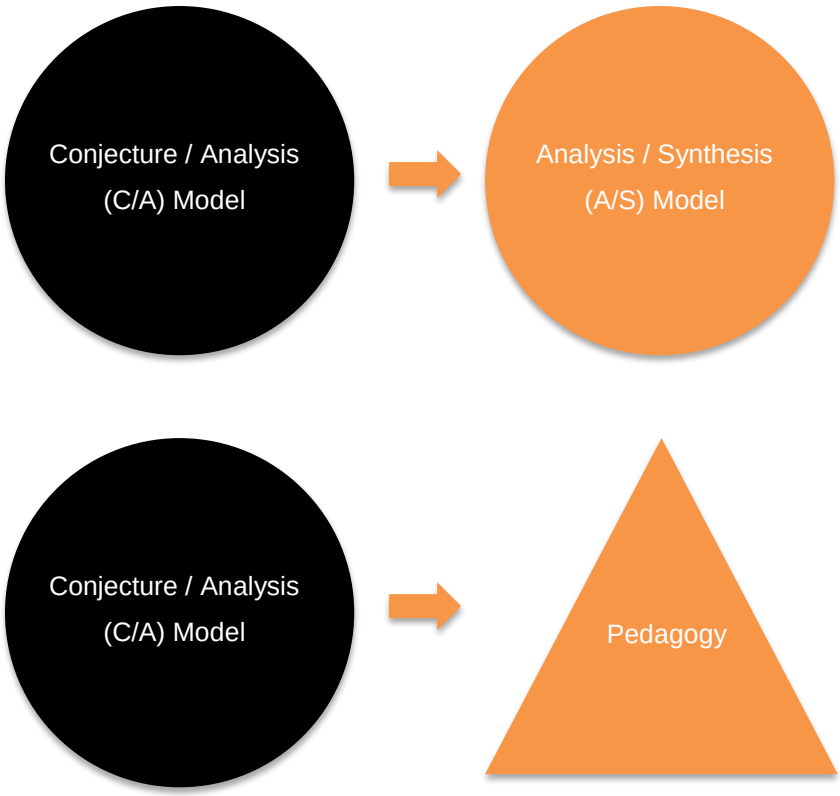


The choice of methodology is justified in this chapter. It is based on best 'fit' which fulfills the objectives. As suggested in the methodological framework of the previous chapter, action research is the primary method of investigation chosen for the empirical work. Action research is widely used in educational research. The author is in a unique position to carry out action research as a teacher in a design institute. This methodology has guided this study in two ways.

1. To develop the model progressively along the action research stages.
2. To use action research as theory in action by demonstrating that conjectures are the link between the theoretical constructs of design ontology and sustainability epistemology.

The primary objective of action research is to improve practice. The objective of the author also is to improve practice by incorporating sustainability approaches in design pedagogy. Under the umbrella of action research a nested methodology is suggested. The nested methodology consists of gauging the present status of design teaching, evolving a tentative model for sustainability pedagogy and validating the model through empirical observations which are part of the action research. The chapter concludes with the explanation of the entire research design with all its stages.

Chapter 4: Use of conjectures in Design Pedagogy

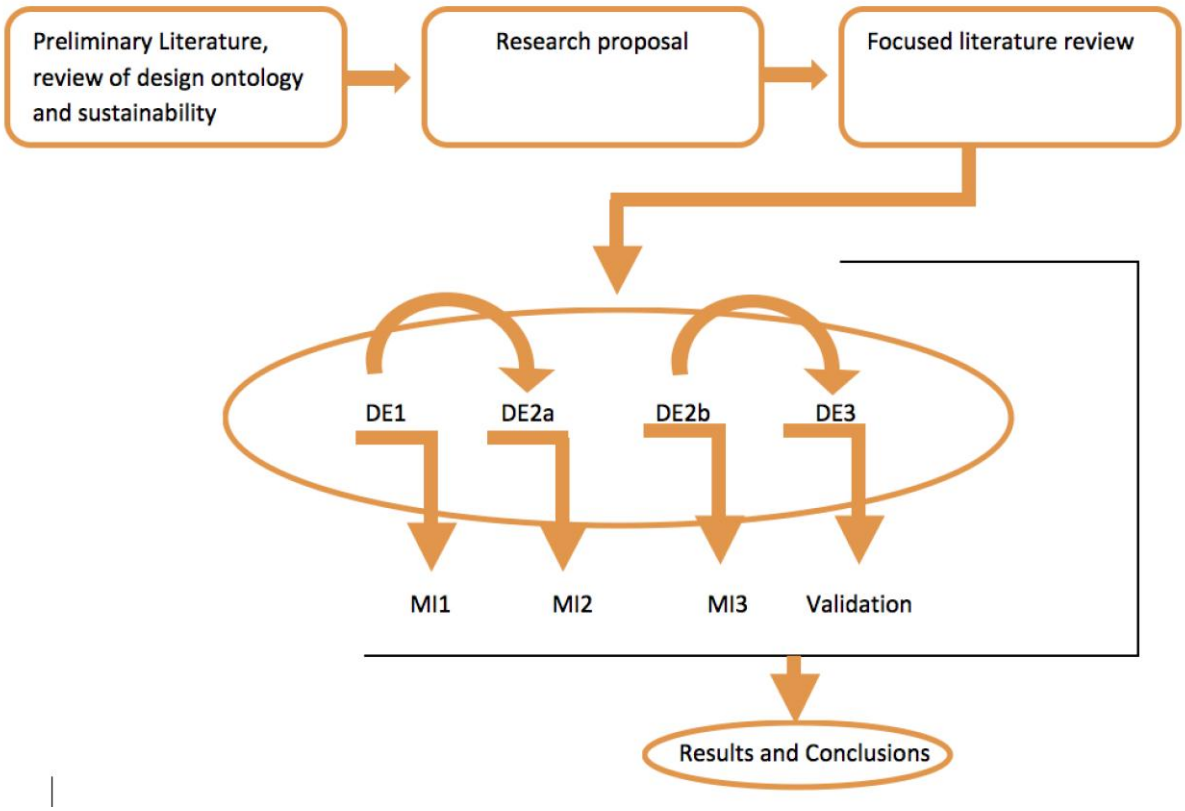


On the onset, literature about current status of sustainability pedagogy is discussed. Glimpses of conjecture-based pedagogy, is seen in sustainability. Wherever it is not used, there is scope of using it. The analysis/synthesis and conjecture/analysis models have been compared and discussed as part of the ontology section of literature review. It is taken up here again for review. In this chapter the two models are understood in the context of pedagogy.

Action research is intimately connected to ideology critique. The critique developed by the author for this research is a combination of author's experience of teaching design and sustainability and empirical observations conducted of another instructor's studio teaching. In

fact the motivation for the research as mentioned in the introduction (Chapter 1) are the critical questions raised in the mind of the author, while teaching design and sustainability subjects.

Chapter 5: Development of Conjecture-Analysis Model for Sustainability (CAMS) through iterations

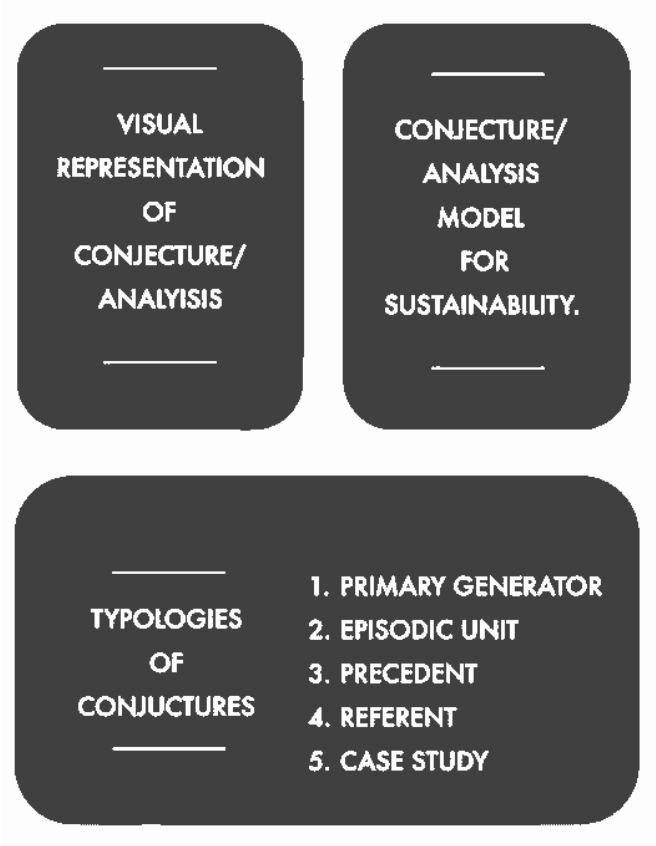


This chapter describes the empirical observations made to derive the conjectures used while designing. In the nested methodology, design experiments have been chosen as the method to collect data. Different pedagogic situations have been chosen to conduct the design experiments, which describe more detailed insights gained into the conjectures that should be used to facilitate sustainability pedagogy. These are action research procedures conducted with a standpoint of teacher-as-researcher. After each step the insights are matched with the model and revisions are made. The reasons for making the revisions are also discussed. Model iterations 2 and 3 are described in this chapter.

Chapter 6: Flexible application of Conjecture-Analysis Model for Sustainability (CAMS)

A set of observations was conducted with three students' dissertation projects. The projects were related with sustainability. The observation revealed that the students used the model in a flexible manner, not in the same order prescribed in model iteration 3. Though all the elements were present, the manner of using it largely depended on the context. The usage pattern of conjectures within the C/A framework has been mapped for each project.

Chapter 7: Summary and Conclusions



This chapter deliberates on the conclusions drawn from the research. It discusses how the research questions raised in the beginning have been addressed. The main task laid out in the beginning of developing a model for sustainability design pedagogy has been achieved. However, the observations also led to yet another area of contribution, which is- typologies of conjecture. This is an important contribution as it further articulates and lends credence to the design activity for sustainability, which follows the C/A model.

The robustness of the model has been discussed citing various insights from the research. A very important part of the conclusions are the developing pedagogic patterns with the community of design educators at large. The model can be generative in as much as creating a case each time it is used. This when documented creates material for other instructors to teach better.

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Chapter 1

Introduction

1.1 Background

Design and sustainability, are not new concepts but they have only been rightfully instituted as formal areas of knowledge for about six decades now. In spite of sustainability being on design's consciousness, the two have never found a common ground to address the unsustainability, which surrounds us. This thesis postulates that a common ground can be found. The common ground is where the basic defining features of design (ontology) and knowledge of sustainability where design can contribute (epistemology) come together.

Ontology is the nature of an entity, its characteristics and the reason for it being the way it is. And how that nature distinguishes it from any other entity. Epistemology is the 'theory of knowledge', the body of knowledge gained over time (historical) and the factors and arguments, which shaped it (philosophy). It can be illustrated through the example of 'stone'. Stone exists in our surroundings. What is stone? What makes stone a stone and not wood? These are ontological questions. What do we know about stone? How do we know it? Will a

sculptor's knowledge of stone be the same as a geologist's or an architect's? What are the boundaries to each one's knowledge? These are epistemological questions.

The larger purpose of this inquiry is therefore to align the ontological features of design with epistemology of sustainability discourse. This alignment will be looked at with a lens of design pedagogy. The aim is to find suitable design pedagogic method for sustainability. Jones, in fact describes sustainability as "a condition or a set of conditions which has normative and ontological dimensions for any discipline (Jones, 2010). The question is whether the discipline of design adopts sustainability as a normative and ontological dimension. Looking at the present scenario, it seems that it does not. When we dig deeper we find that there are challenges to the integration of the two domains. The key ideas of the thesis are linked to these challenges.

1.1.1 Situation of Crisis

This situation is explained as two points of crisis (Margolin V. , 1998):

(1)'Crisis of Will", and (2) 'Crisis of Imagination'. The former crisis suggests that there is unwillingness amongst the designers [and students of design] to assess their work for unsustainable consequences. The latter crisis suggests that, "Too few examples of projects that are directed [towards sustainability, which] serve to stimulate or inspire designers and [students of design]. While such projects do exist, they are for the most part, closed out of academic design courses and professional publications". It is important for sustainability as it is for design to have a database of examples of previously done projects. Teaching is better received and is relevant to students when this is done. The students are encouraged to initiate sustainability thinking right at the onset of the design process and identify pertinent sustainability cases for their projects. These cases may be from varied disciplines and not necessarily from the area of design.

1.1.2 Tenacity of design styles[1]

Tenacity of design styles (Cherkasky, 2004) is another kind of crisis. Cherkasky is interested in how one design style becomes dominant over the others. And further, he looks at how dominant design style might be disrupted, providing openings for change.

We encounter tenaciousness of 'unsustainability' in design pedagogy on many occasions. There are various reasons why unsustainability has become the dominant design style amongst students of design. This thesis explores the reasons for this dominance through critical pedagogy and suggests ways of disrupting it. Amongst students and faculty, it takes much effort to change the worldview and adapt to sustainable ways of thinking.

1.1.3 Embededness of unsustainability in everyday practices

Unsustainability gains legitimacy through its embededness in the system. Vance Packard's (Packard, 1963) argument adds nuances to the discussion of embededness through the description of planned obsolescence.[2] Companies plan the time until which a product is useful. When the product ceases to be useful another product is introduced in the market. This maintains the production-consumption cycle.

Austrian philosopher Ivan Illich explains embededness in civic policy (Illich, 1973). Policies are forced to tow the line in spite of being aware of the unsustainable consequences.[3]

Shove also builds her argument on unsustainability gaining legitimacy through embededness in the system. The key idea in her argument is that consumption is a reasonable

[1] Cherkasky borrowed the term 'thought style' from Fleck (Fleck, 2012) and used it as design style. In his book, 'Genesis and Development of a Scientific Fact', which was originally published in German in 1935, Ludwig Fleck used concepts of 'thought style' and 'thought collective' to describe how a belief becomes legitimatized as a fact.

[2] Brook Stevens, a leading Industrial designer talked about 'planned obsolescence' in a public lecture in the late 50s. Until then it was discussed in boardrooms, behind closed doors. Webster's dictionary defines obsolescence as 'out of use'. But in design terms 'going out of use' can be of three types- obsolescence of function where existing product becomes outmoded. Obsolescence of quality is, where a product breaks down, and obsolescence of desirability is, where a product 'wears out in our minds'.

[3] Ivan Illich describes how the US department of transportation wielded 'radical monopoly' by building national networks of smart highways with taxpayers' money. And further, people are encouraged to buy smart cars so that they can use the highways. Smart highways were a system of roads and other high-tech solutions provided to people. But the catch was that people had to buy smart cars in order to avail the facilities of smart highways, hence doing away with their earlier cars, which were now obsolete. As a consequence people to bought more and disposed more.

consequence of the existing options available to people (consumers). Over consumption is therefore inconspicuous, it is not directly intentional nor is it understood as such. Even social norms and conventions like 'Comfort, Cleanliness and Convenience' (Shove, 2007)[4] have unsustainability embedded in them. Inconspicuous consumption and the role of design in supporting the unintentional consumption is defined as the key problem to which there is a limited response.

It was found that, students understood sustainability better when the context of their projects is situated in the domain of everyday events where unintentional consumption happens. No designer aspires towards unsustainability. Unsustainability happens as a consequence of habitual behavior of stakeholders. The process of identifying unsustainability in situations is a recurring theme throughout the thesis. Design students are encouraged to identify unsustainable consequences and transform them into desirable sustainable situations using insights from previous successful designs and solutions.

1.2 Motivation for the Research

The overriding reason for embarking on this research is to improve the pedagogical approach, while teaching Design for Sustainability. The motivation and the initial research questions arose mainly from author's experience of teaching two subjects- (1) Design Methodology (DM 503), (2) Sustainable systems (SS 306); at the National Institute of Fashion Technology, Mumbai, India. The two main questions, which arose, were:

1. How is design pedagogy different from sustainability pedagogy?
2. Is there an entirely different method for teaching/learning sustainability in design?

The level of similarity of these two approaches suggests that an entirely new pedagogy need not be developed for learning and teaching of sustainability (Fletcher K. &., 2002). The challenge however is that, existing design approaches do not naturally lead to sustainability solutions. But one can choose an appropriate design approach, which

[4] Shove identifies the 3Cs (comfort, cleanliness and convenience) as the social construction of normality, but are 'hotspots of consumption'. She explains comfort through standardization of air-conditioning comfort across cultures. Cleanliness is explored by Shove through laundering and bathing habits and convenience through a plethora of things with which we surround ourselves.

already exists and look for ways in which it can be channelized to yield sustainable solutions.

1.3 Sustainability discourse

Most traditional cultures have been sustainable due to their small scale of operations. Functioning was contained within communities, which were naturally oriented towards social and environmental considerations. As things grew more complex, they had to be addressed at a global level. The sustainability debate at a global level started with two reports, namely, 'The Limits to Growth' (Meadows D. M., 1972) and 'Our Common Future' (Brundtland, 1987). So important were the issues discussed in the international coalitions and so impactful was the reporting that they spearheaded sustainability debate world over.

The Limits to Growth is a 1972 book about exponential growth in a finite world. It was funded by the Volkswagen Foundation and commissioned by 'Club of Rome'[5]. An important excerpt from the book (Meadows D. M., 1972):

Applying technology to the natural pressures that the environment exerts against any growth process has been so successful in the past that a whole culture has evolved around the principle of fighting against limits rather than learning to live with them. But the relationship between earth's limits and man's activities are changing.

'Our Common Future' is a report compiled by 'The World Commission on Environment and Development'. This was headed by the then prime minister of Norway, Gro Harlem Brundtland (Brundtland, 1987), therefore this report is also referred to as The Brundtland report. It defined sustainable development as the development, which satisfies the needs of the present without compromising the ability of future generations to meet their own needs [6]. The Brundtland report came under fire because of its anthropocentric bias. Wolfgang Sachs has been writing in the area on ecology and politics for many decades. He works in the

[5] Club of Rome is a global think tank founded in 1968 that deals with variety of international issues.

[6] Lester Brown introduced the concept of 'sustainability' in the early 1980s. He was the founder of the World Watch Institute. He defined a sustainable society as one that is able to satisfy its needs without diminishing the chances of future generations (Brown, 1982). 'Building a Sustainable Society' was also published as a paperback in the same year (1982). The cover quoted Brown's words, 'We have not inherited the earth from our fathers but we are borrowing it from our children.'

Wuppertal Institute for Climate, Environment, and Energy since 1993. His critical viewpoint about the Brundtland (Sachs, 1998) is:

Even bearing in mind a very loose definition of development, the anthropocentric bias of the statement springs to mind; it is not the preservation of nature's dignity, which is on the international agenda but to extend human-centered utilitarianism to posterity.

But on the other hand the commission report was responsible for important initiatives such as Factor 4[7] (Weizsacker, 1997), Factor 10[8] (Hinterberger, 1999), Kyoto Protocol[9], and Agenda 21[10].

The most relevant and recent initiative for the field of education is the UNDESD. The United Nations Decade of Education for Sustainable Development is a complex and far-reaching undertaking. The overall goal of the DESD is to integrate the principles, values, and practices of sustainable development into all aspects of education and learning. This educational effort will encourage changes in behaviour that will create a more sustainable future in terms of environmental integrity, economic viability, and a just society for present and future generations. DESD had implications for sustainability perspectives in all areas of education, design education included. Some of the notable organizations with regard to design, which got an impetus during DESD are: DESIS, ULSF and Cumulus.

[7] The concept aims for society to last twice as long or enjoy twice as much whilst using half the resources and placing half the pressure on the environment.

[8] It is the radical idea that humanity must reduce resource turnover by 90 percent on a global scale within the next 30 to 40 years.

[9] It is an international treaty, which was adopted on 11 Dec 1997 to fight global warming by reducing greenhouse gas concentration in the atmosphere.

[10] The broad mandate of Agenda 21 is then divided into six themes: quality of life, efficient use of natural resources, protecting global commons, managing human settlements, the use of chemicals and the management of human and industrial waste, and fostering sustainable economic growth on a global scale (Margolin, 1998).

Table1.1 Sustainability initiatives in design education

Design for Social Innovation and Sustainability (DESIS) Network	DESIS Network originates from three main international activities in the 2006-2008 period. European research EMUDE 2005; the UNEP Program 2008; the international conference, ”Changing the change”, 2008. The vision of DESIS is to drive: Design for social innovation Emerging sustainable ways of living Design schools as agents of change
Leaders for a sustainable future (ULSF)	The secretariat of University Leaders for a sustainable future (ULSF) was founded in 1992 as a direct result of the Talloires Declaration[11]. It identifies the urgent need for higher education and a ten-point action plan for incorporating environmental literacy and sustainability into university teaching and practices. ULSF has now become an independent entity in 2007, which functions as a virtual organization.
Cumulus	Cumulus was founded in 1990, operating as an association since 2001, recognized by UNESCO since 2011. Cumulus signed the Kyoto Design declaration in 2008. Cumulus offers wider international context for discussion and developments in education and research of art, design and media.

[11] The Talloires Declaration (TD) is a ten-point action plan for incorporating sustainability and environmental literacy in leading research operations and outreach at colleges and universities. This was composed in 1990 at an international conference in Talloires, France.

These initiatives are at once the mirror and a driver of interest of design schools in sustainability education. Many designers and design academics are now wholly dedicated to the cause of integrating sustainability in design education and more particularly, in pedagogy. The thesis borrows majorly from four of them, as follows.

Table 1.2 Integrating sustainability in Design pedagogy

	Author	**Argument**
1	(Margolin V. , 1998)	Sustainability should be the meta-objective of every design project.
2	(Manzini E. , 2003)	Looking at future scenarios in the 'Sustainability Everyday Project (SEP)'. He has incorporated the learnings into design and sustainability pedagogy.
3	(Shove, 2007)	Design for everyday life. Unsustainability is inconspicuous in our everyday life.
4	(Dewberry E. , 2011) (Dewberry E. &., 2002)	Contextualizing design within the domain of sustainability.

The thoughts of Margolin and Dewberry lead us to the epistemology of sustainability with regard to design. Further, we take forward the idea that contextualizing design within the domain of sustainability. This will help in making sustainability the meta-objective of every design project.

Shove's concept of inconspicuous consumption and Manzini's 'Sustainable everyday project (SEP)' have guided the empirical observations and contributed to the CAMS model proposed by the author.

1.4 Design discourse

The design discourse is really about the story of the philosophy of the two most influential schools of design- Bauhaus and HfG Ulm.

Bauhaus holds the unique position of singlehandedly changing the course of design. It started a new aesthetic, established a design philosophy where none existed and spearheaded a novel way of teaching design, which is relevant to this day, in its original form or with slight changes.

In 1919, the first director of Bauhaus, Walter Gropius, published his famous 'Manifesto'. The initial goal of the program he wrote, 'was to reunify the artistic disciplines of sculpture, painting, applied art and craft.' The 'workshop' was the sculptural basis of the Bauhaus method of teaching. Eliminating the academic connotation of the term 'professor', Gropius had the teachers called 'masters' and the students called 'apprentices' and 'journeymen' to put them into the context of real world trades (Lerner, 2005).

On the other hand, HfG Ulm's agenda was to scientise design. The philosophy was to build design solutions based on analytical rigour. The philosophy was based on the 'Ulm model', which is a more methodological and structured approach to pedagogy. It consisted of a basic course and introduction to consolidated theoretical disciplines. Fendeli (Fendeli, 2001) very aptly captures the philosophical discourse of early design schools.

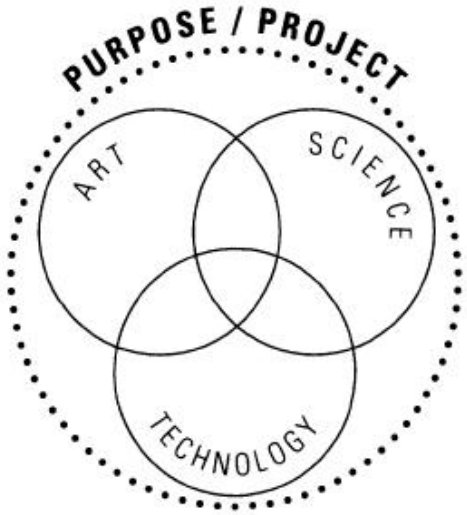


Figure 1.1 Archetype (U model) of Design curriculum. Source: (Fendeli, 2001)

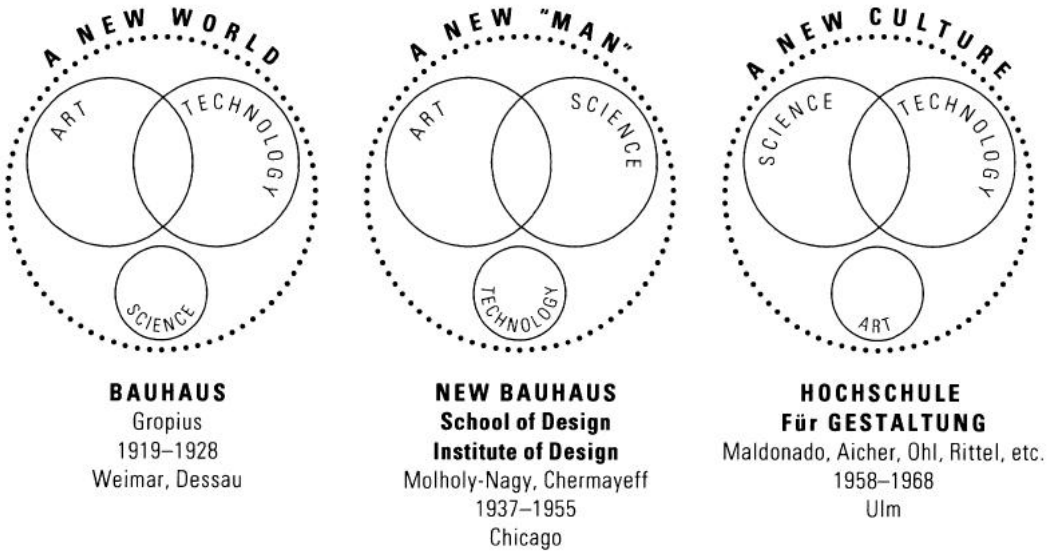


Figure 1.2 Three historical embodiments of Design education. Source: (Fendeli, 2001)

Another important thread in design discourse is the design methods movement in 1960s. The Conference on Design Methods, held in London in September 1962, is generally regarded as the event, which marked the launch of design methodology as a subject or field of enquiry. The desire of the new movement was even more strongly than before to base design process (as well as products of design) on objectivity and rationality (Cross N. , 2006).

From the 60s until now there have been many definitions, interpretations of design. New areas of design have emerged. But what remains almost unchanged is the most widely accepted (and practiced) logical structure of the design process as below (Fendeli, 2001).

'A need, or problem, is identified; situation A.

A final goal or solution is imagined and described; situation B

And the act of design is the causal link by which the situation A is transformed into situation B'.

The above structure worked very well as a distinguishing feature for design methods, but garnered seeds of unsustainability. The final solution (situation B) was always considered to be an artifact leading to a grossly material culture. And as we now realize that we are obsessed with materiality, which has ecologically harmful. But one can sense a change in the design community. A new logical structure that is now emerging as the structure of design process is:

Instead of a problem, we have a state A of a system.

Instead of a solution, we have a state B of a system.

The designer and the user are part of the system (stakeholders)

This shift in design thinking adapts itself very well to the sustainability discourse. The new systems approach urges designers to work within a system and design solutions to be 'situated' within the system. This structure also suggests that the designed state B need not be an artifact, which paints future scenarios of immateriality.

The thesis will delve deeper into the new structure of design process and will deliberate on how it can be given a usable form, which can be used in design pedagogy.

Some important thinkers have marked the milestones in the discussion on Design ontology, which has shaped the theoretical understanding. These have been listed and briefly described below.

Table 1.3 Important arguments in design discourse

	Author	**Argument**
1	(Rittel H. &., 1973)	Problems in design are wicked. They contain uncertainty and complexity. Understanding the

		problem and interpreting appropriately is the key.
2	(Schön, 1987)	Design situations cannot be resolved with ‘technical rationality’ but have to be resolved reflectively.
3	(Jonas, 2001)	Design needs theories, and theories which are not limited or too specific in application but which are generative.
4	(Cross N. , 2006)	Just like ‘science’ and ‘humanities’ ‘design is a third discipline which has its own epistemology and therefore ‘Designerly ways of knowing’.
5	(Simon, 1996)	Design is the creation of the artificial.
6	(Buchanan R. , 1992)	Design problems are 'indeterminate' and 'wicked' because design has no special subject matter of its own apart from what a designer conceives it to be.

1.5 Operational challenges of integrating sustainability into design curriculum

Let us recall the discussion in section 1.1.1 and 1.1.2 where we talked about situation of crisis, tenacity of design styles and the accepted approach of design process. We see the manifestations of these challenges in the delivery of curriculum in design schools. Sustainability pedagogy either gets too specific in teaching particular techniques to particular problems; or the issue gets completely sidelined in the entire design process.

Ramirez further found in his worldwide survey that, 'overwhelming majority of design educators profess deep-seated beliefs in the importance of teaching sustainability in the studio, yet only half use sustainability criteria in assessing student projects' as the design evaluation of student projects were already 'full' with other criteria mentioned above (Ramirez, 2007). He says:

Although academics consider sustainability as a topic that design students need to be exposed to, the classic design criteria- aesthetics, functionality, ergonomics, manufacturability etc.- are still deemed to be the overriding determinants of what constitutes good design, and impacts to society or to the environment do not hold the same significance.

Even though instructors and students are very keen to adopt sustainability into their projects the above reasons seem to be barriers in doing so.

Efforts in this direction continue to be made. In response to the need of sustainability knowledge being made available for design in Higher Education, Kate Fletcher and Emma Dewberry developed a multimedia web-resource. This was a UK government funded project. It was named Demi- Design for the Multimedia Implementation project. Design educators in UK used this widely. The figure below represents how the authors made sense of the present situation of integration of design and sustainability domains.

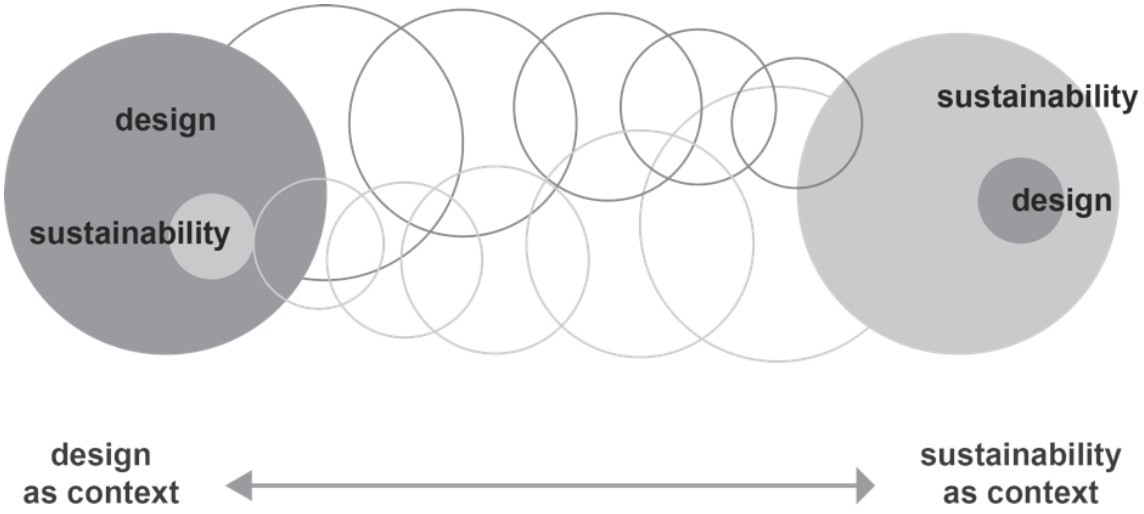


Figure 1.3 Range of possible starting points for education in design for sustainability. Source: (Fletcher K. &., 2002)

At one end is a ‘design context’ where sustainability is ‘understood’ within the frame of reference of current design activities and priorities. At the other end of the continuum is the ‘sustainability context’. Here design is viewed as a dimension of sustainability (rather than sustainability being viewed as a dimension of design as at the other extreme) (Fletcher K. &., 2002). Dewberry later critiqued the earlier work to come up with very useful insights. While Demi may have succeeded in communicating knowledge about sustainability it failed to transform design learning to challenge the core focus of market driven design activity (Dewberry E. , 2011). Limits to sustainable change through design are bounded by the limits of the system in which design operates. An updated version of the previous figure was presented in a later paper by the same authors.

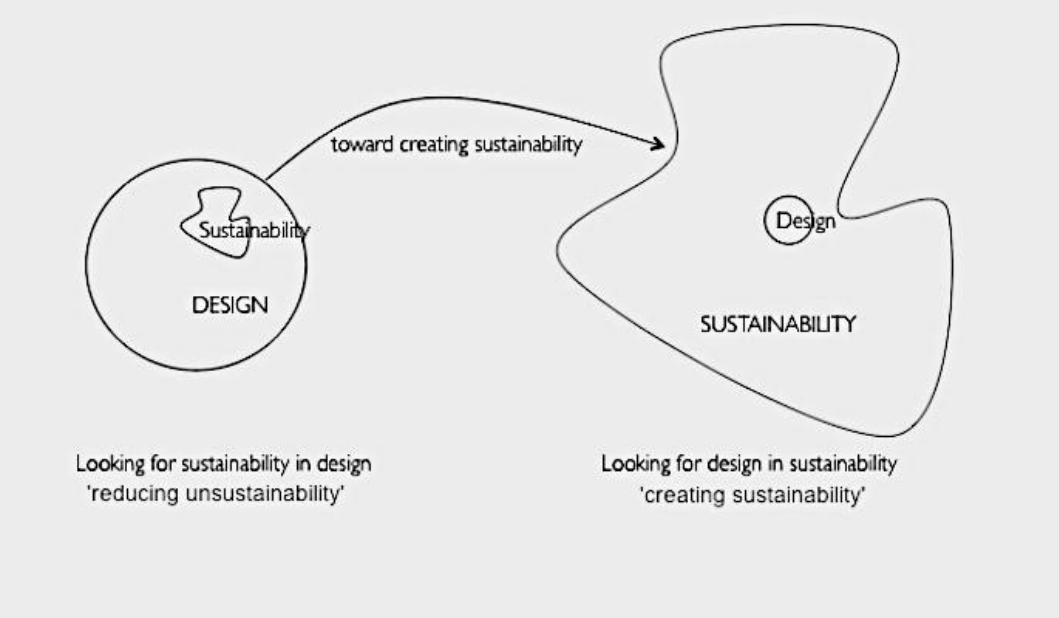


Figure 1.4 A journey for design: from reducing unsustainability to creating sustainability. Source: (Dewberry E. , 2011)

We can conclude therefore that mere knowledge of sustainability is not enough for ‘application’ on artifacts but design needs to be ‘situated’ in the domain of sustainability to create a meaningful effect.

1.6 Need for the research

Sustainability as an objective of design process in studio pedagogy is often not explicit. The fact that sustainability issues need to be tackled within design and design education is uncontested. A pedagogical tool or approach has to be found that will equip the students of design to contextualize sustainability in every design problem as a meta-objective.

The more focused inquiry is into identifying conjectures in pedagogy. This is important because they (conjectures) can be used more effectively to bridge the gap between design and sustainability. Conjectured thinking is natural to the way designers think, but to use it effectively in the area of sustainability in design pedagogy is an unexplored area. Both instructors/facilitators and students will benefit from using conjectures more reflexively. In summary:

1. The use of conjectures is implicit; it can be made explicit and structured.
2. Conjectured thinking is common to design and sustainability therefore it can be used to bridge the gap between the two domains.
3. Expanding the understanding of conjectures and its use in design process has a huge area of possibility. This has not been explored.

1.7 Explanation of key terms

Some terms have been explained below which are important themes in the thesis. It is important also to understand the context in which they are used.

1.7.1 Conjectures

The philosopher of science, Karl Popper, first proposed the theory of conjectures to explain scientific method. He formulated ‘hypothesis’ or ‘conjecturing’. He laid great virtue in trial and error and making mistakes (Bamford, 2002). Science is replete with bold conjectures. Newtonian mechanics turned out to be false, but would we have progressed without accepting it tentatively?

Hillier and Musgrove (Hillier, B, Musgrove, L & O'Sullivan, P., 1972) were the first to look at adopting conjectures into design. They argued that design is a matter of pre-structuring problems either by knowledge of solution types or by knowledge of latencies of the instrumental set in relation to solution types. Also, ”it is not [only] a matter of whether the problem is pre-structured and whether the designer is prepared to make the pre-structuring the object of his critical attention.

In this thesis one has made conjecture or ‘pre-structuring’ the object of critical attention in sustainability pedagogy. One of the main tasks in the thesis is to find how conjectures are used in the design process of sustainability pedagogy.

1.7.2 Conjecture-Analysis

It is a method useful in design process, which arrives at a ‘solution-in-principle’ (Bamford, 2002) in the early stages. This is helpful in dealing with complex, open-ended problems of design. This method is always pitted against Analysis/Synthesis and the debate is still active in design discourse.

As in design, sustainability problems are also complex and open-ended; therefore conjecture/analysis is found suitable for sustainability as well. The entire research is based on its (C/A) enquiry and on unraveling new knowledge about the C/A method.

1.7.3 Analysis-Synthesis

It is the ‘first generation’ methods of design methodology (Dorst K. &., 1995). It was heavily influenced by the positivist approach, which tried to make design rational (or rationalizable). There were many problems when applied to design but design methodologists continued refine it since it gave credibility to design as a serious domain. Adopting A/S meant that design was deliberate and had followed a process and did not just come from the designer's head. This meant that facts would be observed and recorded ‘without reflection, without selection or a priori and without hypothesis or postulates’ (Chelmons A.F., and Henpel, C.G), as in (Bamford, 2002).

1.7.4 Ontology

Ontology has been understood in two ways- one is the ‘nature of being or becoming’ and the other as ‘categories of being’. The first meaning has been explored by understanding what is the fundamental nature of design and how it is different from other disciplines. In this endevour conjecture was found to be the most vital aspects of design ontology. The second meaning of ‘categories of being’ has been worked as taxonomy of ontology and epistemology and their relationships.

1.7.5 Epistemology

Epistemology is the ‘nature and limits’ of knowledge. The knowledge of sustainability is an area of interest here. It is found that designers, especially students of design are unable to apply relevant sustainability knowledge to design. When areas of sustainability are found where design can contribute (epistemology), it makes the sustainability design process more robust.

1.7.6 Action research

This is a research methodology quite commonly used in educational and pedagogic research. The main aspects of this action research are: 1) Improving practice by collecting real data from actual practice, 2) The research progresses in several steps. This is done to allow for reflecting on the insights of one step and applying it to the next.

1.7.7 Design experiment

This is a research method, which could potentially answer research questions raised in the thesis. The hallmark of the method is ‘theory building’ and ‘ecological validity’. Design experiments are conducted to ‘develop theories’, not merely to empirically tune ‘what works’ (Cobb, 2003). This means that instead of separating the variables, like in a conventional experiment, and testing in a controlled environment, design experiment works in an ecological setup of a classroom, which is operating in its normal course. The researcher however, has designed an intervention and observes specific theories and events.

In this research, the researcher intervenes in a design sustainability studio to observe the use of conjectures in design process. The design experiment is conducted to test the theory of C/A as an effective design method.

1.7.8 Sustainability

Sustainability is a key domain of discussion of this research. Among myriad meanings, sustainability is understood in two ways in this thesis.

a. Appropriation of consequences- consequences are the unsustainability factors, which have to be appropriated into sustainability factors. This viewpoint is key to visualize a model.
b. Conserving resources- Resources in the context of sustainability has traditionally been understood as environmental resources, but this thesis includes abstract resources such as knowledge, time and learning also as resources to be conserved.

1.7.9 Pedagogy

The interactions between teacher and learner, is understood as pedagogy. In this context of design, the most effective platform for teaching and learning transactions is –'the studio'. Within the ambit of studio practice, three situations have been chosen to collect data from.

a. Teacher addressing the whole class
b. Discussion of students among themselves
c. One-to-one discussion of student with their instructor.

1.8 Limitations

1. There is no case repository for design cases to be used in Conjecture based studies. Therefore students have used cases available from various sources.
2. Referents have been chosen from various sources, but it is not a comprehensive list.
3. Action research has been conducted by teacher-as-researcher and researcher's observation of another instructor. More number of instructors could not be tapped for the purpose of action research.

4. The learners are all of different levels, therefore it is difficult to analyse all the students' work. Only a few have been chosen for analysis and the justification has been made for the choice in chapter 4.

1.9 Delimitations and Scope

1. The unit of observation is the design process where conjectures are identified and mapped. The final solution is not evaluated for sustainability effectiveness. This is because it is beyond the scope of the thesis due to the limitations of time and it would dilute the rigour of exploring early design process in the context of conjecture.
2. There are models to direct environmental sustainability, but none to guide multidisciplinary approaches such as proposed by this study.
3. The purpose of this action research is to test theories in action. Evidence of the theory working is the success of the study and not the measurement of the outcome.
4. Design and sustainability pedagogy is the focus of the study and not the sustainability curriculum or instructional design.
5. Pedagogic patterns, which emerge in the design studio classes using the model, have to be captured and shared with other design educators. This is outside the purview of this thesis and has been proposed as future work in chapter 7.

Chapter 2

Conceptual, Theoretical and Methodological framework

2.1 Chapter introduction

A broad overview of the challenges of integrating the two large domains of sustainability and design was given in chapter 1. Chapter 2 will present a more focused view within the two domains such that explicit link between design and sustainability can be established. The entire chapter is divided into three frameworks: theoretical, conceptual and methodological.

The theoretical understanding is gained through studying the constituent parts of design ontology and sustainability epistemology. The relevant factors are then picked from the two fundamental theoretical aspects of ontology and epistemology, to build a pedagogical structure for further exploration.

2.2 Theoretical framework

The theoretical discussion about design can be assumed to be well and truly begun, in 1960s with the attempts to scientise design and with it, the efforts to fit in a methodology and structure to design process. In the 1980s, this was challenged most notably by Donald Schön who argued for design as a 'reflective practice' rather than a profession of 'technical rationality' (Schön D. A., 1983).

The theoretical discussions gain teeth with the development of areas such as Design Philosophy and Design Studies. These areas take the responsibility of deliberating on the nature of design. Design, with its own characteristics distinguishes it from other fields. Therefore it stands to reason that, if other disciplines like engineering, management, environmentalism and politics are dealing with sustainability in their own way, design should also tackle the issue in a 'designerly' way. Further, this 'designerly' way also needs to be adapted to the pedagogic context.

Within the domain of sustainability, designers are driven to squarely take the onus for the world of artifacts. Literature in this area will be reviewed to find insights.

2.2.1 Design Ontology

As practitioners and theorists of design reflect on what design 'is' and what it 'is not', the discourse becomes more articulated.

Cross (Cross N. , 2006) credits several journals, which started at this time along with some landmark conferences gave fillip to the discussion on the ontology of design. These included Design Studies in 1979, Design Issues in 1984, Research in Engineering Design in 1989, the Journal of Engineering Design in 1990, Languages of Design in 1993 and the Design Journal in 1997.

The conference 'Discovering Design' made some important discoveries:[12]

It was recognized, that design exists as the central feature of culture and everyday life. And that even though design is a domain of contested principles and values it needs to be characterized in it own terms. (Buchanan R. &., 1995).

[12] The goal of the conference in 1990-Discovering Design was to broaden contemporary dialogue about design among practicing design professionals and individuals from a wide variety of academic disciplines.

Jonas gives a comprehensive explanation of this:

Design is not art because it does not aim at individual expression, but instead to serve various stakeholders. Design is not technology because it deals with fuzzy, discursive criteria rather than objective criteria. Design is not science because it does not offer new explanatory models of reality, but changes reality more or less purposefully. Obviously, design is something very special. (Jonas, 2001)

Another perspective is the 'Design Way' where 'human intention is made visible and concrete through the instrumentality of design'. Here design has been accorded a higher status than the creation of the artifact itself (Nelson H.G & Stolterman, 2003).

Dorst's (Dorst K. , 2011) arguments about design thinking, has ontological dimensions. He says that design thinking is a new paradigm in which there is an eagerness of other fields to adopt design practices. This is because design offers ways of thinking of uncertain and open-ended problems. Within the design research community, this has created the demand for a clear and definite knowledge about design ontology.

We embark on the journey into the enquiry into 'designerly ways of knowing', especially towards enhancing and developing these abilities through education (Cross N. , 2006).

Of the many perspectives of Design, three areas of Design ontology have been identified as being particularly relevant to the thesis:

1. The logic of reasoning,
2. Nature of the problem and
3. Behaviour of designers in the act of designing.

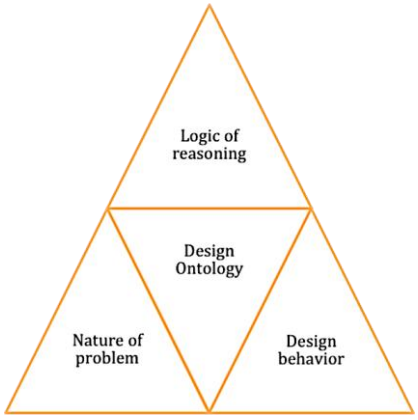


Figure 2.1 Three areas of Design Ontology

2.2.1.1 Logic of reasoning

The discipline of design with its logic of abduction and conjectured thinking has many distinguishing characteristics. When design was on its way to establish itself as a new discipline, it borrowed from the established disciplines of sciences and engineering. But it was soon apparent that design was different. The very logic on which it operated was different. Design operated on the logic of abduction as against deduction and induction.

'Abductive' reasoning is a concept from the philosopher C.S. Pierce (Peirce, 1957). He distinguished it from the other better-known modes of inductive and deductive reasoning. Pierce as in (Cross N. , 2006)) suggested that 'Deduction proves that something must be; induction shows that something is operative; abduction merely suggests that something maybe.' It is therefore [also] the logic of conjecture.

Let us look at the three approaches together.

Table2.1 Logic of reasoning. Adapted from (Kolko, 2010)

Logic of reasoning	**Explanation**	**Application**
Deductive	*A is B.* *All Bs are Cs* *A is deductively C* This form of logic is one that is self-contained, and any argument that uses deduction is one that cannot offer any new findings in the conclusions-the findings are presented in the premises that hold the argument to begin with, That is A, B, and C all exist in the premises that were presented.	This is the form of logic that is traditionally taught in mathematics courses and manifested in logical proofs.

Inductive	*Each time I do A under the same conditions, B occurs.* *Inductively, the next time I do A under these conditions,* *B will occur.* Subsequent experiences may prove this wrong, and thus an inductive argument is one where the premises do not guarantee the truth of their conclusions.	An inductive argument is one that offers sound evidence that something might be true, based on structured experience. This is a logic traditionally associated with scientific enquiry.
Abductive	*When I do A, B occurs*: I've done something like A before, but the circumstances weren't exactly the same. I've seen something like B before, but the circumstances weren't exactly the same. I'm able to abduct that C is the reason B is occurring.	Unlike deduction or induction, abductive logic allows for the creation of new knowledge and insight. C is introduced as a best guess for why B is occurring; yet C is not part of the original set of premises. It is best suited for design.

Problem solving in inductive and deductive logics happens under the conditions of bounded rationality. Design problem solving also starts with bounded rationality but has the capacity and possibility to abduct solutions through the use of conjectures. Here bounded rationality refers to the concept that human problem solvers are rarely in a position to identify all possible solutions to a problem at hand therefore settle for choices that seem to satisfy the required solution properties of a problem, as they see them at the time (Rowe, 1991).

2.2.1.2 Nature of the problem

Not only is the way of finding a solution unique but also the uniqueness extends to the nature of the problem. Yet another characteristic of design activity is heuristic reasoning. The term heuristic reasoning refers to a problem-solving process in which it is unknown beforehand whether a particular sequence of steps will yield a solution or not. Consequently, it involves a decision-making process in which we do not know whether we actually have a solution until the line of reasoning is completed, or all the steps are carried out (Rowe, 1991).

In spite of its uncertainties designers go through the process because of the gems that are embedded in the process. In following the heuristic line of reasoning, it is likely that, "the act of tracing out the intermediate steps exposes unforeseen difficulties or suggests better objectives, the pattern of the original problem may change [so] drastically (Buchanan R. , 1992). As if dealing with an evolving problem was not challenging enough, designers are also called upon to 'treat as real that which exists only in an imagined future' (Buchanan R. , 1992).

So we will work with the definition of a problem as below.

"A problem can be said to exist if an organism wants something but the actions necessary to obtain it are not immediately obvious" (Thorndike, 1931) as in (Rowe, 1991).

Design problems are of two kinds- Well-defined or 'tame' (Rittel H. W., 1973) and Ill-defined or 'wicked' problems (Rittel H. W., 1973). Well-defined problems are those for which the ends, or goals, are already prescribed and apparent; their solution requires the provision of appropriate means (Newell, Shaw and Simon 1967, p 70) as in (Rowe, 1991). And ill defined are those problems without definitive formulation, or indeed the possibility of becoming fully defined (Churchman, 1967, Rittel 1972, Bazjanac 1974) as in (Rowe, 1991).

Rittel identified ten properties of wicked problems in 1972.

1. *Wicked problems* have no definitive formulation, but every formulation of a *wicked problem* corresponds to the formulation of a solution.
2. *Wicked problems* have no stopping rules.
3. Solutions to *wicked problems* cannot be true or false only good or bad.
4. In solving *wicked problems* there is no exhaustive list of admissible operations.

5. For every *wicked problem* there is always more than one possible explanation, with explanations depending on Weltanschauung[13] of the designer.
6. Every *wicked problem* is a symptom of another, 'higher level' problem.
7. No formulation and solution of a *wicked problem* has a definitive test.
8. Solving a *wicked problem* is a 'one shot' operation, with no room for trial and error.
9. Every *wicked problem* is unique.
10. The *wicked problem* solver has no right to be wrong- they are fully responsible for their actions. (Buchanan R. , 1992)

Why are design problems indeterminate and therefore, wicked? However the answer to the question lies in something rarely considered: the peculiar nature of the subject matter of design. Design problems are 'indeterminate' and 'wicked' because design has no special subject matter of its own apart from what the designer conceives it to be (Buchanan R. , 1992).

2.2.1.3 Design behavior

The uniqueness of design is not manifest only in logic of reasoning and the nature of the problem but is also invested in the active stakeholder of the design process- the designer. The design(er) behavior while working on a design problem is the topic of discussion of this section.

Donald Schön published his work on 'reflection-in-action' in 1987. Since then his theory has found an unshakable place in design discourse. He argued that 'knowing-in action' is a set of constructions that he has accumulated in his earlier practice. He brings this forth in "subsequent cases of his practice" (Schön D. A., 1983).

Schön elaborated his treatise on 'reflection-in-action' through many detailed observations with his students. One pertinent observation is related below.

Quist's [student] relation to this situation is *transactional* [14] (Dewey, 1949). He shapes the situation, but in conversation with it, so that his own methods and appreciations are also

[13] Weltanschauung identifies the intellectual perspective of the designer as an integral part of the design process.

shaped by the situation. The phenomena that he seeks to understand are partly of his own making: he is in the situation that he seeks to understand (Schön., 1987).

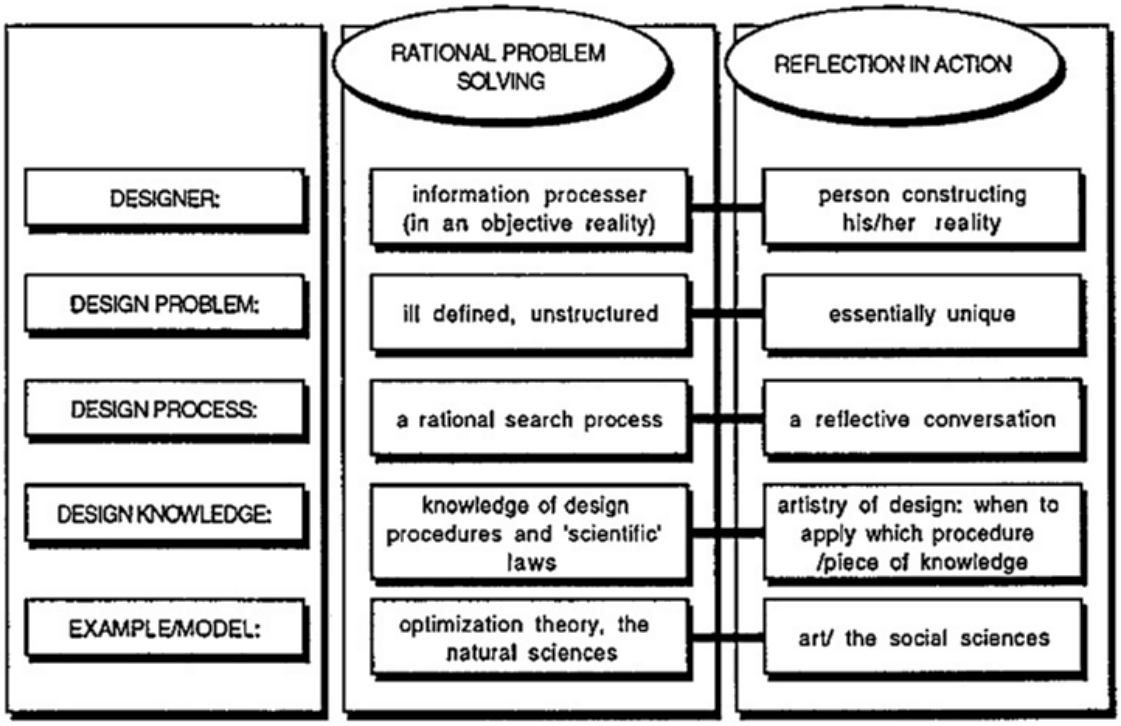


Figure 2.2 The rational problem solving paradigm and the reflection-in-action paradigms Source: (Dorst K. &., 1995)

Schön's argument of reflective practice is understood better when viewed in comparison to the existing positivist paradigm of rational problem solving. It is summarized in the figure above.

2.2.2 Sustainability epistemology

The fundamental epistemological lens, through which we will view sustainability for design, is that of Herbert Simon. Natural science, Simon wrote, "is knowledge about natural objects and phenomena; the 'artificial' on the other hand, was about objects and phenomena invented by humans" (Simon, 1996). Humans he said operate in the artificial world 'to

[14] The 'transactional' relationship of a reflective thinker with a situation by being 'in conversation with it' was first mentioned by Dewey in 1933 in his book- 'How we Think'. Schön's PhD thesis is based on Dewey's theory of enquiry confirming the lineage of 'reflective practitioner'.

achieve their own goals'. The boundaries between the artificial and the natural need to be both recognized and honoured. Now, turning our attention to design, we know that designers are by and large creators of the artificial world. But designers often do not recognize or honour the boundary between artificial and natural.

Margolin takes a contemporary view on the natural and artificial. He says that today there are many "who are heavily invested in the artificial; and the artificial needs to be rethought (Margolin V. , 2002). The sustainability discourse has been examined to identify three epistemological entities for consideration of designers, as shown in figure.

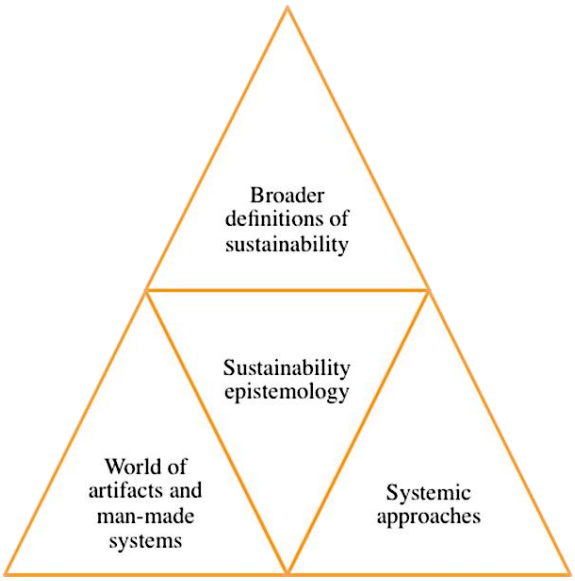


Figure 2.3 Three areas of Sustainability epistemology

2.2.2.1 Broader definitions of sustainability

Schumacher (Schumacher, 2011), an economist, addressed nature as 'capital' as any other. His argument was that if we put in concerted efforts to see that capital (money) is invested wisely and grows over time then why is it that we are so careless about nature as 'capital'? Freer Spreckley first articulated the phrase "triple bottom line" (TBL) in 1981 in a publication called 'Social Audit- A Management tool for cooperative working' where one had to take into account social and environmental performance in addition to financial performance. This broader view of sustainability was adopted by every other discipline. A more enduring version of the same philosophy is oft quoted in the context of sustainability is-

Planet, People, Profit. This kind of cross-fertilization is not uncommon in sustainability discourse. 'Green design' is now 'sustainable design' thus showing 'shifting attitudes' (Madge, 1997). Even large coalitions like Agenda 21[15] have very broad mandates for how design can contribute to sustainability (Margolin V. , 1998).

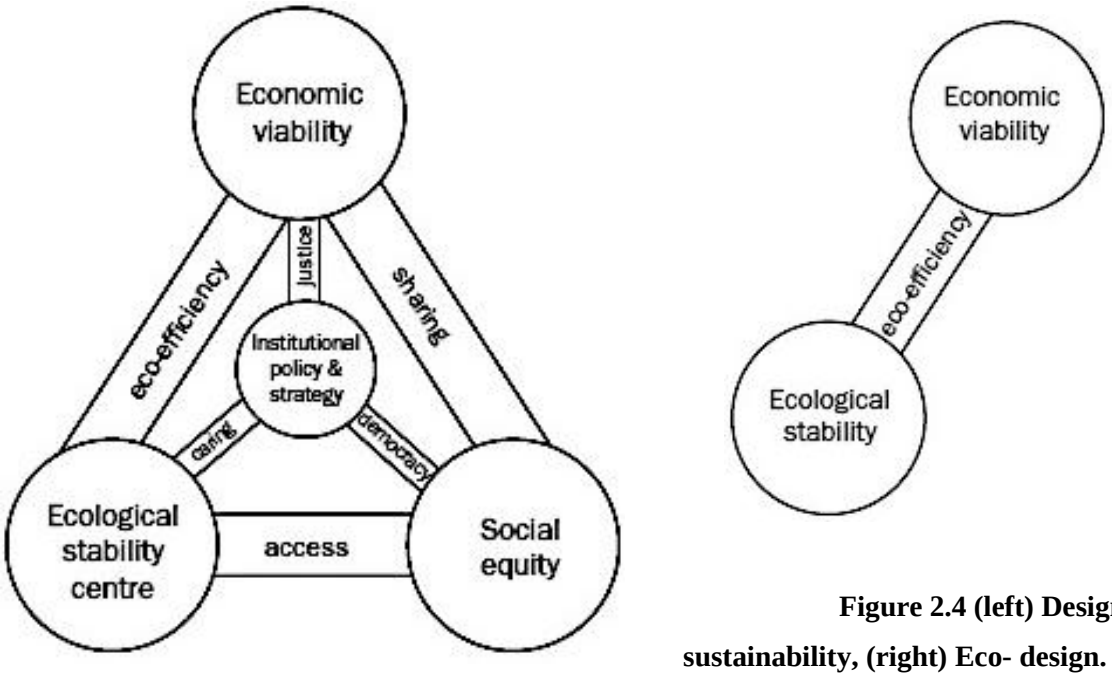


Figure 2.4 (left) Designing for sustainability, (right) Eco- design. Source- (Faud-Luke, 2013)

Sustainability in its very nature defies disciplinary straightjacketing because disciplinary thinking, by its very nature, is exclusory, and this has a limited ability to comprehend and engage the relational complexity of unsustainability (Fry, 2009). Texts on sustainability call for multidisciplinary or interdisciplinary approaches. Fry describes a meta-discipline that "facilitates an exchange of knowledge and dialogue" (Fry, 2009). And design supports this brand of thinking. In a study conducted to find how Kuhn's disciplinary matrix could be mapped on design and non-design disciplines (Wang D. &., 2009), it was found that the elements in the case of design orient outwards towards general culture whereas non-design pointed inwards towards domain specific knowledge.

Clearly, we need a broader definition, understanding and canvas for sustainability. Even the expansion provided by Triple Bottom Line (TBL) might be limiting. As we proceed in the

[15] *…quality of life, efficient use of natural resources, protecting global commons, managing human settlements, the use of chemicals and the management of human and industrial waste, and fostering sustainable economic growth on a global scale*

thesis with the definition of sustainability as ‘conserving resources’, the resources can be of abstract nature like time, knowledge and learning

2.2.2.2 World of Artifacts and man-made systems

Early literature review made a distinction between consumption and consumerism. Consumption is the act of using things to fulfill fundamental human needs. Consumerism is the social system, which exists when the act (of consumption) itself defines the societal goals.

The discussion of this domain takes into its fold, arguments from the areas of material culture, sociology, anthropology and sustainable consumption. Material culture is the study of [material or] artifacts [for] values, ideas, attitudes and assumptions of society (Clarke, 2009). The study of material culture connects directly with design, as this is the milieu in which design is situated. In fact designers are largely responsible for shaping this milieu and people’s responses within it. Saying which, the anthropologist’s view is also relevant that, an ‘object-centered’ consciousness has deep ideological roots. Its origins seem to lie in the universal association of manhood with material processions. In addition to well-known images of manliness like physical strength, toughness and aggression, [Anthropologist David Gilmore] found that in culture after culture, "real" men have traditionally been those who produce more than they consume (Capra, 2004)

Nigel Whitley spent considerable time in ‘Design For Society’ comparing the evils of consumer-led design that testifies to private affluence on a substantial scale… Thus individualism rather than individuality pervades our consumerist society. (Stairs, 2005).

Today most people encounter design through consumption, either by purchasing designed commodities, by consuming design through signs used in advertising and other forms of mediation, or simply as users (Clarke, 2009; Marchand, 2008).

Belief has it that consumption can be titrated and balanced with sustainability. This has opened an entire discourse on sustainable consumption.

It is this unique position of design as the interface between consumers and the activities of consumption, which firmly establishes its potential to influence the environmental and social impact of products and services and hence, to contribute towards goals of sustainable development (Fletcher K. D., 2001).

2.2.2.3 Systemic approaches

The ‘cradle-to-grave’ model of production and consumption was being followed since the Industrial revolution. This was linear in nature. Sustainability demands a cyclic model. ‘Cradle to cradle’ (McDonnough, 2010) was devised in response to this demand, where a product’s life cycle comes back to where it began. This is now popularly known as recycling, up cycling and down cycling.

These measures however have limited application when the situation gets complex. This is because “complexity stems from the nature of problems. They rarely present themselves individually, but come related to other problems, in richly interconnected problem situations. As a result, once you examine them, problems seem to get bigger and to involve more issues and stakeholders” (Jackson, 2003).

Systemic approaches in the domain of sustainability are very essential due to the consequences our acts have on society and environment. As Tatum describes, “Designers also need a grasp of the profound ‘consequentiality’ of their work. Not only are the possibilities almost limitless, the choices we make among those possibilities carry profound and far-reaching implications for how we will live” (Tatum, 2004).

The two most fundamental works that argued for systemic theories are- ‘Autopoiesis and Cognition’ (Maturana, 1991) and ‘Limits to Growth’ (Meadows D. M., 1972).

Professor Humberto Maturana and his colleague Franscisco Varela undertook the construction of systemic theoretical biology in their book ‘Autopoiesis and Cognition’ in 1928. They claimed that “if living systems are machines, that they are physical autopoietic machines, is trivially obvious: they transform matter into themselves in a manner such that the product of their operation is their own organization.”

The other is the report- Limits to Growth, which was an outcome of the initial meetings of the Club of Rome. They undertook an ambitious task of examining the complex problems troubling men of all nations. The report documented that, “The basis of the method is the recognition that the structure of any system- the many circular, interlocking, sometimes time-delayed relationships among its components- is often just as important in determining its behavior as the individual components themselves. The world model described in this book is a System Dynamics model.

But one can sense a change in the design community. A new logical structure that is now emerging as the structure of design process is:

1. Instead of a problem, we have a state A of a system.
2. Instead of a solution, we have a state B of a system.
3. The designer and the user are part of the system (stakeholders)

This shift in design thinking adapts itself very well to the sustainability discourse. The new systems approach urges designers to work within a system and design solutions to be 'situated' within the system. This structure also suggests that the designed state B need not be an artifact, which paints future scenarios of immateriality.

2.3 Literature on pedagogic approaches of integrating Design and sustainability

The theoretical discussion in the preceding sections still leaves the pedagogic implications to be discovered. Clarity of how the instructor will deliver and the student will learn is very important. What designers know about their own problem-solving processes remains largely tacit knowledge- i.e. they know it in the same way that a skilled person 'knows' how to perform that skill. Cross emphasizes this when he says, "but teachers of design have a responsibility to be as articulate as they possibly can about what it is they are trying to teach, or else they have no basis for choosing the content and methods of their teaching" (Cross N. , 2006).

Literature on pedagogic approaches of integrating Design and sustainability and the challenges of doing so, are explored in this section. Table of different perspectives, challenges and insights derived from design and sustainability education and teaching.

Table 2.2 Design and Sustainability education perspectives

Author	Description
(Dewberry E. , 2011)	1. Current curricula tend to be discipline based. Sustainable development on the other hand is a trans-disciplinary subject and requires a reflective and iterative approach to see emerging discipline links. This enables learners to

	contextualize the subject and to understand the perspective and scope of specific themes; 2. The concept of responsive, dynamic and process learning to enable a 'real' understanding of sustainable development poses a conflict with the established, pre-defined learning outcomes currently used to measure student performance; and 3. Sustainable development has been described as being too abstract. To avoid such claims it is important to promote an educational philosophy that connects everyday living to the more generic policy objectives. This is encouraged through local ownership of learning - both content and process - and is something that can't be governed 'centrally' through rigidly defined curricula content and outcomes.
(Knight, 2009)	Many designers have found the idea of sustainable design 'too hard', both emotionally and on a pragmatic level. Repeatedly telling people about the dangers of carbon and other greenhouse gases leading to climate change either bores them or frightens them so much they are unable to act, they feel powerless.
(Betrabet Gulwadi, 2009)	The body of knowledge acquired by a design student should not only represent factual information, but also a way of thinking and reasoning that can be applied to future problem-shaping and problem-solving processes – that is, a way of activating the knowledge-in-waiting (theoretical and practical base) and transforming it to knowledge-in-use (what is being applied to situation-at-hand).
(Scholz, 2006)	Case studies, and in particular trans-disciplinary case study (TCS), are a powerful tool for teaching and research on complex

	environmental problems to conduct individual, organizational, and societal sustainability learning.
(Fletcher K. &., 2002)	1. While information on design for Sustainability does exist, it is in general, abstract, limited, dispersed and not in a language accessible to designers. 2. While the target audience for the demi project through the funded period was the design populace, both staff and students (from across the full range of courses including product design engineering and fashion and textiles), its potential audience is the design community at large.
(Walker, 2008), (Unaka, 2014)	Utilizing design charrette for teaching sustainability
(Trebilcock & Ford, 2006)	The evidence suggests that the integration of sustainability at early stages of design process guided by knowledge and experience in the form of precedents; while later stages of the process are supported by analysis tools; from simple methods to sophisticated tools.
(Trebilcock M. , 2009)	The integration of environmental sustainability issues in the design process does not seem to alter the C/A nature of the design process, but it actually seems to reinforce it.
(Ramirez, 2007)	Although academics consider sustainability as a topic that design students need to be exposed to, the classic design assessment criteria – aesthetics, functionality, ergonomics, manufacturability, etc. – are still deemed to be the overriding determinants of what constitutes good design, and impacts to society or to the environment do not hold the same significance.

(Clune, 2009)	Focus on technical design skills, without adequately defining the problem of unsustainability, negates effective improvements required to move towards sustainability.
(Boyle, 2004) (Sprain, 2012)	Boyle identified six key problems of incorporating sustainability into Engineering education: lack of textbook, lack of examples, lack of time, and knowledge of sustainability by staff and maturity of students. This holds true for design education too.
(Sprain, 2012)	Case-based approaches are particularly well suited to teach about sustainability and to build capacity to address the challenge of tackling wicked sustainability problems.
(Manzini E. &., 2003)	When we view things from the sustainability perspective, this need to reinvent the everyday increases enormously and the most elementary functions of daily experience appear as questions that are not easy to answer.

The literature on design and sustainability compiled and reviewed above served two important purposes-

Firstly, the theoretical understanding is gained through reviewing literature related with theories and approaches in design and sustainability, thus providing synthesized coherence (Locke, 1997) to the literature presented.

Secondly, the literature helped in problematizing the situation (Locke, 1997). The existing literature was ‘incomplete’ and ‘inadequate’. How can designers know sustainability such that they can design appropriately; is seldom discussed. Through sustainability literature, one has tried to build an epistemological construct for the thesis. Also, the literature on ‘conjecture’ in the context of design is limited. The available literature presented, raised broad research questions that have been framed in table 2.3.

2.4 Research clarification (Broad questions)

Table 2.3 Broad research questions

Research problems	1.Designerly ways and means of integrating sustainability into design process are not adopted in design pedagogy.	2. Sustainability pedagogy either gets too specific in teaching particular techniques to particular problems or the issue gets sidelined completely in the entire design process.
What I need to know (Research questions)	1. How can the relationship between ontology and epistemology be understood better in design pedagogy?	2. How can sustainability approaches be imparted through design process in design pedagogy?
Why I need to know this?	1. If ontological features of design integrate sustainability epistemology, there are greater chances of sustainability becoming the meta-objective of design process.	
Proposition/ Hypothesis	1. A suitable designerly method can be identified which effectively incorporates sustainability knowledge in design process.	2. It is possible to find explicit links between ontology and epistemology.

2.5 Conceptual framework

Conjectured thinking further articulates problem solving in design. Karl Popper was the first to propose the theory of conjecture, where conjecture is understood as a possible solution to a problem. In fact, Cross (Cross N. , 2006) situates abductive reasoning within the logic of conjecture.

Thomas Kuhn, a scientific philosopher, coined the term exemplar. He said, "By it I mean, initially, the concrete problem-solutions that student encounter from the start of their scientific education, whether in laboratories, on examinations or at the ends of chapters in science texts" (Kuhn, 1996). Elsewhere in his discourse Kuhn has described exemplars as 'shared examples' or 'symbolic generalizations'. Schön (Schön D. A., 1983) adapted it to design by equating exemplars to designers' way of functioning, "where designers bring prior knowledge to bear upon new situations", that the designer is faced with.

Cross's argument was that while scientists are 'problem' focused, designers are more 'solution' focused. And therefore conjectured thinking becomes more relevant. Literature on previous research tells us that case-based approach and precedent-based approaches have been used to aid design process. But this thesis argues that there are additionally other types of conjecture as well.

Akin developed a case tool for Case based Instruction (CBI) called Electronic Design Assistance Tool (EDAT). He found out that cases are not full and complete descriptions of earlier designs. In fact, designers retrieve earlier cases for considering relatively narrow design features rather than wholesale information (Akin, 2002). We take this insight of Akin to support our argument that case or precedents cannot be taken as the only conjectures. Designers use more types of conjectures and they should be articulated in a model for it to have greater effectiveness.

1. The role of the conjectured solution is a way of gaining understanding of design problem (Cross N. , 2006).
2. Keeps problem contained within manageable bounds (Hillier B. &., 1991) as in (Cross N. , 2006).
3. An early idea a designer 'holds on to' is a 'primary generator' (Darke, 1979). This plays a positive role of keeping the problem within manageable limits.

4. Conjecture is the ‘extra ingredient’ to knowledge, which helps solve design problems (P.H, 1966) as in (Cross N. , 2006).
5. It is the ‘ordering principle’ in problem solving (P.H., 1966) as in (Cross N. , 2006).
6. Variety reduction occurs early in design process with conjecture or conceptualization of a possible solution (Cross N. , 2006).
7. Design is essentially a matter of pre-structuring problems (Hillier B. &., 1991).
8. As with science, it is not a matter of whether the problem is pre-structured but how it is pre-structured, and whether the designer is prepared to make this pre-structuring the object of his critical attention (Hillier B. M., 1972).
9. There is a set of 'internal variety reducers' and these are an expression of the designer’s cognitive map. This cognitive map acts as a kind of plan for finding a route through problem material that would otherwise appear undifferentiated and amorphous (Hillier B. &., 1991).
10. In the context of design, classifications and code formalizations would not be deterministic, but would constitute an extension of the designer's basic cognitive capability, and provide him with a position of strength from which to make his conjectures (Hillier B. &., 1991).

2.5.1 C/A vs A/S, the two paradigms

As mentioned earlier, in the early years when design was trying to establish itself as a discipline, it borrowed from the established discipline of science. The decade of the 60s was hailed as the decade of design science. Early methodologists got busy theorizing on the cognitive and pragmatic aspects of design based on scientific reasoning. Design methods embraced the analysis/synthesis approach, which had its roots in the positivist tradition. But A/S came under fire and C/A was pronounced as a more suitable method for design. Table 2.4 compiles the arguments, which underlie the two paradigms.

Table 2.4 Comparison between Analysis/Synthesis and Conjecture/Analysis design methods. Compiled from (Hillier B. M., 1972) and (Bamford, 2002; Thorndike, 1931)

	Analysis/Synthesis	Conjecture/Analysis
Core argument	Problem solving involves 'decomposing' problems and 'piecing together' solutions.	Essentially a matter of pre-structuring problems either by a knowledge of solution types or by a knowledge of the latencies of the instrumental set, in relation to the solution types.
Dealing with the 'problem'	Problem will be understood by collecting 'observed' and 'recorded' facts, without selection or a priori guess as to their relative importance.	To help structure an understanding of the problem, and to test its resistances, one must conjecture approximate solutions much earlier in the process.
The 'solution'	Synthesis is a process by which pieces of a puzzle gradually come together, and so a solution is typically visible only towards the end.	Without a solution-in-principle at some intermediate stage a 'vast variety' of design decisions cannot be taken.
'Fit' with the ontology	In the four key stages- Briefing, analysis, synthesis and evaluation; creative thinking is relegated to stage four in evaluation. This is a dis-analogy with design.	'Design development' is thus constructed by solution-in-principle.

The A/S model is mostly prescriptive and can be placed in the realm of design methodology, while the C/A model is mostly descriptive and can be placed in the realm of design theory (Trebilcock M. , 2009)

2.5.2 Research clarification

We now need to take stock of the conceptual framework discussed thus far in order to formulate the focused research questions. Table 2.5 summarizes the research clarifications.

Table 2.5 Research clarification

Research problems	1. C/A is not used in a structured manner in design pedagogy	2. Conjectures are not available in usable form, therefore cannot be applied in current projects	3. There is negligible empirical work done in the area of applying C/A to sustainable pedagogy
What I need to know (Research questions)	1. Is C/A an appropriate base model to build a new representation of C/A for sustainability in design pedagogy?	2. What are the relevant conjecture-typologies that come into play while designing?	3.What are the ways in which these typologies can be used for developing a model representation of C/A for sustainability?
Why I need to know this?	1. The use of conjectures is ad-hoc. It has not been systematized as a visual representation of a	2. Conjectures are an effective tool for decision making in design process and this can be leveraged as a pedagogic tool to	3. Use of C/A approach to integrate sustainability pedagogy offers great potential and

	model. This is a gap that needs to be addressed.	integrate sustainability in student design projects.	this potential is not been fully tapped.
Proposition/ Hypothesis	1. C/A is the appropriate base model of sustainability in design.	2. Conjecture-typologies are the epistemic units of the C/A model for sustainability.	3. Conjectures are the link between ontology and epistemology.
What kind of data will answer the question	1. Recording of design studio proceedings by other instructors.	2. Recording of design charrettes/workshops conducted by researcher as instructor	3. Relevant literature in the area of design theories, methodologies and design thinking.
Where will I find the data (Data source)	1. Design studios/classes	2. Student design projects which includes the discussions amongst students, with instructor, drawings, presentations made by students	3. Didactic delivery by instructors in terms of presentations, desk crit (critique of student work), showing examples of previous designs in terms of samples, documents or field visits

In what way or manner will I find the data (data collection methods)	1. Action research will be the methodology used. Several inductive studies will be conducted in various pedagogic situations to find insights. The insights from one study can be used to plan and improve the next.	2. Design experiments conducted in pedagogic situations.	
How will the data answer the questions (data analysis methods)	1. Content will be analysed to find precedents and nature of precedents.	2. Drawing up a relationship matrix for ontology, epistemology and conjectures.	
Research contribution	1. Visual representation of Conjecture-analysis model for sustainability (CAMS)	2. Demonstrating how conjectures form the link between ontology and epistemology.	3. Identifying five typologies of conjectures.
Validity	1. Action research is carried out in various modes. Participant, non-participant, teacher-as-researcher etc. have been used. It has been conducted in convergent and divergent modes.	2. Since it is a theory testing approach. The validity is in the theory working rather than the final solution.	3. The insights from each stage of action research are used to refine the model. The iterations add to the validity.

Generaliz -ability	1. The pedagogic model is not restricted in its applicability. It can use information from a domain outside design and produce input in any area of design such as graphic design, product design, fashion design etc.	2. The alternative solutions and sub-solutions can be used again in another context.	

2.5.3 Focused research questions

1. Is Conjecture/Analysis an appropriate base model to build a new representation of Conjecture/Analysis for sustainability?
2. What are the relevant conjecture-typologies, which come into play while designing?
3. What are the ways in which these typologies can be used, for developing a model representation of Conjecture/Analysis for sustainability?

2.6 Methodological framework

The Methodological framework approach has been given a different treatment than 'Methodology and Research Design' of chapter 3. The methodological framework is broader in its intent. It looks at how theoretical and conceptual frameworks come together to answer the research questions. It also describes the methodological approach of enlarging an existing model. There are three main ideas guiding the methodological framework.

1. Top-down/Bottom-up approach, Figure 2.5
2. Enlarging the original theory, Figure 2.6
3. Generative theories

2.6.1 Top-down and Bottom-up approaches

The top-down approach is through literature. Theories and concepts of design and sustainability discourses have been reviewed. This has been discussed in section 2.2 of theoretical framework. Three aspects each have been laid out for each as below.

Design Ontology

a. Logic of reasoning- Abductive
b. Nature of the problem- wicked
c. Design behavior- reflective

Sustainability epistemology

a. Broader definitions of sustainability
b. World of artifacts and man-made things
c. Systemic approaches

The bottom-up approach is to conduct empirical studies to identify conjectures in pedagogy.

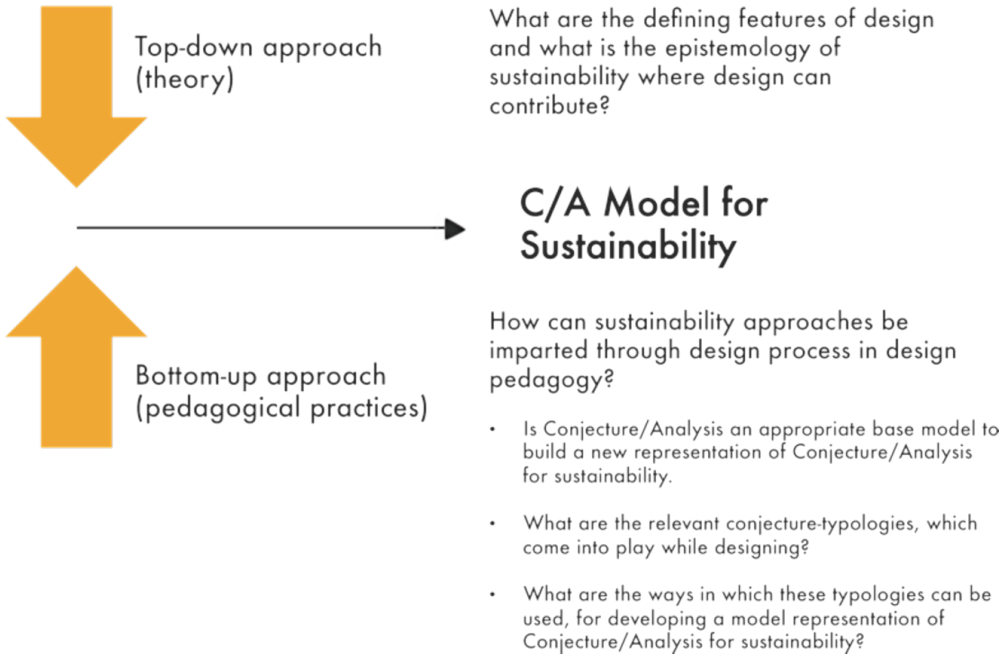


Figure 2.5 Top-down and bottom-up approaches

2.6.2 Enlarging the original theory

Since C/A starts with ideas that can be quickly tested against constraints and is inclined towards theory building, C/A has been identified as the original theory to be enlarged.

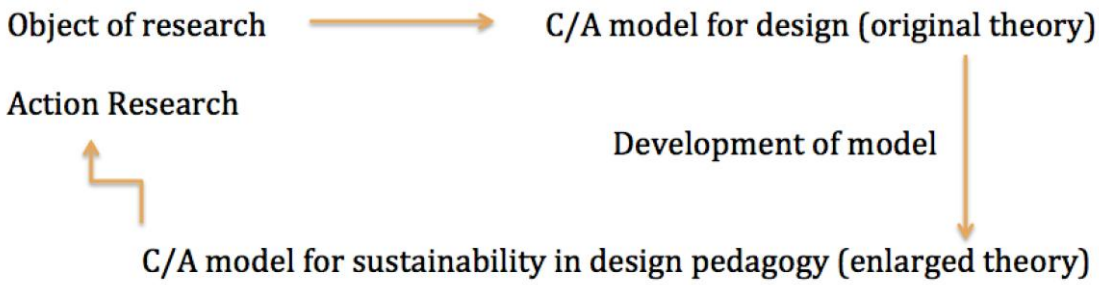


Figure 2.6 Enlarging the original theory

2.6.3 Generative theories

Finally we deal with an important aspect of design research, which is creating generative theories. We borrow from two main arguments. One is Jonas (Jonas, 2001), who says that research in design builds small theories, which are like 'learning pathologies'. This is undesirable. What should be done instead is create generative theories, which help in designing practice and design education.

The other argument for generative theories comes from Stolterman (Nelson H.G & Stolterman, 2003), where the concept of 'Ultimate particular' has been described. It says, design research should be fed with the result of action, taken through judgment and formed by intention not with abstract reasoning and logic.

It is with this in mind that the empirical method chosen to enlarge the original C/A model to CAMS is Action Research. Action Research is used to build theories and hence called 'theory in action'. This has been explained in Chapter 3

2.6.4 Summary of research questions

1. What are the defining features of design and what is the epistemology of sustainability where design can contribute?

2. How can sustainability approaches be imparted through design process in design pedagogy?
   2a. Is Conjecture/Analysis an appropriate base model to build a new representation of Conjecture/Analysis for sustainability?
   2b. What are the relevant conjecture-typologies, which come into play while designing?
   2c. What are the ways in which these typologies can be used, for developing a model representation of Conjecture/Analysis for sustainability?

2.7 Chapter summary

This chapter unravels the literature in the two broad domains of Design and Sustainability. A theoretical framework is formulated by using the defining features of design and sustainability. Conjecture is found to be the most suitable element that could form a link between design and sustainability. And as a corollary, conjecture/analysis is the most suitable base theory to be used. Through the review of literature it was found that C/A offered the scope of enlarging into a model for sustainability. This had not been done earlier hence revealing the gap in literature. The conceptual framework clarifies the various research components. The research questions are framed as a part of conceptualizing the research study. The way the questions are arranged top-down and a bottom-up approach yields the Conjecture Analysis model for sustainability. Action research has been used as the methodology for the empirical work. Theories are being tested and understood in the entire process; therefore the action research may also be called theory-in action.

To summarize, therefore the literature establishes that conjectures are an effective tool for decision-making in design process and this can be leveraged as a pedagogic tool to integrate sustainability conjectures in student design projects.

Chapter 3

Methodology and Research design

3.1 Chapter introduction

It has been discussed earlier that efforts were made by designers to beat a problem into orderly shape so that it could be dealt with like a problem in natural sciences. But now there is acceptance that design problems are ‘wicked’ (Rittel H. W., 1973). Buchanan (Buchanan R. , 1992) probed into what makes design problems indeterminate and he found that this is because there is no particular subject of design and it is whatever the designer conceives it to be. If we compare how subject matters are dealt with in design and non-design disciplines, we find that design ‘orients itself out towards general culture’ whereas non-design disciplines ‘orient inwards towards domain-specific knowledge’ (Wang D. , 2009).

With this background we can appreciate that design research is also faced with challenges due to uniqueness of the domain of design. Design research is a fairly new entrant into the area of formal research. Therefore there are no ‘designerly’ research methods. This is the reason why, design researchers find themselves borrowing from other domains and

adapting it as their own. It might be recalled that the subject matter of the thesis is also to find a ‘designerly’ method for sustainability in pedagogy. Interestingly, the community of designers finds itself at crossroads to find domain specific tools for both the content of the research as well as the method to carry it out. Choosing a method for the research study was a challenging one.

One way to engage with a research project is to determine a paradigmatic stance and methodological approach, beforehand, but as Ben Mathews (Mathews, 2004) cf (Heape, 2007) states,

“One of the greatest difficulties in approaching a field such as design is that because it spans, traverses, invades, borrows or relies on a number of different fields, many methodological issues are contested and contestable.”

An alternative and more ‘practical’ approach is to allow the methodological considerations and the range of methods one uses to be determined by the question one poses with regard to the research project in hand and as Julia Brannen (Brannen, 2005) cf (Heape, 2007) suggests:

“We are likely in many research projects to ask a number of questions each of which may have different methodological implications. The kinds of questions we pose lead therefore not only to the choice of method, but increasingly commonly, to a complex of methods.” It has led to a nested methodology for this research project as well. This is described in detail in section 3.3.

3.2 Methodological implications based on research questions raised

We will also base our methodology and methods on the research questions posed (section 2.6.4). The first question is about the 'defining features of design' and the 'knowledge of sustainability which is relevant to designers', in other words what are the ontological and epistemological issues of design and sustainability, and can they be integrated? This question has been resolved through sifting through the domain literature of design and sustainability and identifying factors, which form the ‘web of meaning’ for the tentative model. Bryman has listed several ways of doing and using literature review. Here, in this thesis, literature has been actively used as a part of the methodology. The ‘situation is problematized’ (Bryman.A.,

2008) through literature. Conjecture was found to be useful to link the ontological and epistemological elements together. Also C/A was found to be the original theory that needed to be expanded.

The second research question asks if sustainability approaches can be imparted through design process in design pedagogy. It has been hypothesized that this can be done through an appropriate model. In order to build the final model we start with a tentative model, which is based on existing theories. The existing theory chosen is the C/A approach. Further, a more focused second question, questions the appropriateness of the C/A model. The comparison of the two main theories in design A/S and C/A, have been discussed at great length in literature review. The greatest gap here is that C/A theory is not represented visually. So the study proceeds by enlarging the earlier model (a conceptual/descriptive C/A model in this case). It starts from what is known and then proceeds by enlarging the mapped area and connect the new intelligence to the known facts. The existence of the tentative model helps in selecting the logical structure of the entire research project and planning it. The model helps to decide which material has to be collected.

This model is a working hypothesis. During analysis the model is validated, by seeing whether the collected material conforms to the model or not. This leads us to deliberate on what kind of material needs to be collected to build the model. Since the study and the application are going to be in design pedagogy, we will look at the design studio as the research site. The revisions have to be made based on empirical observations. These empirical observations have to emerge out of observation of students' experience of design process. And these observations have to be done stage-wise. Action research is a popular method in educational research. It suits our purpose very well. The material is collected through action research and necessary correction to the model is made after each stage of action research.

Further, there are two more focused questions. The first aims at finding relevant conjecture-typologies, which come into play while designing and the other aims to find ways in which these typologies can be used, for developing a model representation of Conjecture/Analysis for sustainability. This also calls for empirical work with design students and observation of their design activity; which is well achieved through action research in the pedagogic environment.

The whole exercise of building a model starts with existing theories and progresses with testing the theories in the field. Therefore the action research is better described as theory-in-

action. Also the theory testing of the nature described cannot be achieved through a conventional experimental setup but requires an appropriate method such as ‘design experiment’. Design experiments ideally result in greater understanding of a learning ecology--a complex, interacting system involving multiple elements of different types and levels-by designing its elements and by anticipating how these elements function together to support learning (Cobb, 2003).

In summary, when we look for methodological implications as a response to the research questions raised, it points us towards a nested methodology. It is not the choice of one method but a group of methods, which compliment one another. Detailed description of the nested methodology follows in the next section.

3.3 Nested methodology

The empirical methods have been divided into a nested methodology, which consists of

1. **Ideology critique or Critical pedagogy**. It sets the vision for action research. This is an important first step in action research where an existing condition is understood and interpreted.
2. **Action research**. The overarching methodology and in many ways the overall philosophy of the thesis. The various stages help in gaining insights, which are matched with the model, and revisions are made as and wherever necessary.
3. **Design experiments.** This is best suited to the in-vivo observation cycles of action research of the teacher-as-researcher. The purpose is to gain insight into the complex learning ecology. This is in contrast to the conventional experiment method where some factors are separated under controlled conditions and are tested.
4. **Data collection and analysis**. These are the instruments of data collection and analysis within the design experiments.

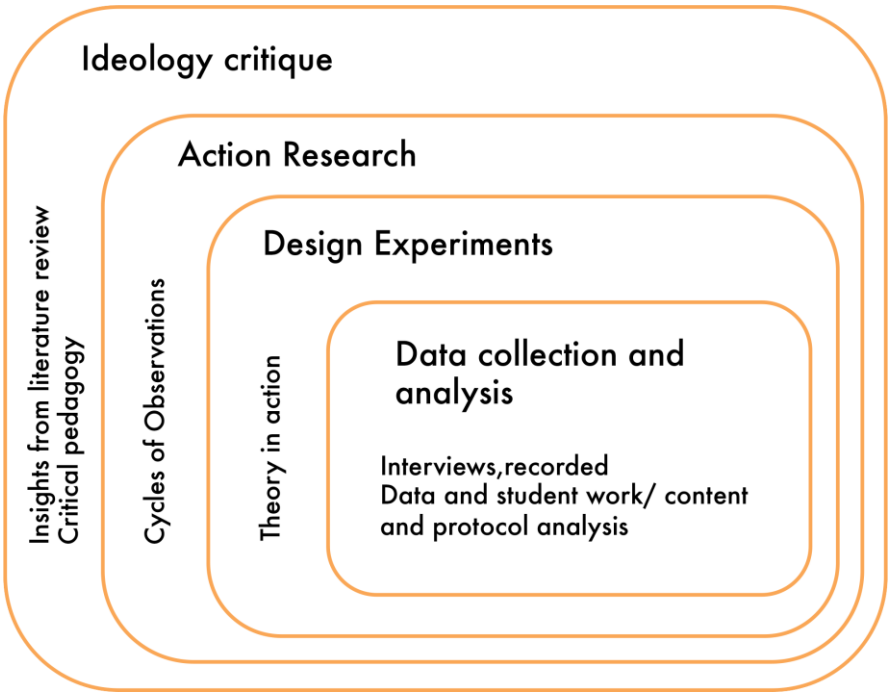


Figure 3.1 Nested methodology

3.3.1 Ideology critique

An attitude of critical pedagogy was maintained throughout the research. Critical pedagogy goes hand-in-hand with the overarching methodology for the research, which is Action research.

In critical pedagogy the argument is advanced that educators must work with, and on, the lived experience that students bring to the pedagogical encounter (Cohen, 2013). The critique recorded in this thesis emanates from two sources. One is the teaching experience of the author where several issues were brought out by fellow instructors and the students themselves. The second source is the observation of another instructor's design studio, which gave insights into how the conjectures are used in design pedagogy and how students are using it in the design activity.

Habermas (Habermas, 1985) cf (Cohen, 2013) suggests that ideology critique through reflective practice can be addressed in four stages:

Stage1: A description and interpretation of the existing situation

Stage 2: A presentation of the reasons that brought the existing situation to the form that it takes.

Stage 3: An agenda for altering the situation.

Stage 4: An evaluation of the achievement in practice.

The steps above were followed and are reported in chapter 4. A point to be noted here is that Stage 3 as described by Habermas has been interpreted as strengthening the situation rather than altering it altogether.

Critical view of pedagogy revealed the following areas, which need attention.

1. Students are unable to bridge the domains of design and sustainability as they see them as separate.
2. They find the sustainability inputs very abstract, which cannot be applied to their projects.
3. The students are not able to recall the didactic input at the time of application into their projects.
4. Instructors do not have access to designerly techniques with which to teach sustainability.
5. Large global issues are discussed in explanation of Sustainability. The picture is painted as bleak. A more positive and objective outlook is required.
6. Students feel that sustainability is a dry and technical subject and there is no room for creativity in it.
7. Special courses are designed to deal with sustainability; therefore it is viewed as an exclusive area by itself. This discourages sustainability to be integrated as a meta-objective of any design project.
8. Design for sustainability looked at very narrowly and not holistically.

All the points are discussed in detail in chapter 4.

3.3.2 Relevance of Action Research

Stenhouse (Stenhouse, 1980)suggests that action research should contribute not only to practice, but also, to a theory of education and teaching which is accessible to other teachers. Action research is conducted as a series of design experiments. These design experiments

have used a step-by-step actionable theory building exercise. They contribute to structuring the Conjecture Analysis model for Sustainability (CAMS).

In order to answer the research questions, the methodology had to involve gathering 'real' data from actual practice of researcher. Further, it involves developing, implementing, monitoring, reviewing and intervention cf (Newby.P., 2010), as in (Cohen, 2013). Another consideration for choice of methodology was that the intervention had to be applicable in educational research. Considering the above, action research was chosen as the overarching methodology. Action research starts with small cycles of planning, acting, observing and reflecting which can help define issues, ideas and assumptions more clearly (Cohen, 2013). The author is in a unique position to implement these cycles in pedagogy. It can also be further extrapolated to 'gradually include more of those involved and affected by the practices in question' (Cohen, 2013).

All educators do some form of action research in the regular course of their teaching, but the crux of the matter is the rigour with which one applies oneself.

Action research involves keeping a personal journal in which we record our progress and our reflections about two parallel sets of learnings: our learnings about the practices we are studying… ...and our learnings about the process (the practice) of studying them (Cohen, 2013).

Critical pedagogy (or ideology critique) goes hand in hand with Action research, because without a constructive criticism of the present practices it is not possible to improve for the future.

In the world of education Haberman's stages are paralleled by Smyth (Smyth, 1989) as in (Cohen, 2013) who, too, denotes a four-stage process: description (what am I doing?); information (what does it mean?); confrontation (how did I come to be like this?); and reconstruction (how might I do things differently?). It can be seen that ideology critique has both a reflective, theoretical and a practical side to it. Without reflection it is hollow and without practice it is empty.

The fundamental aim of action research is to improve practice rather than to produce knowledge. The production and initialization of knowledge is subordinate to and conditioned by, this fundamental aim.

Action research is not a one-step process but a multi-step process, which are also called research cycles. The cycles are of two kinds: Convergent and Divergent. Elliot (Elliot, 1991) explains:

1. ***Research cycling.*** [It] involves cycling between action and reflection [and] developing different ideas. The whole research topic, or different aspects of it; singly and in combination, are taken round several cycles, then experiential and reflective forms of knowing progressively refine each other.
2. ***Divergence and convergence.*** Research cycling can be convergent, in which case the researchers look several times at the same issue, maybe looking each time in more detail; or it can be divergent, as researchers decide to look at different issues on successive cycles. Many variations of convergence and divergence are possible in the course of an inquiry. It is up to each [researcher] to determine the appropriate balance for their work. The following figure (Figure 3.2) shows the convergent and divergent cycles of action research for this research study.

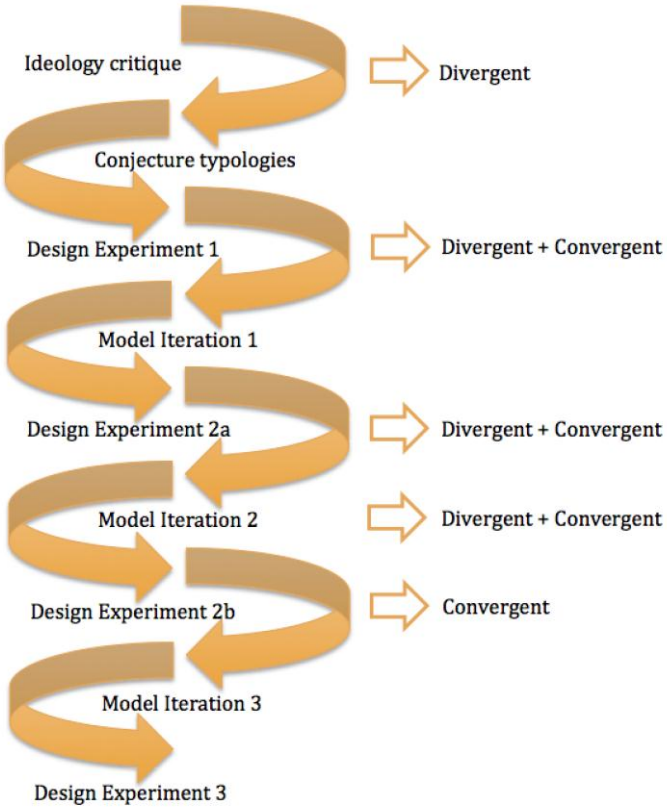


Figure 3.2 Action Research process

3.3.2.1 Theory in action

Action research is not being followed to measure a phenomenon but to prove that a theory works. The CAMS model is based on several theories that form a web of meaning. Each model is a demonstration of how the theory works. Moreover this gives the opportunity to design teachers to theorize in practice. Elliot (Elliot, 1991) says, "teachers often feel threatened by 'theory' [Looking 'through the eyes' of practicing teachers]. Theory is something they cannot apply or use in relation to their practice.

1. First, teachers feel 'theory' is threatening because it is produced by a group of outsiders who claim to be experts at generating valid knowledge about educational practices. To bow to a 'theory' is to deny the validity of one's own experience-based professional craft knowledge.
2. Second, theory is often 'generalizations of teachers practices'. Generalization constitutes the denial of the individual practitioners' everyday. [It] will contradict their experience of themselves as sources of expert knowledge.
3. Third, feelings of threat are further enhanced by the researcher's employment of models of practice derived from some ideal of society, like social inequalities and injustices, a fostering of narrow and limited conceptions of human potentials and abilities.
4. Therefore validation happens incrementally with each cycle rather than a conclusion to the whole study. This is a process of theory in practice or theory in action."

We will follow the four steps of theory in action.

Sagor (2005:4) sets out a straightforward four-stage model of action research:

Stage 1: Clarify vision and targets

Stage 2: Articulate appropriate theory.

Stage 3: Implement action and collect data.

Stage 4: Reflect on the data and plan informed action (Cohen, 2013)

3.3.3 Design Experiments

Design experiments have both a pragmatic bent of 'engineering' particular forms of learning and a theoretical orientation of developing domain specific theories by systematically studying those forms of learning and the means of supporting them. The authors clarify what

is involved in preparing for and carrying out a design experiment, and in conducting a retrospective analysis of the extensive, longitudinal data sets generated during an experiment. Logistical issues, issues of measure, the importance of working through the data systematically and the need to be explicit about the criteria for making inferences are discussed.

Design experiments are conducted to develop theories, not merely to empirically tune "what works." These theories are relatively humble in that they target domain-specific learning processes. For example, a number of research groups working in a domain such as geometry or statistics might collectively develop a design theory that is concerned with the students' learning of key disciplinary ideas in that domain. A theory of this type would specify successive patterns in students' reasoning, together with the substantiated means by which the emergence of those successive patterns can be supported. This emphasis on theories reflects the view that the explanations and understandings inherent in them are essential if educational improvement is to be a long-term, generative process. Design experiments ideally result in greater understanding of a learning ecology- a complex, interacting system involving multiple elements of different types and levels-by designing its elements and by anticipating how these elements function together to support learning. Design experiments therefore constitute a means of addressing the complexity that is a hallmark of educational settings. Elements of a learning ecology typically include the tasks or problems that students are asked to solve, the kinds of discourse that are encouraged, the norms of participation that are established, the tools and related material means provided, and the practical means by which classroom teachers can orchestrate relations among these elements. Design experiments are crucibles for the generation and testing of theory (Cobb, 2003).

3.3.4 Data collection and analysis

Under the overall methodology content analysis is chosen since the data involves content collected in class. Content involves drawings, presentations and discussion with instructors and within students themselves. The coding is done according to occurrence of precedents and design decisions, which are the units of analysis. The method of deciding codes, defining their levels of abstraction and making speculative inferences from them is described in detail in chapters 4 -6.

In this chapter, we discuss the methodology and methods suitable to answer the research questions. The appropriate methodologies are Action Research and Critical pedagogy. Action research because one is actually trying to find ways and means to improve one's practice. The conditions for action research, is also served where the author is a part of a system where changes can be affected at various levels.

1. Classroom level interaction with students
2. Curriculum level
3. Networking level with other pedagogues for adopting the technique.

3.4 Research Design

The research study started with an exhaustive review of the two large domains of design and sustainability. The discourse was traced in terms of historical development, basic characteristics of design and sustainability, points of convergence and points of departure. The literature gave direction to the formulation of the research proposal. The proposal essayed that conjectures were an important tool in design pedagogy, which were used by students and instructors in the design activity. Therefore it stands to reason that it should be leveraged into development of a model, which could be used effectively for sustainability pedagogy. This led a more detailed literature review of conjectures, conjecture/analysis method in design and other related theoretical arguments in the area of design theory and methodology. The detailed review helped in formulating the operational research questions. These research questions pointed towards action research as the overarching methodology, and other methods nested within it. As proposed by the research proposal, iterations of the model were developed through empirical observations, conducted within the ambit of action research. Results and conclusions were drawn on the basis of the final iteration of the model representation.

The challenges faced while applying the methods for this study, is discussed. The fact that the teacher as researcher mode is employed, has the danger of bias creeping in. In the concluding section of the thesis the threats to validity and ways it has been dealt with is discussed.

Further, we found that the generalizability of the technique proposed lies in overcoming the following restrictions.

1. The area of work not being restricted to a particular branch of design such as Architecture, Product design or Fashion design.
2. Not looking at only a class of sustainability problems such as environmental, social or economic; but straddling all of them.

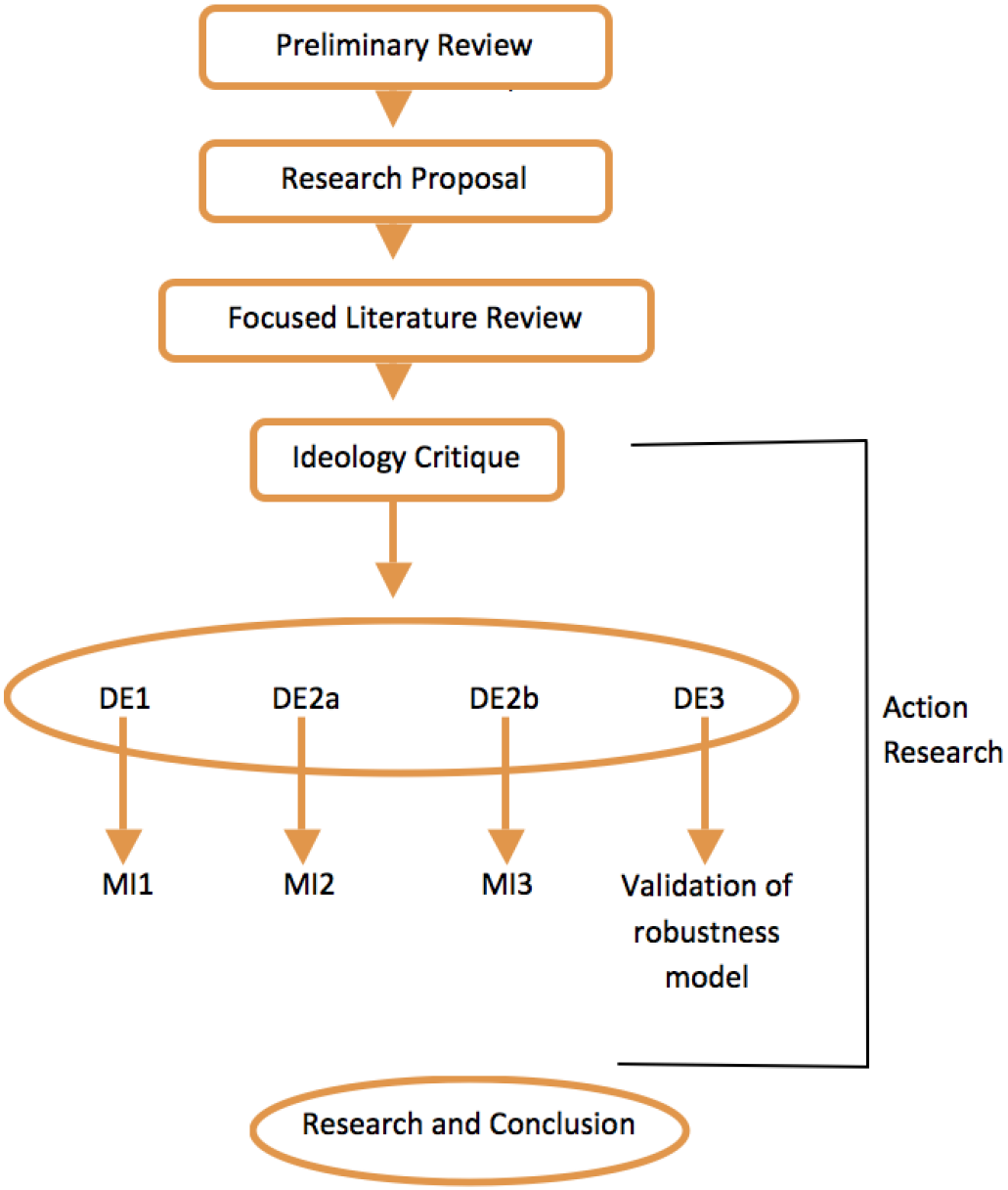


Figure 3.3 Research design

3.5 Chapter summary

Following the direction gained in literature review we summarize that conjecture/analysis approach is an effective tool for decision making in design process and this can be leveraged as a pedagogic tool to integrate sustainability conjectures in student design projects. There reside two key ideas in the above summary. One is that C/A is effective in design pedagogy and the second that this can be leveraged in sustainability pedagogy. In order to chase these two ideas, a nested methodology was devised. This methodology first looked critically at how conjectures were being used currently in design pedagogy and how sustainability approaches can be delivered within the developing model, through inductive stages of action research. Each stage yielded critical insights, which were progressively applied to the next stage of action research and also matched with the developing model to make alterations if necessary. The collective insights were used to build a conjecture/analysis model for sustainability (CAMS). Each stage is a design experiment, which is conducted with ecological groups of students. Design experiment is a valuable method as it allows observation of the student group in their natural settings. The tools of collection of data are interviews, video and audio recording and collecting students work in terms of their presentations, drawings. The methods for analyzing the data are content analysis and protocol analysis.

An overview of the stages of action research, are laid down in this chapter. The detailed description of how action research has been used in pedagogical contexts has been described in Chapter 4 & 5 and 6. The different iterations in the development of the model (CAMS) are explained in Chapter 5.

Chapter 4

Use of Conjectures in Design Pedagogy

4.1 Chapter introduction

As discussed in the previous chapters, C/A is the preferred choice of approach for this research. Another important feature of C/A, which makes it suitable to design, is the fact that C/A is a constructivist method where the context and constructs of the designers using C/A also contributes to the final solution. Saying which, the reasoning is that C/A does not look at the problem solving activity in isolation 'but includes the experience of the problem solvers in the whole process' (Heape, 2007). This statement dovetails with the reasoning that, like A/S, C/A is not a methodology but a theory (Trebilcock M. , 2009), validity of which is testing conjectures. This works well in the face of uncertainty of design and sustainability problems.

With this background the chapter starts the empirical observations of how instructors and students work on a design problem in a design studio. This is the first step of action research where the current practice of teaching and learning is observed, as a critique on the current ideology.

There are two inputs into the ideology critique; one, where the product design module of the second year students of an industrial design programme is studied for conjecture usage; and the second, where the insights from the author's earlier teaching experience are also taken into consideration for deriving conjectures.

Until now the discussions have been relating to design and sustainability in general with few references to pedagogy. Chapters 4, 5 and 6 apply and discuss the theories in the pedagogic contexts only.

4.2 Discussion of C/A paradigm in the context of pedagogy

'Conjecturing approximate solutions' (Hillier, B, Musgrove, L & O'Sullivan, P., 1972) in order to understand the design problem has a marked resonance in pedagogy. Students need to pre-structure the problem and change it as they progress, because 'without a solution-in-principle at some intermediate stage, a vast variety of design decisions cannot be taken' (Hillier, B, Musgrove, L & O'Sullivan, P., 1972). Students are novices who need the anchor of conjecture to build their knowledge and skills. General principles cannot be applied to tackling design problems since every design problem is unique, a 'universe of one' (Schön D. A., 1991). Experienced designers deal with every design problem through 'artistry' of reflective practice. But Schön (Schön., 1987) argues that this 'artistry' need not be relegated only to the expertise of experienced designers, but could be taught in professional schools. This thesis proposes that reflective practice can be inculcated in students through conjectured thinking.

Another convincing argument for C/A in pedagogy is that of Trebilcock. She says A/S concentrates on dismantling 'parts' towards reaching the 'whole' (Trebilcock M. , 2009). When applied to pedagogy students very often get entangled in the 'parts' jeopardizing the overall coherence. C/A logic on the other hand assists design decisions that integrate several variables, so that the whole is more important than the parts.

Two empirical studies using C/A for pedagogy have influenced this research. The first is that of Kees Dorst, where he compares the different paradigms A/S and C/A, to demonstrate the 'closeness' of each method, to the way designers experience design activity. Though rational problem solving process (A/S) has its merit where the problem is fairly clear-cut, reflection-in action is 'closer' where the designer has no standard strategies to follow and

is trying out problem/solution structures (Dorst K. &., 1995). And this is usually the case when a design student encounters a sustainability issue. Dorst appeals that the theoretical base of Schön's theory should be developed so that 'more rigourous and generalizable conclusions' can be drawn. Development of CAMS is an attempt in that direction.

The second empirical study where A/S is challenged is that of Chris Heape. In his PhD thesis he maps the 'actual experience of designing' into a 'Design Space' (Heape, 2007), which challenges the rational decision making of A/S, and argues for an organic way of dealing with design problems.

In the author's teaching experience, the students consider 'design' problems different from 'sustainability' problems. Most often students go through the entire design process with the classic design criteria- aesthetics, functionality, ergonomics, manufacturability etc. (Ramirez, 2007), and add 'sustainability' criteria later. This does not work very well for integration of design and sustainability. Sustainability considerations for design should be there in early design stage for it to be meaningful. Sustainability problems are also 'wicked' (Rittel H. W., 1973) just as design. Addressing design problems by situating them in sustainability context and using conjectures to make sense of the problem immediately creates a link between design and sustainability in the student's mind. Further, as one proceeds in the design process, testing resistances to conjectures helps students deal with complex and uncertain terrain of sustainability.

After the macro literature survey presented in Chapter 2, a more detailed literature was also studied of previous research done in the areas of 'Precedent based knowledge' 'Case-Based Reasoning' and 'Episodic thinking', which are relevant to Conjecture based pedagogy. All these concepts came to life during the observation of the studio of another instructor.

4.2.1 Precedent based Knowledge

Precedents may be previously employed solutions by famous designers. Another way of looking at it is that precedents transform 'internal memory' of designers to 'external memory'. This means that 'external memory' has to be tangible pieces of information, which is more accessible and searchable. The precedents can be in the form of pictures, graphical representations, processes, text and verbal. The knowledge assimilated through the study and use of precedents is known as Precedent based Knowledge.

Large databases of precedents exist in the areas of Law, Medicine and management pedagogy and practice. This formalizes this way of thinking in these fields. Design being different from law, medicine and management, the treatment of precedents in design should also be different. No two, design situations are ever identical, and Goldschmidt (Goldschmidt, 1997) cf (Lawson B. , 2004) points out that this is not necessary for precedent to be useful for a designer. In fact unlike the lawyer, the designer is not trying to demonstrate a close parallel with the precedent but is rather using something that is sufficiently similar in some respects to become a useful point of departure. Goldschmidt therefore argues persuasively that the term 'precedent' is less satisfactory than the term 'reference' as a generic description of this phenomenon in design. In fact she prefers to see precedents as a sub-class of the more general idea of reference. The author furthers the idea of precedents being a sub-class of a bigger idea. The bigger idea is that of conjecture. The typologies of conjectures identified are listed at the end of this chapter where precedent is one kind of conjecture.

4.2.2 Case Based Reasoning

Case Based Reasoning as a method in AI is considered to be the brainchild of Janet Kolodner (Kolodner, 1984) cf (Akin, 2002). Her work developed a computer-based system that could browse a repository of cases (recipes), find a match to the problem at hand (preparing a dinner) and adapt the recipe to the problem at hand (prepare a vegan dinner out of vegetarian recipes). The technique proved to be not only a powerful generative system but also one that would find broad applicability in other areas. Even more relevant to our topic here, Rivka Oxman (Oxman, 1994) developed a case base that assists designers in consulting design precedents. Schön (Schön D. A., 1991; Schön D. , 1987) an early student of the method, aptly coined the term 'reflection in action' to describe the process that takes place in the design studio which is akin in many respects to the case method.

Key roles that the instructor plays in this method are facilitating the discussion around a given case, selecting and presenting the case, and in some instances codifying and structuring the case, leading successful discussions through case examples collected in the classroom.

The other key ingredient of the method, obviously, is the cases. Historically, cases used to consist of brief, and at times cryptic, descriptions of situations, which then had to be

elaborated extensively on subsequent stages of the instruction process. The corpus of cases and their proper representation is obviously the prerequisite for any successful implementation of this method, regardless of the discipline of application.

4.2.3 Episodic thinking

Episodic thinking is use of knowledge from internal and external sources (Visser, 1995). Internal source is quarrying one's own experiences and external is the 'shared' experience with others. Both are very important especially for students of design where they are not yet exposed to the rich repertoire of precedents from which to draw from.

4.3 Critical Pedagogy

An attitude of critical pedagogy is maintained throughout the research. The critique has been presented in two ways. Firstly, design studio of another instructor is observed, with the purpose of extracting conjectures used by the instructor and the students. This is a product design studio where the instructor guides the students through a certain design process to satisfy some objectives. The critique presented will be to describe the early design process to gauge the frequency and the nature of conjectures used. Although the entire studio module was of duration of 15 days, only the first stage of the studio (1a, 1b, 1c, 1d), (Table 4.1) has been transcribed for the purpose of analysis. The design studio observed was a learning ecology where many factors are acting. The factors cannot work in isolation nor can the isolated factors be studied in controlled conditions like a laboratory experiment. This lent credibility to design experiment as a valid method of data collection. Secondly, the author gleans her teaching experience for describing responses to bridging design and sustainability pedagogies. These reflections also deliberate on the initial motivation of the research, which is to answer the question, whether design and sustainability pedagogies are fundamentally different. The author's observations conforms to the belief that there is a strong similarity between design and sustainability pedagogies, yet there are also some distinguishing factors with regards to sustainability, which need to be interpreted appropriately during deliverance by instructors.

4.4 Observation of another instructor's design studio, 2011

The observation was done of the course PD2, Product Design 2. It was conducted for students of semester 3, Masters of Design at Industrial Design Center, IIT Bombay. The class consisted of 12 students and one anchor faculty. The faculty would bring the expertise of other faculty members as and when required.

The theme introduced by the faculty to the students was- 'design of electrical accessories'. The solutions would be geared toward solving problems of wiring, wiring management and facilitating operation. The stages of the design process followed in this course, is given in Table 4.1 below. 1a is the slice of data chosen for analysis. This is the stage where the faculty introduces 'what to design'. The presentation is verbal discussion; power-point slide presentation and showing examples of real world designed products in the class.

Table 4.1 Design process for product design course.

Stage 1	Stage 2	Stage 3	Final stage
1a. Introduction to theme	2a. Presentation of brief	3a. Mock up	4a. Prototype/model
1b. Brainstorming	2b. Fine tuning	3b. Model making	4b. Solid model (3D model in solidworks)
1c. Theoretical inputs / case studies	2c. Concept generation		4c. Report
1d. Gathering info from field			4d. Presentation

The project given was to develop an understanding of wiring accessories in the residential context. This will be done through

- Field visits
- Talking to users

- Documenting existing situations through visual media
- Collecting samples of existing products in the market
- Prepare a product brief in order to arrive at a design solution.

In a studio class usually the problem is introduced right in the first couple of sessions. The learning happens through the evolution of the problem into the solution. The theoretical inputs, field visits, talking to users and surveying the market are given as part of solving the problem.

The main keyword that the instructor and the students were working with was wiring accessories. The instructor had identified this as the problem area through personal experience and observation. The input given towards understanding the problem can be broken into the answers to the questions-What, Why, Where, Who, How.

What- The first task was to populate the space of wiring accessories with products fitting the category. This was identified as anything that couples into the electrical wiring of the house forming a system. A list of luminaires, lighting accessories, electrical appliances and wire management devices was drawn out.

Why- this was the task of need identification. The instructor had already identified a need from the users' point of view and as a gap in the market. This was discussed in class, and students had to support this with their own observation of interior spaces and searching literature.

Where- Locations were identified within the residential interior where these wiring accessories are required. A visual mapping of the space was done.

Who- various levels or strata of users was identified

1. Interior designer/architect, who buys the accessories on behalf of the client
2. Electrician, who services the electrical devices
3. End user

How-How does one procure the products? How much does it cost? How does the accessory adapt, control or make the user experience more enjoyable?

The final design solutions arrived at by the students are listed in Table 4.2.

Table 4.2 Final categories of products chosen by students.

Assignment brief	Student	Product brief
Develop an understanding of wiring accessories in the residential context. This will be done through Field visits Talking to users Documenting existing situations through visual media. Collecting samples of existing products in the market. Prepare a product brief in order to arrive at a design solution.	1	Door bell
	2	Main circuit breaker board
	3	CFL holder
	4	Immersion rod
	5	Wire manager (extension boxes)
	6	Plug points in kitchen
	7	Ceiling fan regulator
	8	Spike guard
	9	Mobile charger
	10	Night lamp
	11	Switch
	12	Switchboard

4.4.1 Conjectures found in studio observation

Conjecture is the unit of observation. Every utterance, object or reference to a previous experience has been flagged as conjecture. Following are some excerpts from the transcribed material.

Music player of this size (shows a notebook to the students), because I want to give music to people who are on move. He saw the new possibility, new market, he himself was a jogger…and…he saw that jogging is a boring activity at the end…okay…so he said…let me give a…music when people are moving, like travelling in a train…okay…Bombay-Pune,..a..even in Bombay, many people are going to VT from Kalyan,...and….one, one and half hour everyday up and down, three hours in train, isn't it boring?! So, music when you are on the move.

Apple also introduced their iPod around 2003…okay…that product was far better designed, but better design is not only the selling feature, it was not doing really good…okay...after one year about 2000. In 2004 they introduced iTunes concept, music available for downloading…okay…at very cheap rate…90 cents,

You will get a legal copy of music...everybody started downloading, the business…grows like anything. People are carrying 200, 500 songs in their iPod, and it's such a nice, you must have seen the interaction of that, the interface, fantastic!...okay…so the consumer…I talking about this..but consumer focus, but only consumer focus iPod was not working, when they understand…understood that okay consumer wants something more…legal ownership of songs and iTune is bringing more revenue than the iPod. but.. Okay, only five models are there, look at the Nokia store, look at the Samsung, look at LG, look at Sony Ericson and what not and what so…How many models are there in their stores…and it is apple is surviving the competition…. okay…their strategy is different, we will talk in fact I am going to talk about those also, the philosophy and then strategies which will help you to learn….whole issue comes should be as a break through on internet…okay, always break through will give you real great benefit, because you will become the leader…listen you are going to introduce the product first and if it becomes a hit in the market you will enjoy that leaders, so like today we call plain paper copy, copier as a xerox , get a xerox, Xerox is not a word.

Student: Xerox, Xerox is a company

Instructor: Xerox is a company, okay now if you if ask for a switch, you ask for Anchor…okay this becomes like a words, they are the first to introduced something new in the market.

Student: the iPod also, mp3 player when you walk na very less people will say mp3 player everybody says iPod iPod , iPod , even if it is a….

Instructor: iPod okay iPod, actually mp3 players came before it appeared in 2000, but the iPod set the standard, so whoever sets the standard becomes synonymous to that, okay so if you invent something, okay, it is like a break through, whatever you will be it will be, you will be the leader in the market.

Transcript 1

Instructor embedding product analogies as precedents

Let's look at this sequence…

This was a project given to the students some years ago. Actually it was very vague at the time…at the same time you have to do something for the entrance door and the entire batch was supposed to find out what they can do with the entrance door.

They can either design an entrance door, an accessory….what ever...it is to do something.

This group felt they should do something which the person who comes in…the entire activity of coming in is simple. So they went and observed what people do when they come in to the house…and what happens inside the door. There are people who come and open the door. I'll just show you some examples…People come and press the bell….okay…typically in Bombay the door is closed…chain in unlocked position because nobody is that careful that as soon as someone comes, they need to put the chain, so the first thing you do is put the chain. When a child has to open the door…you train…at least in Bombay…how many of you are Bombayites? So they are trained saying that it is not safe to open the door…to first open you put a chain and…or you look through a magic eye…In the magic eye the image is distorted…it actually scares you more than opening the door. So now when you start putting the chain in, there is a sound by which the person outside knows that the chain has been put. He is not going to like it…would you like it if somebody put a chain on your face.

Then what you do is that you open the door and peep through. The visitor is also going to see you. And worst thing you do is…after you have identified the person you are supposed to close the door otherwise the chain doesn't open…and after that you open the door and let them in. Now think about this…is this the right way of letting a person in?...obviously there is some flaw. Of course people in Bombay seem to think this is the only way.

Now of course new technologies have come…there are one way cameras, mics. On of the students actually watched it a little more carefully…so when people come in…his data showed that at least 70% of the people who ring the bell are known to you…they are either from inside campus…why do you go through the rigmarole of doing all this for 70% of the people…so he realized that there's some way people announce…and almost everybody has some kind of pattern that they build by knocking. (sounds made on table). They will standardize the pattern on their own which announces their arrival…that's the easiest thing to do. Tell your mother that I have come. Looking at this, we thought that why not convert this into an idea so…

He was bit of a musician, he did a little research to find out…what are the number of notes that are required in order to make a unique note…which is not easy to copy, except for musicians…musicians can copy easily…he actually tried 2,3,4

People can make a note.

Then of course there are lot of other things. The point I'm making is there are very few universal…for which you can have a standard…very few problems…

You can identify them based on your expertise, there is always a limitation. Designers will always argue their point…they tend to identify something saying this should be done. Any other designer would do the same and you can identify problems

All of them had observed that there is and opportunity….so obviously observing people is a creative process…because all the time you are observing, you are looking for new opportunities…you are not looking at exactly what he does…that is not the thing. So I change that particular situation through my input as a designer. Can I make it a little more convenient for the people.

The reason why it is called active people watching is that at that point you are actually interacting with the situations saying that can I change this. Can I make it…at the time you… not at the time…you can also take a recording and go back and see it, but...on the spot itself.

One thing in the real world, the problems are not there but they need active people watching for instance most of the people have adjusted to the fact the world will be like this. If you are asked what is wrong…look at yourselves also, lot of them didn't deal with…what kind of sound, what kind of experience…that's why experience design is impressive.

But it has its own limitations. The real world problems don't really exist. We have to discover them, they don't come.

Transcript 2:

Case study of previously done student project being explained to current students

Student: Save sancha, the, for making save we have this traditional….
Teacher: Ha save making thing, there are again two, okay one is the wooden one then the woh thoda mechanical advantage wala screw wala aa gaya, okay, uh…..
Student: Sir, the instrument which we use for cutting the supari…arkita…sarota
Teacher: Uh, arkita or the sarota, ok so in these what else has not changed ….your basic door, front door has it changed
Student: Fan, fan not that much, fan
Teacher: Fan main bhi itna zyada kuch change nai hua, okay we have fan experts so I have requested him to give a take on the technology behind the fan…Professor Ram Chandra worked in Crompton Greaves for almost 24 years ok with the fan division, ok he is our fan expert, he will talk about the fan and the what, okay……holder for the bulb…switches
Student: Changed, changed, changed a lot
Teacher : Kya change hua hai usme?
Student: Form…types hai (……) safer na
Teacher: Uske pehle black wala tha, have you seen that, okay toggle wala aur rocker wala, nai nai who toggle hai, usko toggle bolte hain and then this came, which is called as a rocker, okay uh that was one change, then there are these modular plates…..
Student: Sir, fan regulator bade bade hote hai… ha, who bhi nahi hai….
Teacher: Who bhi abhi chote ho gaye hai…okay
There are electrical, electronics, capacitor type and technology is also changing. What else?
Student: Even table lamps, they changed to CFL table lamps.
Teacher: Even it is changing, so it should go in the first. Lamps are changed, okay, our, our incantation lamp, okay our tube lights which were almost like a one and a half inch tube diameter, it is becoming thinner and thinner. Okay…uh, hold fitting is becoming slimmer and what else has not changed.
Student: Sir, scissors are used for cutting cloth…watch…clock
Teacher: Uh, cloth cutting scissors
Student: Clock…clock…clock…clock…..
Teacher: Clocks, oh there are many new designs available today na….
Student: There is that grandfather clock.
Teacher: Grandfather… ya so what is happening in this not change, okay, we start using this adjective 'grandfathers clock'. Traditional uh…. uh this thing, grinder jo stone wala jo rehti thi na, even idli banane ke liye some traditional orthodox people they still use that stone wala this thing, okay…
Student: Ha…in Kerala
Teacher: They are recently change but ha….
Student: Even in our houses they buy those because they last for years.
Teacher: Ya, okay
Student: Iron has changed…
Teacher: Iron has changed…now let us look at this electrical things…okay, what our domain is electricals, in houses, residential houses…okay, we are going to look at the switches, sockets and these some small, small items like irons, uh your mixers and grinders, okay small one, not the cabinet and the complete kitchen system vagera hum nai bol rahe hai. Small things okay, so our user, now who is the user for this product. Say if we say that the switches, yeh switches ke liye kaun user hai?
Student: Sir, puri family, everybody,everyone…….
Teacher: Bolo, abhi age ek list banate jao ap…
Student: Maybe the kids, because (…)
Teacher: Who is selecting the switches?
Students: Housewife, Man or lady,head of the family, contractor, sir lady, contractor, no no the ladies, contractor
Teacher: Architect friend, you should throw some light. Yeh kaun select karta hai?
Student: Electricians, woh electricians…

Transcript 3:

Instructor bringing in the constructs of students to help them visualize their own project.Hindi words are in green.

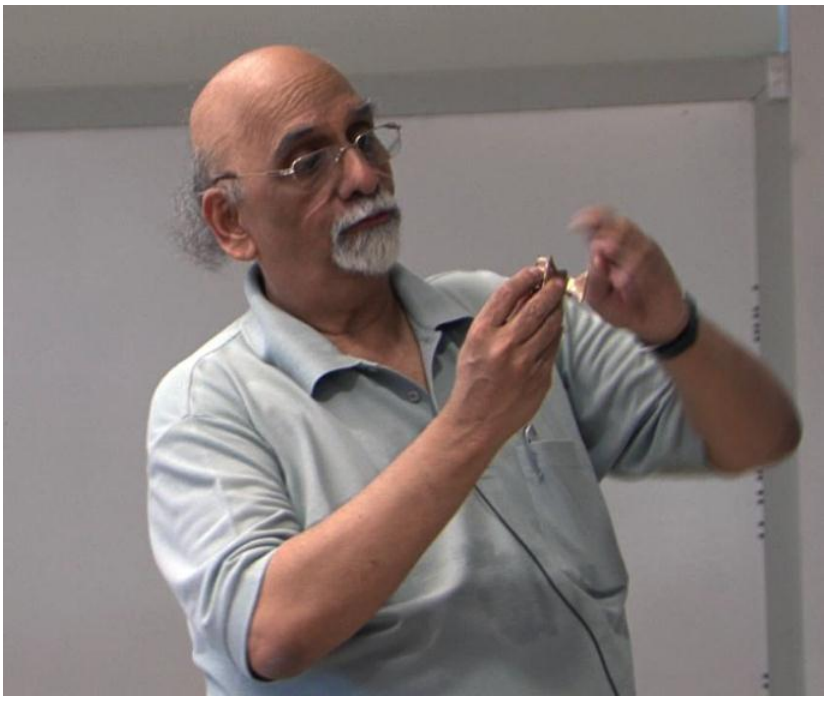


Figure 4.1 Instructor showing product samples in class

The instructor shown in the figure above has a collection of various products that have been meticulously collected and catalogued for the purpose of demonstration, which he admitted, was effective.

Figure 4.2 Instructor explaining professional project done earlier as case study

Since it was a project done by instructor himself, he was able to give many personal insights into the project. Implementing those insights into their projects has greater credence than a theoretical reference.

Figure 4.3 Students showing product samples collected from market, in class

Students followed a synchronous mode of collecting samples available in the market currently. They went to shops, which stocked popular brands such as Anchor, Crabtree, and Havells etc. They collected various kinds of electrical and wiring accessories from the market and brought it back to the studio to be shared and discussed. Along with the samples, information about pricing and range was also found. Interviews of the various stakeholders such as architects, interior designers, electricians and end users was done by students to find brand/product preferences, influences of price of product and reliability, ease of use and safety etc.

Table 4.3 Conjectures used matched with typologies they signify

Conjectures used	Comments	Typology
1. Reference to personal experience of the instructor	The instructor brings in personal experiences that have occurred from his boyhood till present to illustrate lifestyle changes, technology advancement, evolution and market dynamics.	Episodic
2. Reference to earlier student projects	The instructor presents projects done by previous students as examples of design process and challenges faced to produce the design solution. We find this tool to be effective for students as they can relate much better to it.	Precedent
3. Reference to famous designer's work	The instructor uses this as a tool for making the students aware of well-known designers. Some of the work from designer's work may be directly applicable but the rest adds as repertoire of knowledge about design.	Precedent
4. Reference to sections in books	Sharpens students' skills to use documented literature for their design projects.	Referent
5. Domain Knowledge in other areas. a) User studies b) Innovation c) Design of ceiling fan	Three experts were called for domain specific input. These are similar to exemplars proposed by Thomas Kuhn (Kuhn, 1996). These inputs are useful for students at later stages of design. These are explained through some projects done earlier.	Case study and precedent
6. Actual samples shown in class by instructor	This tool is very effective as the students get to 'see' and 'feel' the product.	Precedent
7. Project done by instructor	Gives an opportunity to instructors to explain the details of the design process, which is usually absent in any design case study.	Case study

8. Examples of electrical accessories (form, usage, innovation and function)	Some informative examples of electrical accessories, which has not been covered in any of the above.	Case study
9. Actual samples from market (students)	Students search the market for available samples of wiring accessories and get it back to class. When all the students share with instructor it helps inculcate peer learning.	Precedent/primary generator
10. Personal experience of students	Instructor invites personal constructs to be discussed. These bring out the parallels between what the student knows and what they need to design.	Episodic/primary generator

There are five major types of conjectures, which emerge from the observation as listed in table above. These also conform to explanations given in literature.

1. Primary generator 

Students latch on to a 'relatively simple idea very early in the design process' (Darke, 1979). Students should be encouraged to take it forward not 'as is' but by testing against constraints to get a better understanding of the problem. This is termed as a 'primary generator', which is the prima facie solution and is the 'window to the solution space' (Lawson B. , 2004). In the observation conducted, we find that the samples got back from the market become the starting point to ideate for one's own design. This is because of several reasons. One student said, "It is tried and tested… ...product is already selling in market." Another said, "When I went to the market, I didn't have anything in my mind. When I saw the new bulb holder, I was very interested in its mechanism… ...I thought I should work on this."

Examples from students' own experience are also a rich repository of primary generators. Transcript 1 shows how the instructor traces changes in products over the years by drawing on the student's own experience. The products talked about are: Sev making machine, fan, fan regulator, switches, table lamps, irons, In this list, some have seen many changes quickly and others not. In this example, the instructor invokes collective memory of an artifact, which a student articulates as a personal memory.

Instructor: Remember, this traditional thing…grinder.

Student: ...in Kerala.

Instructor: They are recently changed.

Student: Even in our houses they buy those because they last for years.

2. Referent 

It is important for instructor to provide a list of referents to the students in order to bridge 'learning of declarative knowledge in theory class and the procedural knowledge needed to solve design problems in studio environments' (Khorshidifard, 2011)[16]. For our purposes, we will define referents as 'a design situation, which consists of design problems, design solutions and design process' (Dorst K. , 2006). Another support for the idea of referent is that knowledge valuable to students in their design problems is not instrumentally accessible when they work, ...they do not know what they know' (Tzonis, 2014).

In the observation conducted, the instructor brings some books on ' how to conduct user study' to class to show how prescriptive guidance in books can also be used as a referent in their design process.

3. Episodic 

'Common-sense knowledge' is of utmost importance in students' understanding of design. It is observed that an already 'lived experience' either from an 'internal or external source' (Visser, 1995), helps students in interpreting a complex design situation. It will be worthwhile if instructors encash this behavior and consciously create design situations which give students a sense of déjà vu. It is proposed that this can be done through situating a design problem in day-to-day life. There is an academic interest in this area where designers 'reach a design solution by adopting interactions everyday design cases' (Kim, 2014).

The whole process of design pedagogy in a sense is a series of episodic events. In our particular case, the brief- 'managing wiring accessories', also came from instructor's personal

[16] Khorshidifard's paper was based on Kolb's learning model (Kolb, 1984) has relevance to our enquiry. According to Kolb learning is a process whereby knowledge is created through the transformation of experience. Knowledge results from grasping experience and transforming.

(Kolb, 1984) experience where he came across many challenges while building his own house. Consequently, the instructor embeds episodic elements in the discussion of the project and so do the students. Episodic events are very likely to become the primary generators of the project. The example of the products used in households makes a connection with students. This is also mentioned in point 1 in the discussion of primary generators. Some conjecture typologies can overlap.

4. Precedent

Precedents are commonly used conjectures in design process. They are ‘whole or partial solutions’ or ‘previously employed solution by a famous designer’ (Lawson B. , 2004). There is some amount of work done by designers to create digital databases of design precedents. Precedents are used quite frequently in law and medicine. Lawyers and doctors have extensive databases to refer to. We propose the same for design. Here the precedents come from discussion of product and their features. Instructor uses examples like the earlier music players, and how iPod came along with different experiences for the user. Through this ideas of innovation were imparted to students. You can change the way to store music, by downloading music rather than recording it to a device.

5. Cases

The academic activity of developing cases studies is absolutely missing in design. Instructors do present case studies to students. In fact they are quite detailed but many times cannot be used because they are not documented at the time the student wants to refer to it while designing.

Design cases are representation of knowledge which develop naturalistically as the designer or someone close to the design collects key artifacts and reflects on the reasoning behind decisions and the efficacy of those decisions (Boling, 2010).

In the studio observation, two very strong case-study inputs were given in the form of instructor presenting his own project done earlier. He explained the nuances of the design and management of the project. Another example of case study is that of an expert invited by the

instructor for input in user study. The expert explains the project done by students on how doorbells are used in Mumbai.

4.5 Critique from author's earlier teaching experience

Critical view of pedagogy revealed the following areas, which need attention.

- Students are unable to bridge the domains of design and sustainability as they see them as separate. Special courses designed to deal with sustainability therefore are viewed as an exclusive area. This discourages sustainability to be integrated as a meta-objective of any design project. Current curricula [in design] tend to be discipline based. Sustainable development on the other hand is a trans-disciplinary subject (Dewberry E. , 2011). Dewberry also suggests ways in which this can be tackled (Figure 1.3 & 1.4). This approach has been discussed and applied by the author with the students. However, it has not been reported in this thesis.
- Students find sustainability inputs very abstract and therefore cannot apply it in their design projects. Design and sustainability are looked at very narrowly and not holistically. Large global issues are discussed in explanation of sustainability. The shocking picture painted makes an impact on the students but they are unable to see how they can connect it with their work or how they contribute as designers to make a difference. To take away the abstractness, one needs to promote an educational philosophy that policy connects everyday living to the more generic policy objectives (Dewberry E. , 2011). Student projects connecting with everyday practices have been conducted as Design experiment 2a reported in section 5.6. This line of thought was further strengthened by work of Shove and Manzini. Shove most famously put forth the idea of the three Cs, Comfort. Cleanliness and Convenience (Shove, 2007). These three Cs are legitimate and accepted norms of everyday life. Shove claims that it is in the everyday activities that unintentional or 'inconspicuous consumption' happens. The 'Sustainability Everyday Project' (Manzini E. &., 2003), took this

seemingly mundane part of human lives to be the potential agent of change to predict sustainable scenarios.

- The success of a design solution is dependent on how people use it. This is why there is so much emphasis on user study in design. In this vein the author conducted a small study to gauge people's perception of sustainability by laddering up to their core values from an object they used in their day-to-day lives (Appendix 1). The dichotomy between design and sustainability has been addressed in this empirical study by targeting the everyday consumption practices of people. This might be a good place to look for insights to direct design towards sustainability and wellbeing. Therefore it is worthwhile to find ways of thinking regarding sustainability amongst people through the products they consume. In furthering this idea, it was found that people's sustainability concerns ultimately translate into their personal benefits and wellbeing. This positive connection between sustainability and wellbeing can be leveraged to make more people to accept sustainable living. These insights will also be taken to pedagogy to contextualize design within sustainability.
- Students are not able to recall the didactic input at the time of application into their projects. As Tzonis observed, "In our research, whereby students are taught in class new knowledge potentially valuable to their design problems but they never use it because although they have stored it in their memory, the knowledge is not instrumentally 'accessible' when they work. In other words they do not know that they know" (Tzonis, 2014).
- Instructors do not have access to designerly techniques with which to teach sustainability. Students feel that sustainability is a dry and technical subject and there is no room for creativity in it. The fact that the same design methods can be used in sustainability problem solving as well, escapes them. Students at first instance relate to sustainability with keywords such as recycle, reuse and recycle. This understanding, though useful, is limited and tenacious, therefore difficult to overcome.

4.6 Study of Visual Models

In the description of models of design process Heape has mentioned two categories of design process models- Prescriptive and Descriptive. In this thesis two more categories have been added- Conceptual and Generative. Thus there are four categories of visual modeling of design process that will be described i.e. Conceptual, Prescriptive, Descriptive and Generative. We are particularly trying to capture the concept of C/A in design process, of which there are very few examples. These examples are fragments of C/A or where the idea of conjecture has been used in general design process.

4.6.1 Conceptual

These models explain the overall concept of the phenomena. Therefore these models are useful in a macro-level understanding of context but cannot be used for application to any empirical study.

Darke introduced the term ‘primary generator’ in design discourse. She envisaged it to be the original idea, which the designer takes forward. This way the vast problem space of a design project gets limited and gets direction.

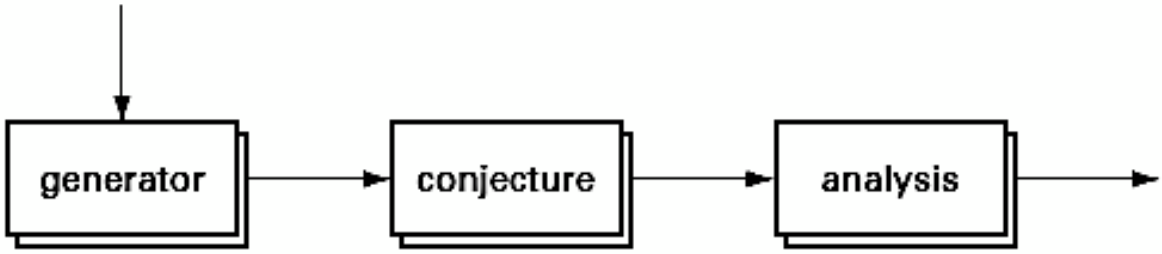


Figure 4.4 Primary generator as conceptualized by Darke, Source: (Lawson B. , 2004, p. 46)

The A/S and C/A models have been compared and discussed in the last section. Even though the two paradigms have their distinguishing features, Trebilcock suggests that in special cases they can be integrated in design process. Trebilcock gives visual form to the Integrated Design Process (IDP) as proposed by the International Energy Agency (IEA) Task

23. Here the various tools used in design process are placed in continuum. It can also be seen as collaboration between engineers and designers.

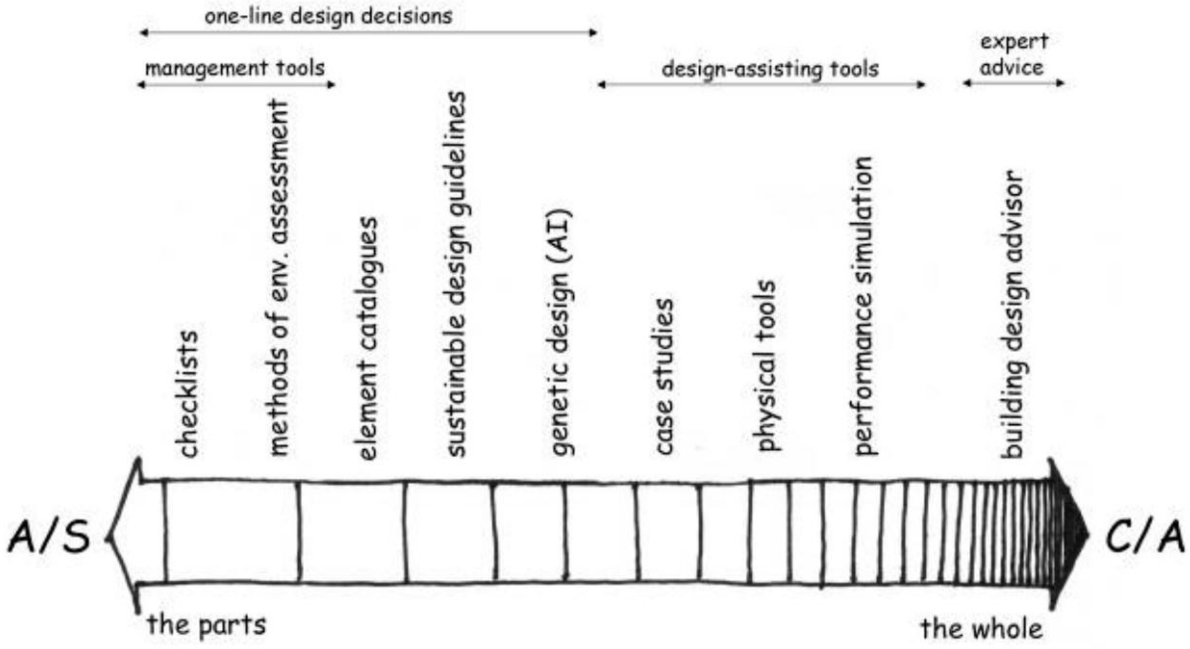


Figure 4.5 Integrating A/S and C/A paradigms. Source: (Trebilcock M. , 2009)

4.6.2 Prescriptive

These are more structured models, which give stepwise directions to follow. This thesis borrows from Chris Heape's thesis in listing the prescriptive processes in design. These depictions of the process suggest a linear stepwise framework in order to start with problem and reach the solution.

Figure 4.6 The model for general problem solving (Jones, 1970), Source: (Heape, 2007, p. 33)

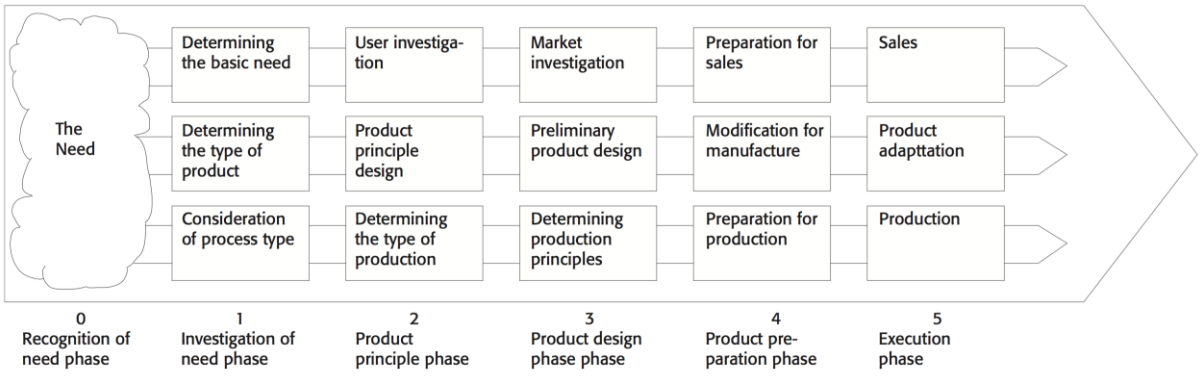


Figure 4.7 The model for integrated product development. Source: (Andreasen and Hein 1987, p27) as in (Heape, 2007, p. 33)

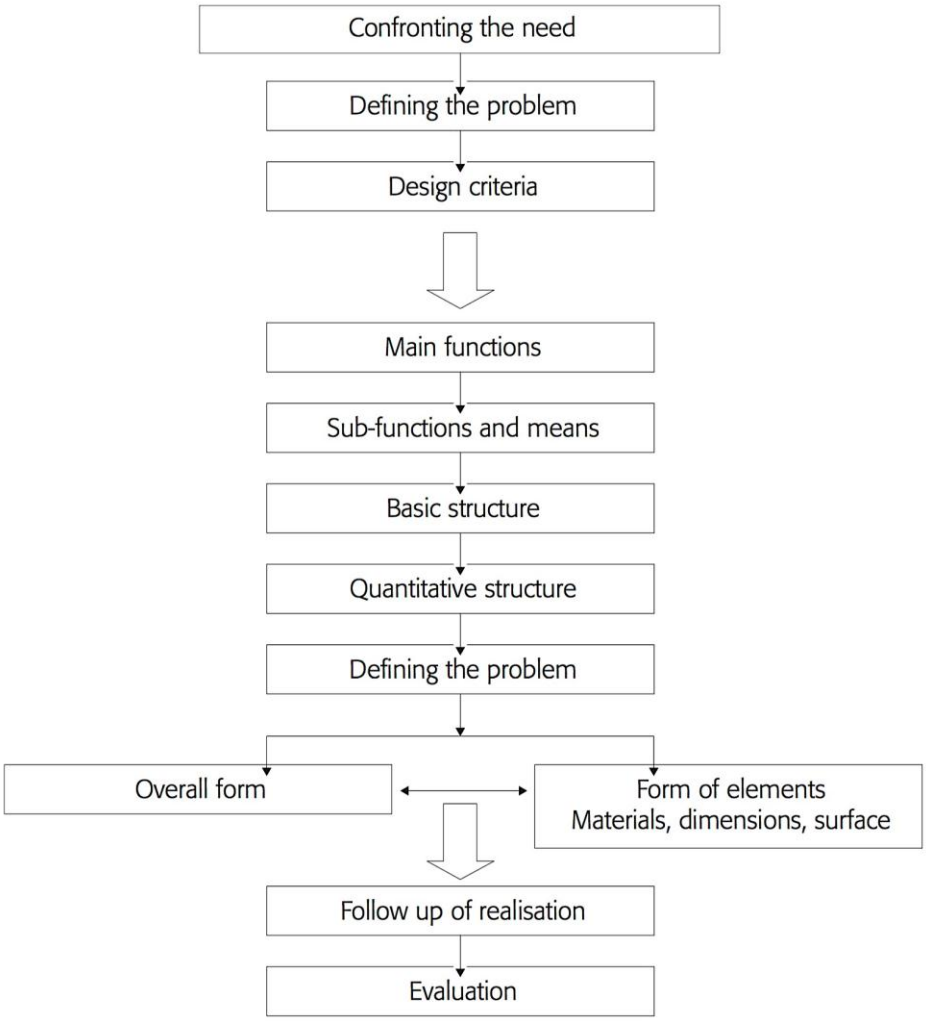


Figure 4.8 Model for product synthesis. Source: (Andreasn and Hein 1987, p15). Source: (Heape, 2007, p. 33)

Blessing identifies 4 strategies as to how to proceed through the prescriptive stages, (Figure 4.9), where 1a stages are executed sequentially, i.e. “in principal only once”; 1b, “the main flow throughout the activities and stages…as acyclic flow”; 1d, where a “sequence of activities is repeated in every stage…which can be defined as a “concentric model… a combination of stages, activities and the part of the solution space considered, indicating an increasingly specified product”.

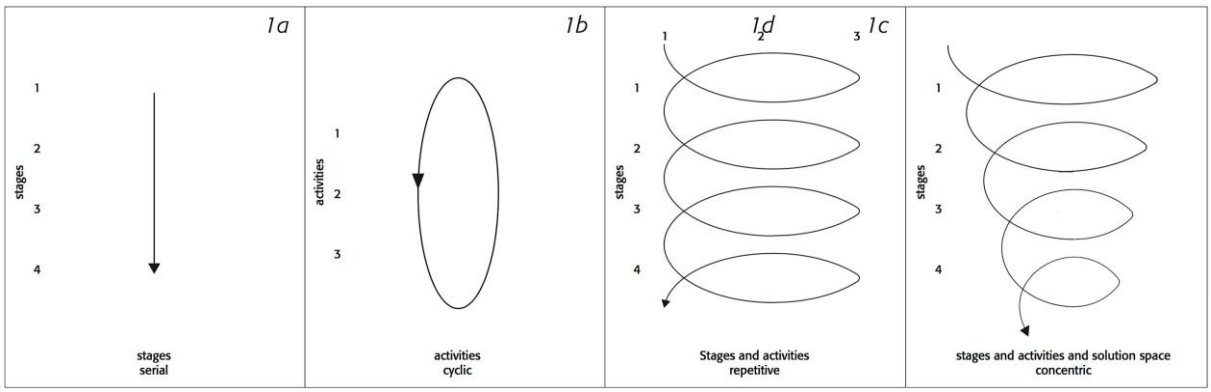


Figure 4.9 Flows through a prescriptive process (Blessing, 1996). Source: (Heape, 2007, p. 31)

One of the early inspirations for the C/A model for sustainability design, proposed by the author was Eilouti's precedent based model (Eilouti, 2009). This model (Figure 4.10), though an analysis-synthesis model, had ingredients, which directed how precedents (an important typology of conjecture) worked. Thus, in order to use a precedent in design, first it must be identified as relevant. This is generally identified as the matching problem.

The visual representation of the model is divided into two parts where a concrete precedent is matched through various parameters and converted into an abstract version. This abstract version is progressively matched, adapted and developed into a concrete precedent, which can be used in the current project. This is the prospective part of the model.

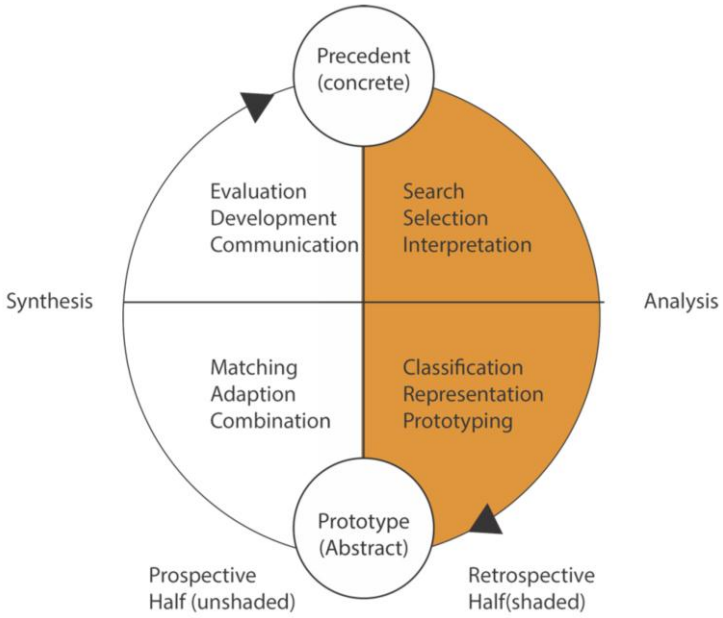


Figure 4.10 Precedent based design (PBD) model. Source: (Eilouti, 2009)

Erik Stolterman introduces an alternative view of the differing approaches fostered within design education where he distinguishes between a "guideline view", to a design process, which emphasizes the control and precision needed to attain the "expected and wanted qualities", as a "…process for producing a right or wrong answer or solution" (Stolterman, 1994). The alternative he identifies is the "aesthetic approach", where the designer can only be "guided through the design process by his own ideals and values" and where the focus is on the product". The designer's knowledge of the product will lead the designer where his/her ability to judge quality and recognize when he/she reaches their goal determines when the process is complete.

His conclusion is that an educational situation should be established which can "stimulate a continuous process of reflection on the nature and preconceptions of design work…". This point of view is not accompanied by a visual representation.

As a progression to Stolterman's thought we have Hickling's cyclic, iterative and whirling visual model. Hickling developed a diagram (Figure 4.11), which is a departure from the earlier linear models to include 5 cyclic clusters. The 4 circles at the four ends of the diagram represent four decision-making steps of:

1. Shaping- Can we choose a definition of the problem to help us to get a grip of it?
2. Generation- Can we choose a range of alternative solutions for comparison?

3. Comparison- Can we choose a set of comparisons and preferences as a basis for choice?

4. Choice- Can we choose what to do now…to leave some things until later?

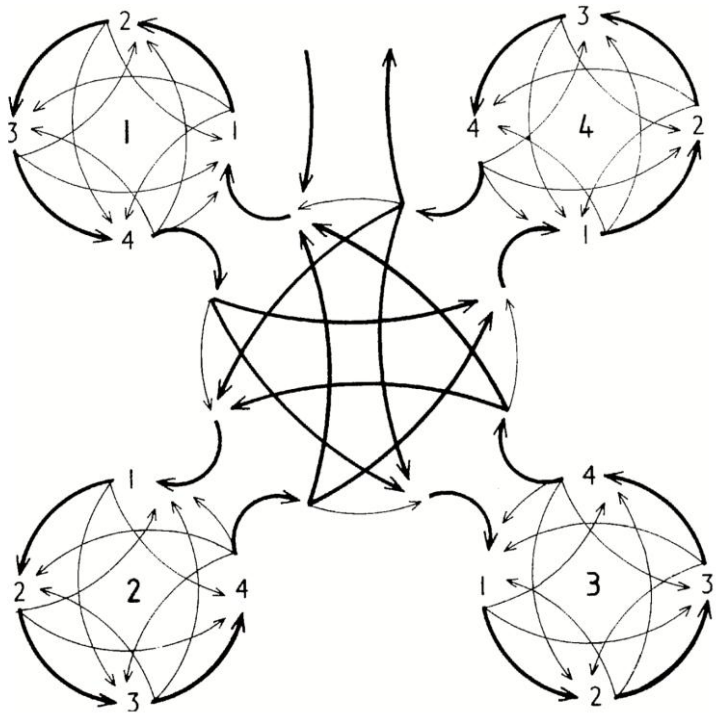


Figure 4.11 The cyclic, iterative, whirling process (Hickling, 1982). Source: (Heape, 2007, p. 39)

The four circles are interlinked to indicate referencing back and forth of the 4 stages. Mathews (Mathews, 2004) states as one of his conclusions that, "the historical situatedness of the designer is seen as being vital to generating, conducting and maintaining design project work". He cites Bucciarelli as saying that "history matters. No design begins with an absolutely clean sheet of paper…product and system design, quality and better designs, are situated within particular historical, political and cultural contexts" (Bucciarelli, 1994, p. 198)

Schön (Schön D. A., 1991) indicates, "in actual designing, designers often learn from earlier trials to reframe alternatives and even the problem itself. Moreover, each design project helps to prepare the designer for future projects". This aspect of historical situatedness raises the question as to how design students are engaging with their design tasks, as their design experience is limited, particularly in the initial phases of their studies. What is the historical situatedness of their design situation and how are they doing this?

Clearly students need guidance in developing a repertoire of experience. An alternative view to developing 'situatedness' through experience and possibly to help students and 'novices' with the design process is Goldschmit's description of 'importing information'. She talks about how "In recent years computational technologies have permitted the creation of relevant databases and methods of indexing, accessing and searching them, so as to tap information and knowledge that can be useful in design problem solving. Currently, models of design process build heavily on knowledge bases, including some procedural knowledge. Few of these models can be described as computational counterparts of procedures used by humans and if so, only in simple, moderately ill defined situations. They are counterparts in the sense that they solve problems, but they reach a solution using a different path than that used by a human mind (Goldschmidt, 1997).

Though prescriptive models have come under fire for their rigidity, we cannot ignore their importance. Blessing (Blessing, 1996) and Brandt (Brandt, 2001) are of the opinion that prescriptive models can provide a good framework for development projects in practice… it is essential to establish what is being modeled… and whether these models can support development work in practice" (Brandt, 2001, p. 216)

4.6.3 Descriptive

This category consists of descriptive accounts of how designers solve problems. It is quite different from how linear or prescriptive models prescribe them to be.

The first example is a study of subjects who were given a design task to solve. The outcome is recorded as graphical representations of mainly two parameters, concreteness and correctness. Conclusion of the authors is that if confronted with complex problems, individuals usually tend to exhibit rather stable individual styles of problem solving and that designers organize their design processes according to their individual style of problem solving (Eisentraut, 1997)

Concreteness

grade	description
0	sketch of principle
1	sketch (not to scale)
2	drawing roughly to scale
3	preliminary drawing to scale
4	layout drawing (to scale)

Completeness

grade	description
p	part
gp	group of parts
mp	more than one group of parts
e	entire product

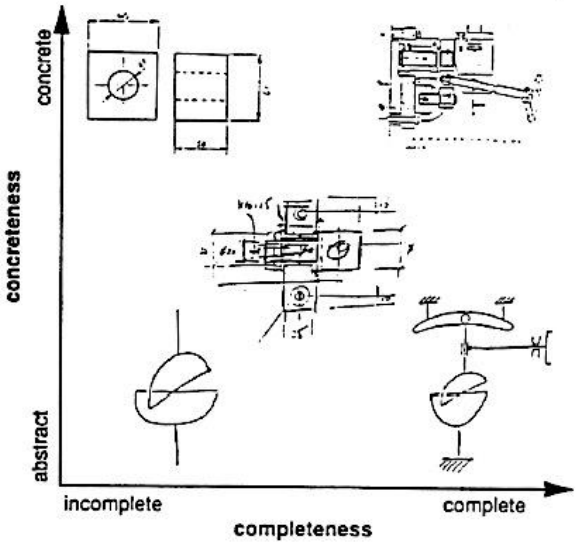


Figure 4.12: Representation of individual problem-solving styles. Source: (Eisentraut, 1997)

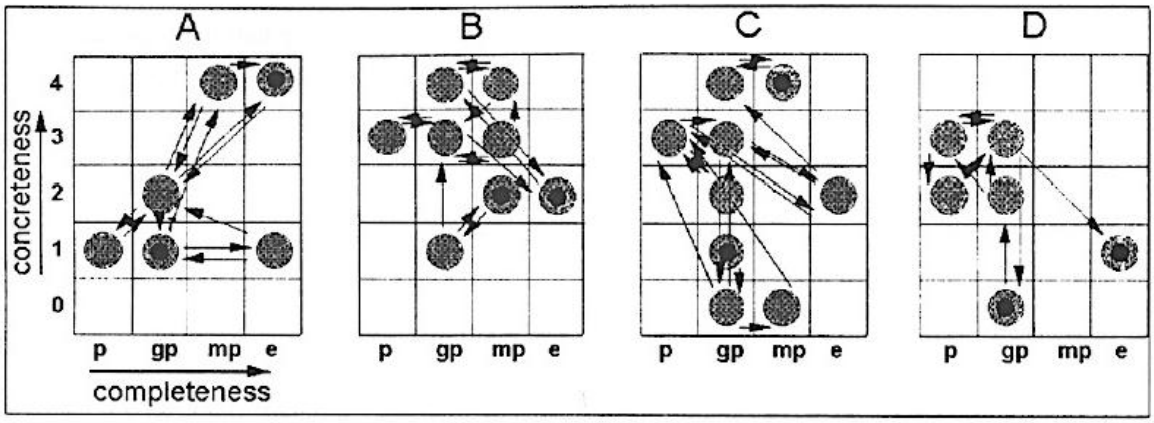


Figure 4.13 Plotting the factors correctness and completeness of individual problem solvers. Source: (Eisentraut, 1997)

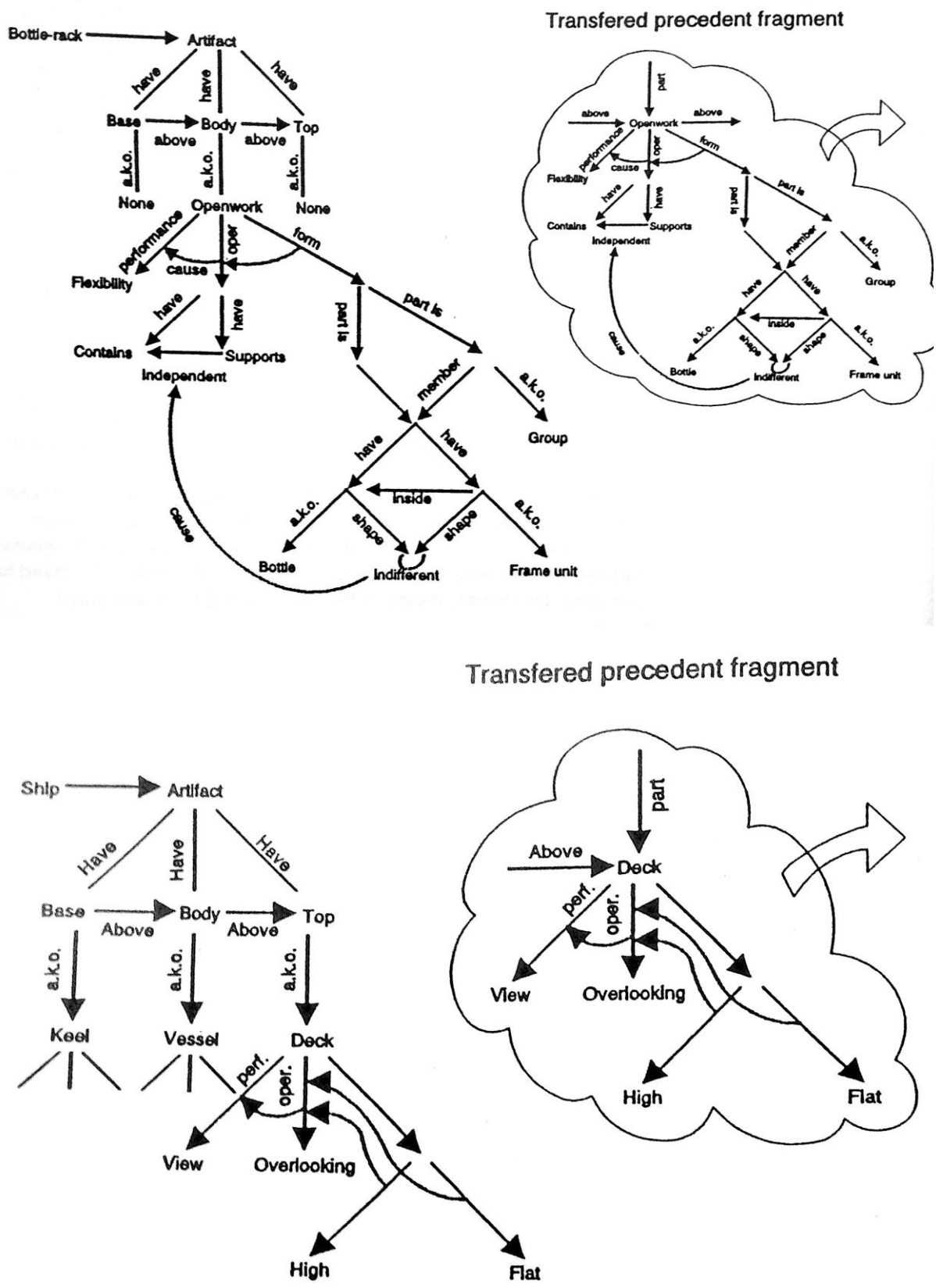


Figure 4.14 Choosing precedents to transfer to current situation. Source: (Tzonis, 1991, p. 154)

The second example is the one developed by Chris Heape. He developed a representation of Design Space, which he developed by working with groups of students and documenting how they actually traverse the journey of design process. He embraces the complexity and messiness of the process. Heape came up with a series of visual descriptions of the construction, exploration and expansion of Design Space: opening perspectives, differentiating the parts, generating syntheses and the complete context of a space with a design proposal as an emergent composition and its web of inter-weavings traced by trajectories of exploration, experiment and synthesis.

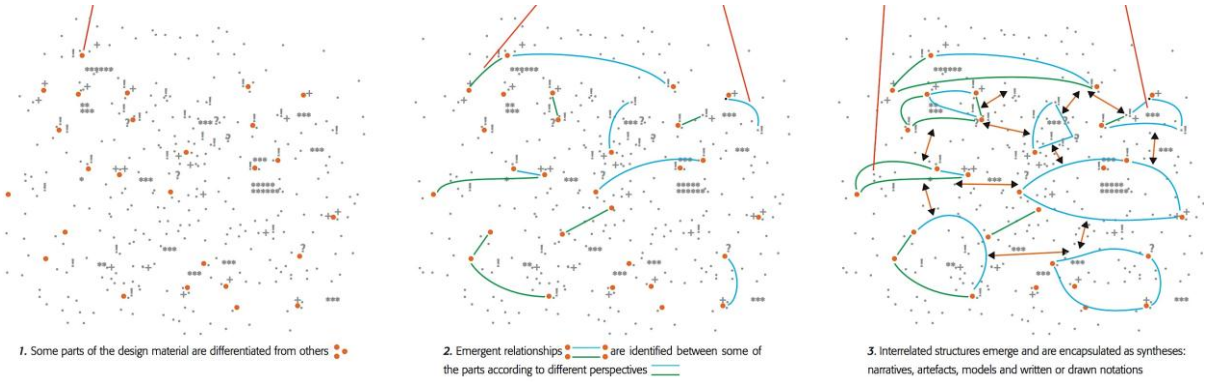


Figure 4.15 Development of relationships of their narratives, drawings and models in the design process of students. Source: (Heape, 2007, pp. 298-295)

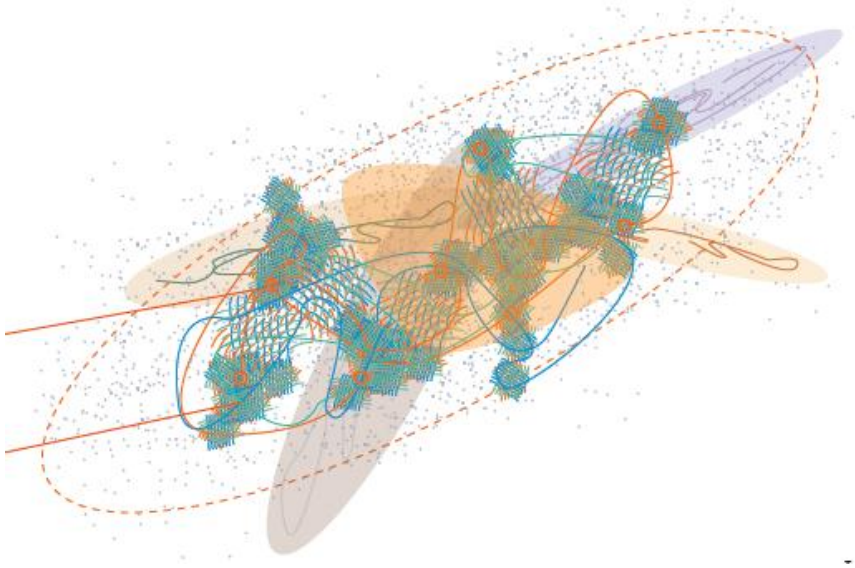


Figure 4.16 Complexity and messiness of design process. Source: (Heape, 2007, p. 301)

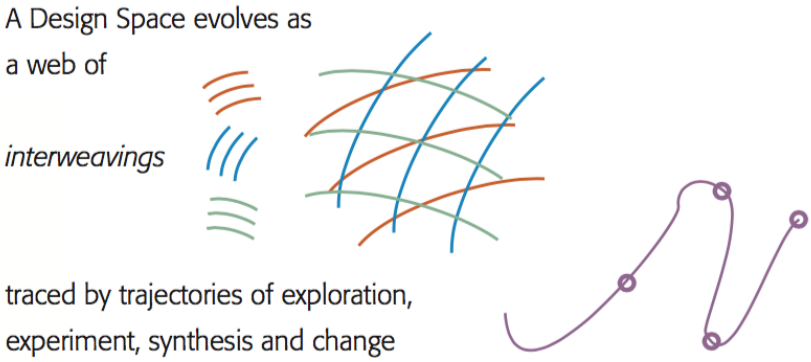


Figure 4.17 Notations in the design space representation above. Source: (Heape, 2007, p. 294)

4.6.4 Generative

Generative models do not arrest the design process but lend flexibility that is required. Blessing and Brandt suggested that, ”Prescriptive models are a good framework to know what is being modeled”. So generative models can be looked at in conjunction with prescriptive ones or even conceptual and descriptive models.

Linkography was proposed by Goldschmidt (Goldschmidt, 2012) to assess design productivity. The visual representation of Linkography graphically represents the design process as a combination of sequentially listed moves and links among them. The data captured in Linkography can be used to study a variety of design situations and generates discussion and gives new insights.

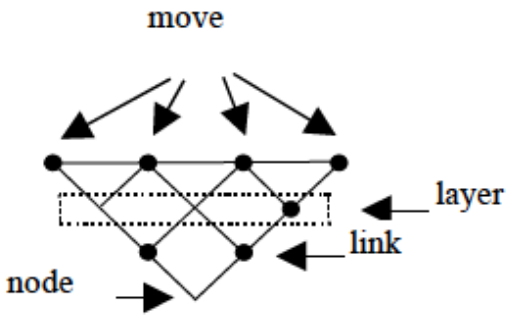


Figure 4.18 Elements of a Linkograph. Source: (Goldschmidt, 2012, p. 49)

Jonas (Jonas, 2001) proposed this methodology integrates and puts into operation the product development process. It has to be abstract and flexible enough to cover projects in firms, educational projects of any size, public development projects, and policy-making projects. And it has room for individual approaches.

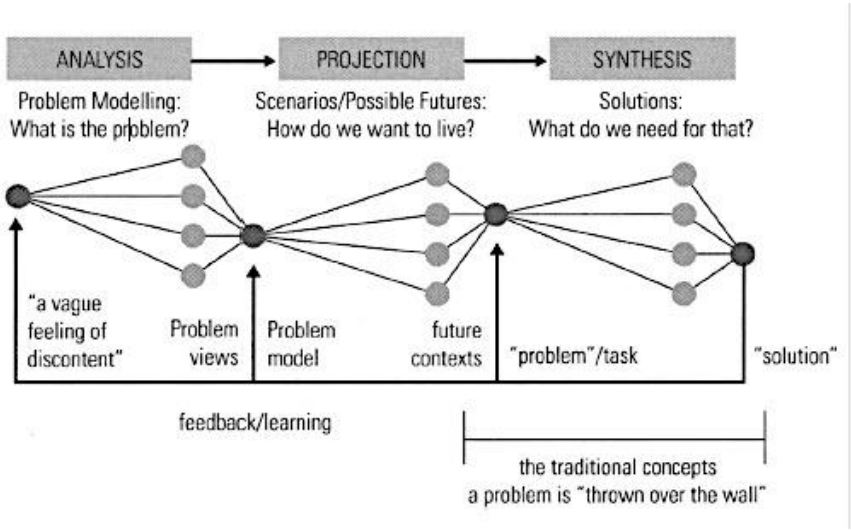


Figure 4.19 Broadened concept of design. Source: (Jonas, 2001)

4.7 Chapter summary

This chapter elaborates the first step of action research- that of critical pedagogy. This is done through observation of another instructor's studio and insights from the author's own teaching experience. The observation of the studio practice was done with the purpose of capturing conjectures. And indeed five kinds of conjectures were revealed. They are primary generator, referent, episodic, precedent and cases. These conjectures can now be used in two ways. One, it can be used as building blocks to develop the model and second, it can be used to link the ontological and epistemological factors of design and sustainability respectively.

Before attempting to develop the model, existing visual models have been studied. The visual representations are grouped into four categories- Prescriptive, Descriptive, Conceptual and Generative. The examples are fragments of C/A or where the idea of conjecture has been used in general design process.

Chapter 5

Development of Conjecture Analysis Model for Sustainability (CAMS) through iterations

5.1 Chapter introduction

Ideology critique was conducted in a divergent mode as discussed in the previous chapter. In this chapter, three design experiments namely DE 1, DE 2a, DE 2b are discussed, which are all conducted in a combination of divergent and convergent modes. Divergent modes are in the line of introducing new contexts in pedagogy such as:

I. Allowing discussion on a wicked problem
II. Situating a problem in everyday practices which students are familiar with.
III. Encouraging different interpretations of resources, which need to be conserved' such as time, knowledge etc.

Convergence is gaining more detailed insights of how conjectures can be used by students and instructors, thus enhancing the conjecture/analysis model. The design experiments are action research procedures conducted with a standpoint of teacher-as-researcher. At each stage insights add to the evolution of the model. There are three model iterations developed in this chapter.

5.2 Design Experiment 1 (DE 1), 2012

The design experiment was conducted where two groups of students were given the same task. Their protocol was analysed to gather insights into what types of conjectures they use to interpret the problem given. The problem was based on everyday consumption practice, but a multilayered one. A non-participant observation was conducted by the researcher, in which the instructor preset the problem statement. It incorporated broad sustainability issues, such as production-consumption dichotomy and social wellbeing.

The problem is as below.

"A parent bought a Barbie for her daughter. In a week's time, the child wanted Barbie's bedroom, then a bathroom. Another week later, the child wanted new clothes for Barbie. Barbie has also become the child's identity. A group of concerned parents get together, to demand a solution to reduce Barbie's needs and therefore the child's desires. You have been invited as a team member to find a solution for the above scenario."

The students were chosen from senior years of different design disciplines of Fashion design, Communication design and Master's program in design from National Institute of Fashion Technology (NIFT), Mumbai. They had no exposure to sustainability issues in a formal course. Their understanding was from informal secondary sources only. During the entire length of the protocol the researcher was a silent observer except when the students needed assistance. This happened once in the entire protocol, when they wanted the brief repeated. The students were also provided with paper and pencils, incase they needed to note down or sketch something.

The discussion of the groups lasted around 35 minutes. This was video recorded and transcribed. For the first group, the entire transcription consisted of one hundred and seventy (n=170) segments out of which, there were forty-six (n=46) instances where conjectures occurred. For the second group, the entire transcription consisted of one hundred and ten segments (n=110) out of which there were thirty-one (n=31) instances where conjectures occurred.

5.2.1 Breaking down the protocol into 'useful' conjectures

The retrieved conjectures along with its linkages to problem statement and design decisions form an interesting pattern. This pattern can be mapped to provide insights for further analysis. Out of the forty-six (n=46) conjectures, only the useful conjectures have been chosen for analysis. The most important indicator of the usefulness of a conjecture is its link with design decisions and problem interpretation. By this argument, twenty-eight (n=28) instances were found to be useful. Out of these, seventeen (n=17) instances are positively linked to design decisions and twelve (n=12) to problem interpretation. This has been represented in the Figure 5.1 also shows a design decision, which is not connected with conjectures. It is still important due to the fact that it summarizes the decisions taken in the entire protocol- "those are our two solutions do you agree?" The 'solutions' are the design decisions for formulating the brief. In this case they appear as below.

- The image of Barbie should be changed
- The toy should be more interactive with the child

As seen in Figure 5.2 the design decisions are of two levels. One is at descriptive level. The second is at a more abstract level such as:

"*So our solutions is, what I think is first is the personality shift giving a more specific, more realistic personality".*

This is then broken into more descriptive expressions such as:

Say if Barbie comes with a helmet instead of a tiara…instead of a gown she comes with a jacket" or "I think its time we should go ahead from the princess thing and probably give a little more realistic personality ".

Some of the descriptive decisions are repeated. The repetition makes the conjectures important. The repeated utterances did not appear in the same order in the protocol as they have been shown in Figure 5.2. The students meandered into other directions of discussion before reiterating an already mentioned decision. Thus the repeated decision and the associated conjecture make it a stronger candidate for turning into a prospective conjecture (explained in section 5.2.2)

Useful conjectures are the operational conjectures, which are the relevant candidates to be used in the design process. The listing of all the useful precedents is given in Table 5.1 and Table 5.2.

Example of another product similar to the one being discussed:

My Scene doll, Hannah Montana, GI Joe and Robin, Hotwheels, Uno have been mentioned in the protocol. Instances such as the following were mentioned, “I fell for the whole thing, you know I want a tank, a chopper, I want… If you want superman, I buy a batman I don’t want Robin maybe, I can do without the Robin”. And, “I have seen this recent phenomena of Hannah Montana, …Like that was an idol, now its on every bag, every pencil, every T-shirt, every roller skates. Its just the same thing…”.

A similar situation in the student’s own personal experience. The students spontaneously related personal situations from their childhood, “There was a time when I was obsessed with GI Joes, they didn’t solve any purpose, you know, I would buy them, they were expensive”. And, “this is from my personal… this thing that my parents were never too happy seeing me playing with GI Joes but they were happier to see me playing with Uno”.

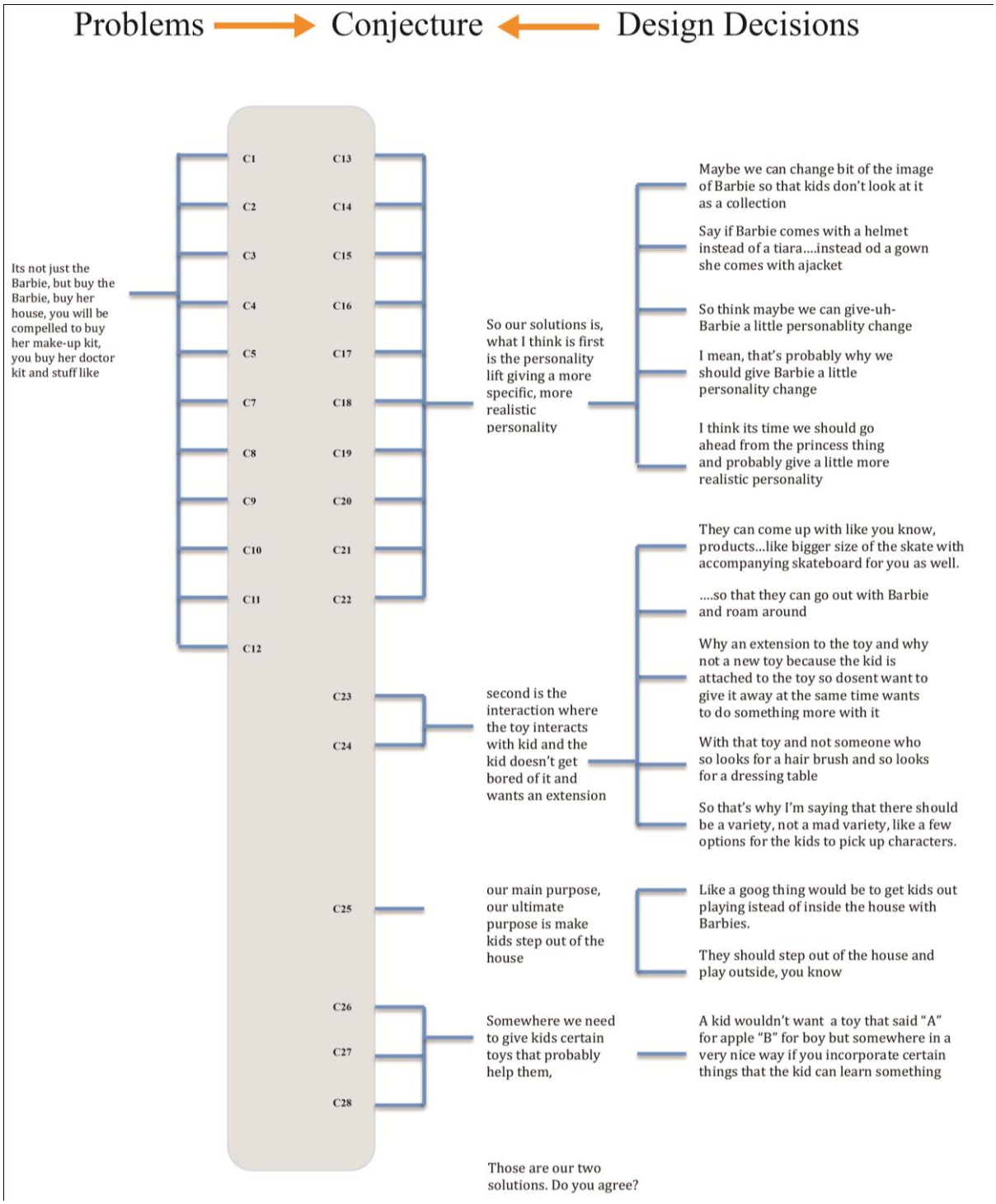


Figure 5.1 Conjecture mapping from protocol of group 1

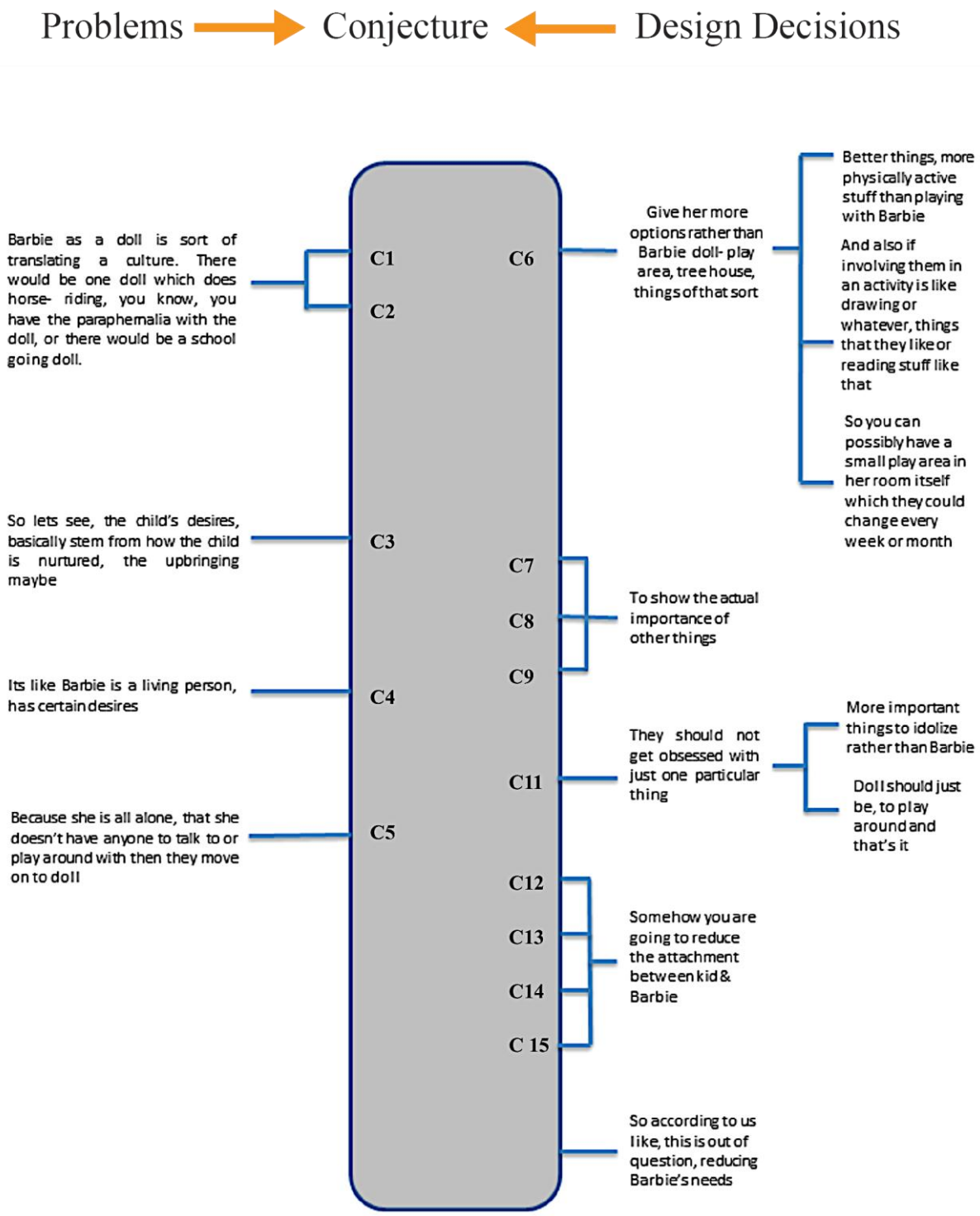


Figure 5.2 Conjecture mapping from protocol of Group 2

In the protocol of the second group, there were fifteen (n=15) useful conjectures. Out of these five conjectures (n=5) were linked to the problem and ten conjectures (n=10) were linked to design decisions. While the discussion of students of group 1 was product focused, group 2 leant towards treating it as a social problem. The second group does not look at Barbie as a product but what it signifies and how it affects the behavior of parents and children. The brief they formulate, therefore suggests altering behavior of parents and children or giving the child more options other than Barbie.

There is a marked difference in the way the two groups deal with the problem. This is because of the conjectures they use to understand the problem and finally the conjectures they choose as primary generators.

5.2.2 Retrospective and Prospective conjectures

This concept is borrowed from Eilouti's (Eilouti, 2009) Precedent-based knowledge analysis/synthesis cycling model (Figure 4.10). Eilouti talks about retrospective precedents as backwards investigation and prospective precedents as forward implementation. It was found to be applicable in this case as well where many retrospective conjectures were derived from the protocol but only a few were taken forward (prospective conjectures) into design decisions and probably even fewer would finally make it to the final solution.

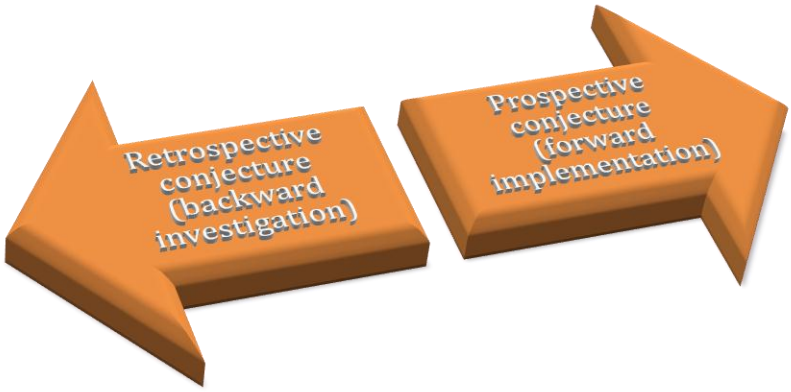


Figure 5.3 Retrospective and Prospective conjectures. Adapted from (Eilouti, 2009)

All the conjectures from 1-28 (Table 5.1 and Figure 5.1) retrieved from the protocol of group 1 are retrospective in nature, but conjectures 13-28 have the potential to convert into

prospective conjectures. Therefore we call it potential prospective conjectures. When they get converted into sustainability conjectures will they be prospective conjectures in the true sense. They can be used in the design process of the new project. Similarly for group 2 conjectures from 6-15 (Table 5.2 and Figure 5.2) have the potential to become prospective conjectures.

Table 5.1 Conjecture typology g roup1

Conjecture	Retrospective	Typology
C1	You know probably the reason why Barbie's sale has gone down is that a new set of Barbie dolls kind, they call My Scene dolls	Precedent
C2	I fell for the whole thing, you know I want a tank, a chopper, I want___	Precedent
C3	Ya, you want more and more	Episodic
C4	want everything around	Episodic
C5	you build your own world and everything around.	Episodic
C6	If you want superman, I buy a batman I don't want Robin maybe, I can do without the Robin	Episodic
C7	But if I buy a GI Joe torpedo, I want the…	Episodic
C8	But you would not want to have three different Hannahs	Precedent
C9	I've seen this recent phenomena of Hannah Montana	Precedent
C10	Like that was an idol, now its on every bag, every pencil, every T-shirt, every roller skates. Its just the same thing,	Precedent

C11	thing is that you want a Hannah bag and Hannah bottle and a Hannah…but that is something you cannot control, you know	Episodic
C12	So there should be a variety. Not a mad variety but a few options to pick up characters.	Primary Generator
Conjecture	**Potential prospective**	**Typology**
C13	that they have shifted the whole idea of girls is shifting from that very pretty looking doll to a very hep sort of a thing...	Primary generator
C14	those Barbie dolls, they come with bikes and not like brushes and make-up kits they come with bikes and dogs	Primary generator
C15	like with this generation we see that most of the girls, they're more tomboyish,	Precedent
C16	like they want to wear jackets and they want their hair to be cut.	Precedent
C17	like how a Batman is a Batman, he doesn't need his car around, he has a very strong identity	Precedent
C18	so and if you see that kid is not just, she's not a princess	Precedent
C19	she's a… A normal girl	Precedent
C20	No, she's a rock star, it definitely shows that there is a way to build up such a personality for a cartoon that people are happy with it,	Precedent

C21	But you would not want to have three different Hannahs	Precedent
C22	So there is an option to have two different Hannahs dolls, because Hannah is such a strong personality that they can have only one Hannah doll	Precedent
C23	There are talking Barbies	Precedent
C24	Had GI Joes been more fun guys and not serious with guns and all, had it been more you know_	Primary generator
C25	mostly you see, they're all sitting inside.	Episodic
C26	there was a time when I was obsessed with GI Joes, they didn't solve any purpose, you know, I would buy them, they were expensive.	Episodic
C27	Same with hot wheels	Episodic
C28	this is from my personal this thing that my parents were never too happy seeing me playing with GI Joes but they were happier to see me playing with Uno,	Episodic

Table 5.2 Conjecture typology group 2

Conjecture	Retrospective	Typology
C1	I mean, children now as in my cousin she would match her shoe her dress with her shoes, her clips and maybe bag	Episodic
C2	So every birthday, they get her something new. It actually happens, you know, and she has all sorts of things	Episodic
C3	If I take the example of my cousin like she's 5years old, my Mami (aunt), she really doesn't think twice before buying her anything. She goes, it costs, its very expensive you know, 700, or sometimes like	Episodic
C4	Well, I'll tell you something, when I was a kid, I had lot of Barbies. I used to ask for a lot of clothes because I was fashion crazy	Precedent
C5	I don't know like the time she spends with, on may be TV	Precedent

Conjecture	Potential prospective	Typology
C6	If she had a sandpit, she'd have friends to come & play with her	Primary Generator
C7	But is there really a need for a bathtub when a shower or a bathroom really does it for you or whatever, you know, If there's something like that because, maybe they could be a little more rational	Primary Generator
C8	There is no water, I mean, there's shortage of water, and a bathtub is totally wasting water so maybe you know, you can add rationale or logic to how you explain	Precedent
C9	I mean lot of times what parents do is that they'd say that this is bad for you, like for chocolates, they'll just tell you you're not going to have it.	Precedent
C10	Clothes, T-shirt that kids wear would have like a Barbie doll whatever print on it. Parents shouldn't encourage that	Precedent
C11	If you show them examples, like flicking through a magazine and there's like this had teeth, whatever, like this teeth whitening sort of ad and you could tell them, this will happen to your teeth, if you eat chocolate	Primary Generator
C12	Instead maybe, one could explain it saying that you know, we'd rather take you for an actual horseback riding next summer, than buy you a Barbie's horse, you know.	Primary Generator

C13	Maybe, not the car because the car is out of price range, maybe something smaller	Precedent
C14	Maybe the child will still want to do it but if you go down to their level and tell them that, have one and you'll see that, you know, teeth get bad	Precedent
C15	If a child is standing in a store and they start, sort of pointing at a thing and like I want this, they could start at something smaller and maybe explain to them that this makes sense right now but a car really doesn't matter	Primary Generator

5.2.3 Typologies of conjecture

There are five typologies of conjecture identified in the previous chapter. Episodic units, precedents and primary generators were found in the protocol of the groups in Design experiment 1.

The first group used the following useful conjectures.

- Ten episodic units (n=10),
- Fourteen precedents (n=14),
- Four primary generators (n=4).

The second group used the following useful conjectures.

- Three episodic units (n=3)
- Seven precedents (n=7)
- Five primary generators (n=5)

The discussion of the first group was richer in conjectures, where the students shared many personal experiences. Precedent number is also high, because they were able to relate many brands of toys to the present problem of Barbies. Accordingly, they abductively arrived at five primary generators, which were product focused.

The discussion of the second group was comparatively sparse in terms of episodic units and precedents. Since this group focused on people and their interactions with Barbie, one expected more episodic and precedent typologies, but the students settled in primary generators pretty early in the problem. This group's primary generator is social issue-focused. Though there are comments on larger social issues, the objectivity is lost quickly, to give way to connecting the situation to personal experiences (episodic).

5.3 Insights from DE 1

1. There are only three kinds of conjectures in the protocol of both groups. This might be because it was a shorter task and the fact that the instructor was absent. Referent and cases are very important to enrich the learning of students.
2. If one holds on to primary generators early in the design process, exploring other conjecture typologies get limited. Darke also cautions (Darke, 1979), that design students create more problems than they solve by selecting impractical or inappropriate primary generators.
3. Since sustainability aspects were not consciously included in the problem, students did not touch on the sustainability epistemology elements. Except the 'artefactual world' aspect. The problem posed was in itself multilayered and wicked. Students dealt with it by using conjectures to narrow down the problem into more workable areas. Primary generators were premeditated. The groups arrived at it through discussion and reflection.

4. The relationship matrix (Table 5.3) of the ontological and epistemological elements is derived from DE 1. Typologies of conjecture are the same for both the groups, only the number of occurrences vary in their protocol. The three typologies have been placed in the relationship matrix below.

Table 5.3 Relationship matrix for DE 1

DESIGN / SUSTAINABILITY	REFLECTIVE	ABDUCTIVE	WICKED PROBLEMS
BROADER DEFINITION OF SUSTAINABILITY	—	—	—
ARTEFACTUAL WORLD			
SYSTEMIC	—	—	—

Episodic units are converted into useful precedents through discussion amongst students. But this has limitations. When we look at the relationship matrix we find that relationship is established between Artefactual world and all the elements of design ontology. The context of Artefactual and wicked is established in the problem statement given to them. They were able to do the reflective and abductive because of their design backgrounds. But they were not able to tap other sustainable factors. This indicates that they probably need scaffolding in terms of referents and cases to further contextualize design within sustainability (Figure 5.4).

Therefore, MI 1 is proposed. The visual form of MI 1 has taken inspiration from Eilouti's model (Figure 4.10) where retrospective precedents are converted into prospective precedents. The nodal points in Eilouti's model are concrete and abstract precedents. In MI 1 they are replaced with episodic units since that was found to be a good starting point both in the case of observation of another instructor's studio as well as DE 1. The second step is scaffolding with sustainability referents and cases. This has greater chances of converting into sustainability precedents.

5.4 Model Iteration 1

The insights from the previous sections are taken into consideration to create a ‘web of meaning’ for the tentative model.

The model was conceptualized as conversion of retrospective useful precedents to prospective sustainability precedents. The model is represented as being divided into two equal halves. One half is the retrospective part, and the other is the prospective part of the design process. The stages of the model progress in a clockwise manner, ‘useful precedents’ being the first step. A protocol conducted with students revealed that there were many precedents, which were referred to, but only a few were taken forward. These candidate precedents, which are taken forward are the ‘useful precedents’ represented in the model. The aforementioned student protocol also revealed that the precedents mentioned by the students were mostly episodic in nature. The didactic inputs given earlier were not called upon consciously to understand the problem better. This is why the students have to be provided with scaffolding during the early design stages so they are able to gain a better understanding of the problem. This scaffolding is in the form of referents. The second observation of the action research shows several kinds of referents provided to the students- market survey, books, checklists etc. Since our study is dealing with the class of sustainability problems, the referents provided are sustainability referents. This completes the retrospective part of the model. Now with the combination of useful precedent and sustainability referent, one can move on to the prospective part of the model. The combination of useful precedent and sustainability referent has to yield a suitable sustainability case, which describes how a similar problem situation has been solved to yield a desirable sustainable solution. The sustainability case is broken down and a part or several parts are combined to form the sustainability precedent that can be used in the problem at hand. Thus converting the useful precedent into a sustainability precedent, which can be used in the current student project to guide it towards sustainability.

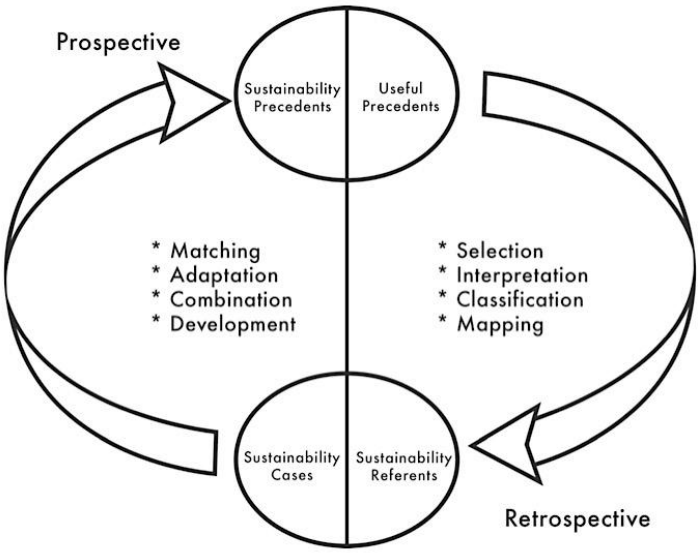


Figure 5.4 Model Iteration 1. Adapted from (Eilouti, 2009)

Model iteration 1 uses precedents, referents and cases, which are all essentially conjectures. Therefore there was an anomaly in using them in the A/S model. The analysis/retrospective part needs to be replaced with conjecture/retrospective.

1. To proceed towards sustainability, an understanding of unsustainability is crucial. This model therefore can be conceived as one, which converts unsustainability into sustainability.
2. If understanding and identifying unsustainability is assumed to be the first step of the model then unsustainability works as the primary generator described by Jane Darke (Darke, 1979).
3. When students begin designing a practical project they cannot recall the theoretical inputs given during the didactic delivery. It is important to scaffold the process by giving them a list (cheat sheets)[17] of unsustainability and sustainability approaches they can use. These will henceforth be called referents.
4. The unsustainability referents have to be provided to the students as the first step. Additionally, during the first step, students are guided by their own personal experiences. These are from episodic memory of something they have experienced before, and they see a likeness to the present situation.

[17] Cheat sheets are a list of sustainability approaches given to students to choose from. In consultation with the instructor, students choose the one most appropriate for the context of their problem.

5. Once unsustainability factors are identified, either from episodic memory or from the list/guide provided to them, sometimes a combination of both, they have found their primary generator.
6. The primary generator, which is indicative of unsustainability, is also a precedent as it has occurred in an actual situation observed by students.
7. Now, one is faced with the challenge of converting the primary generator of unsustainability into a sustainability precedent.
8. The unsustainability precedent has to be matched to a list of sustainability approaches/referents. The student with the help of the theoretical input given before, along with the list of approaches and instructors' guidance chooses an appropriate sustainability referent.
9. The combination of unsustainability precedent and sustainability referent is used to find an appropriate sustainability case. The case is identified as appropriate, if the case has solved the problem of converting the unsustainability factors into a sustainable solution, using the same sustainability referent as chosen by the student.
10. This is the last step of using conjecture to understand the problem at hand. When one begins to analyse the sustainability case, it needs to be broken down into smaller parts and mapped out on paper. These smaller parts may be in terms of solution, sub-solution, search space and process.
11. The case thus broken into parts is interpreted, adapted and sometimes combined to match with the problem at hand.
12. The matched elements are finally chosen abductively as the sustainability precedents to be used in the problem at hand.

Thus the conversion of unsustainability into sustainability occurs.

5.5 Insights to take forward from Model Iteration 1

An attitude of critical pedagogy was maintained throughout the research process. It gave rise to some valuable insights.

1. Studio pedagogy is best suited for application of the C/A approach. The present pedagogical practices have been studied critically to glean the use of conjectures.

2. Understanding of unsustainability is important. It was found that students found it easier to identify unsustainable situations or consequences of designed products or environments. Subsequently they were able to convert them into sustainability solutions.
3. Theoretical input is important to develop the vocabulary of sustainability referents. It is only when students are familiar with history, terminologies, initiatives taken in the area of sustainability, will they be able to transfer sustainability into design projects.
4. A database of sustainability cases is essential. The cases need to be recorded and rigourously documented for further use.
5. Conjectures can be retrieved, categorized and mapped into a usable form.
6. Episodic data is more effective as sustainability projects. Episodic data in this research is the 'experience born out of everyday occurrences'. The information embedded in the 'everyday' has been used by Don Norman (Norman, 2013) to invest in 'everyday' to learn lessons in design and sustainability; Manzini (Manzini E. &., 2003), invests in 'sustainable everyday' to move towards sustainable future scenarios. The effort in this research is also to choose situations out of students' own everyday experiences as episodic data for sustainability projects.

5.6 Design Experiment 2a (DE 2a), 2013

The preceding two pedagogic observations of Ideology critique and design experiment 1 did not have explicit focus on sustainability but the insights from the observations served well to creating an iteration of the C/A model for sustainability. MI 1 projects the use of sustainability conjectures. Design experiment 2a and 2b are pedagogic exercises where sustainability is the explicit focus.

This is a participant observation conducted in the studio with researcher-as-teacher. The subject 'Sustainable systems' (SS306) is conducted at National Institute of Fashion Technology, Mumbai. The class consisted of 32 students and they worked in groups of 3-4.

Early literature made a distinction between consumerism and consumption. While the former led to unsustainable apathy, we find that consumption is not avoidable. An exploratory study was conducted to find the attitudes and values of people through 'sustainable consumption' (Appendix1). The respondents were interviewed through 'laddering technique'.

The key insights were:

1. Embedded sustainability concerns are indicators of personal wellbeing and benefits to people.
2. The values that are derived in the study are actually the preferred states of wellbeing which people wish for in their relationship with products.
3. It is not just the designed product but also the practices of consumption surrounding the product, which needs to be addressed.
4. Everyday activities, which have become 'normalized' in the daily routine, are very often unsustainable without people's conscious knowledge of it.

All the insights were helpful in increasing the understanding of the author. Insights 3 and 4 were particularly pertinent to the pedagogic context have been used in DE 2a and consequently in MI 2 as the unsustainability precedent (or consequence) which acts as a primary generator for the whole project.

Didactic input in terms of definition of sustainability, Brundtland report, Limits to growth, three pillars of sustainability and different approaches to environment and social sustainability were given. They were directed to the 'Sustainable Everyday Project' site[18] to cases and other resources in the project. The bibliographic index containing papers on sustainable consumption was shared with the students (Scholl, 2003), (Mont, 2004), (Tanner, 2003), (Young, 2010), (Marchand A. W., 2008). As mentioned in the action research process DE 2a was conducted in divergent and convergent modes. The divergent mode was to test the concepts of:

1. How well the students learn when the sustainability problem is situated in the everyday artefactual context. For this purpose the following situations were given to the students.
    a. Washing utensils (section 5.6.1)
    b. Buying grocery (section 5.6.2)
    c. Washing clothes
    d. Having a bath

[18] http://www.sustainable-everyday-project.net/urbact-socialinnovationincities/resources/

2. Actively introducing referents to students when they work on their projects instead of leaving them to recall the referents from the didactic input given to them. The three referents given to them were the 3Rs.

a. Reduce
b. Recycle
c. Reuse

3. Guiding the students to think in systemically. Systems thinking is the epistemology of sustainability as identified in literature. The referents were woven into the everyday activities the students were studying.

4. Understanding of unsustainability

The convergent mode of action research is to find how students, when given the above context use conjectures.

The task given to the students was to choose a situation of everyday practice from the four options given to them. Once the choice is made, they had to go to field to observe the activities in detail and analyze the information collected for the following:

1. The resources being used in the system.
2. Choose two resources that were being misused leading to unsustainability.
3. Apply any one of the referent given (3Rs) to match the unsustainable use of resource.
4. How the titrating of resources in the two systems affect each other.

As per MI 1 (Figure 5.4) they chose useful precedents (which were part episodic) as the various activities, which are involved in, or lead to washing utensils.

Since they had already been given the referents, this group of students quickly chose- 'reduce' as the referent they wanted to apply to the situation. They studied cases and gathered information about different detergents and cleaning brushes available to wash utensils and formulated a brief of designing multipurpose brushes to reduce the plethora of cleaning devices opted by households. The feedback given by the instructor (author) was that this was a 'rebound effect' (Manzini E. , 2003) where they were creating another albeit more

specialized device to solve the problem, which in fact is contributing to unsustainability. Consequently, they changed the focus to looking at reducing the utensils used in cooking, cutting, serving and eating. There was another round of hunting for cases and finding sustainable precedents.

5.6.1 Washing utensils

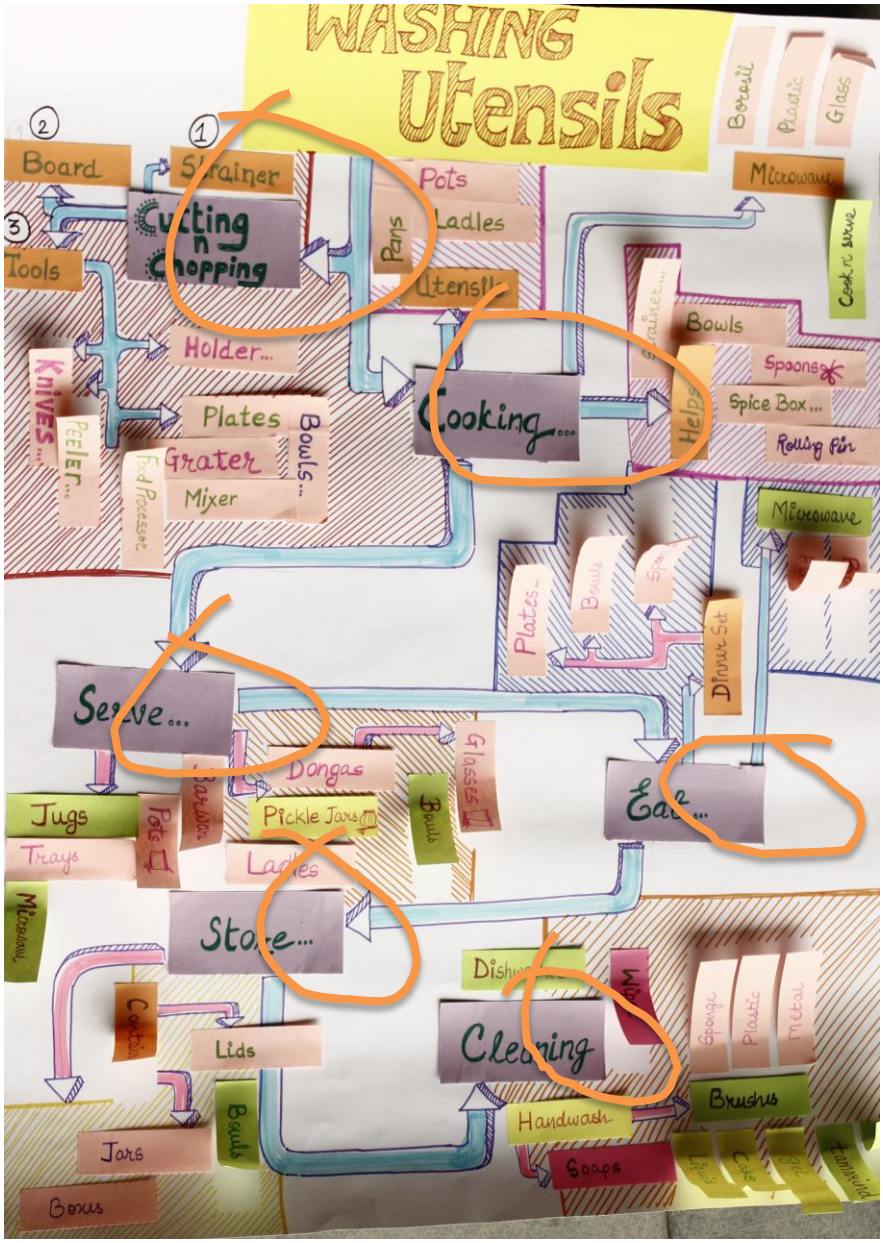


Figure 5.5 Breaking down the activity of washing utensils into useful precedents. Source; Student work. Surpreet, Dhara, Anshu, MDes NIFT 2015

The first systemic insight from the students was that washing utensils couldn't be studied in isolation; one has to start from the beginning- cutting, cooking serving, eating and washing. These became the useful precedents to start the project. The referent the students wanted to apply was- Reduce.

Figure 5.6 Picking precedents from what is available in the market. . Source; Student work. Surpreet, Dhara, Anshu, MDes NIFT 2015

Figure 5.7 Picking precedents from case examples from what is available online. Source; Student work. Surpreet, Dhara, Anshu, MDes NIFT 2015

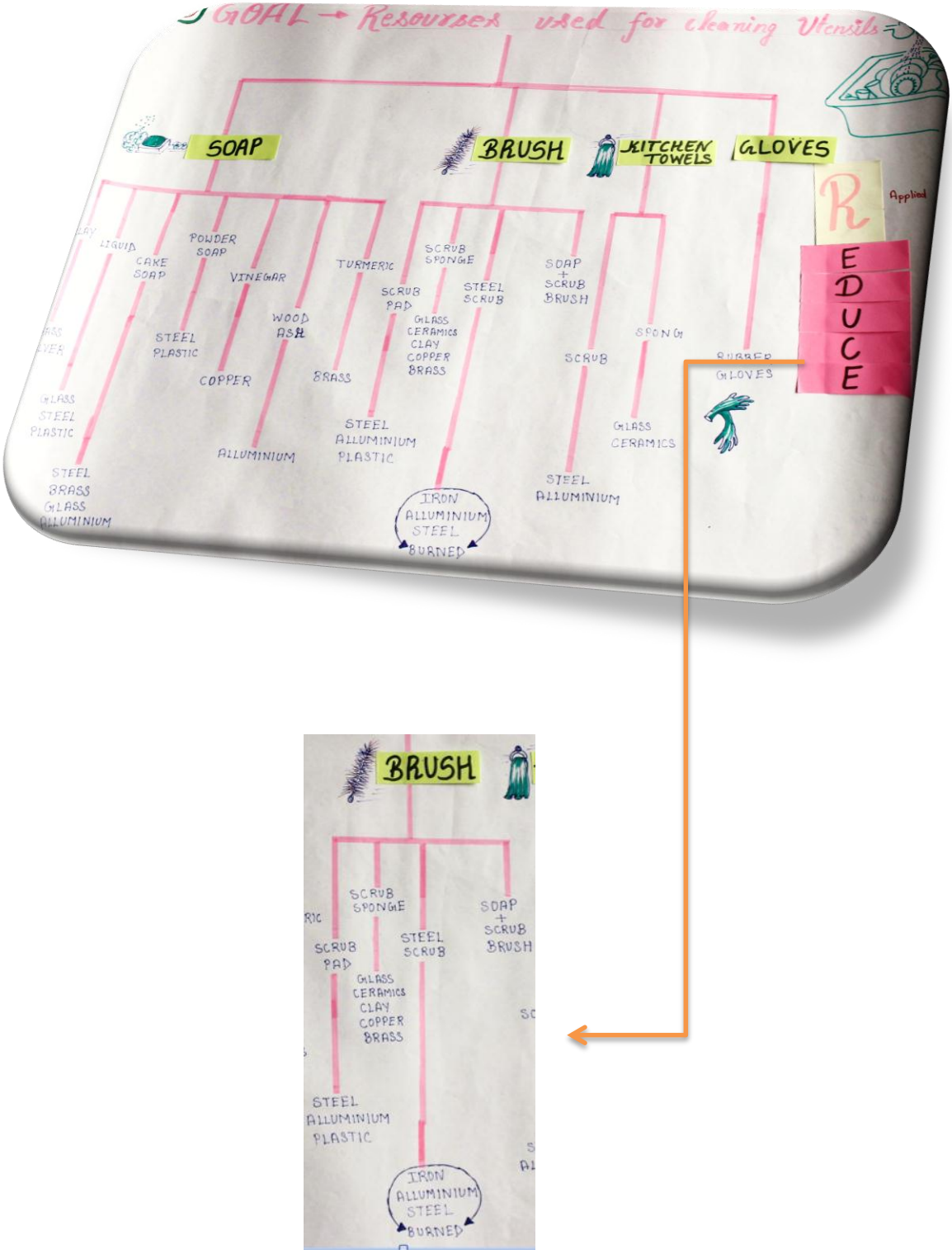


Figure 5.8 Rationalizing the devices used to washing utensils and matching with referent 'reduce'. Source: Student work. Surpreet, Dhara, Anshu, MDes NIFT 2015

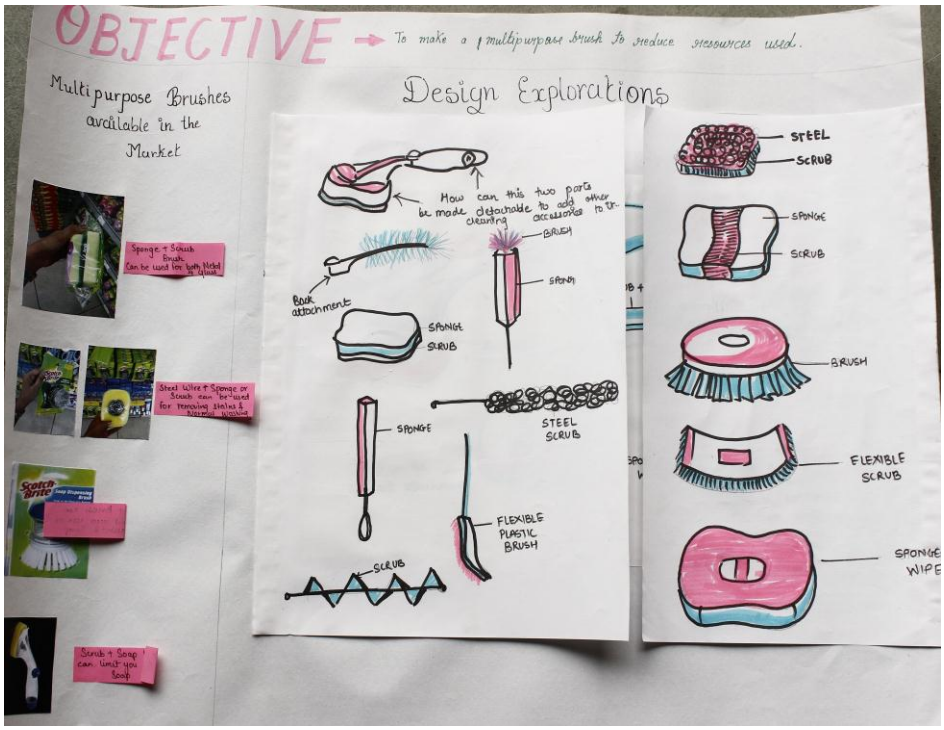


Figure 5.9 Taking forward multipurpose brushes as the precedent for reducing resources. Source: Student work. Surpreet, Dhara, Anshu, MDes NIFT 2015

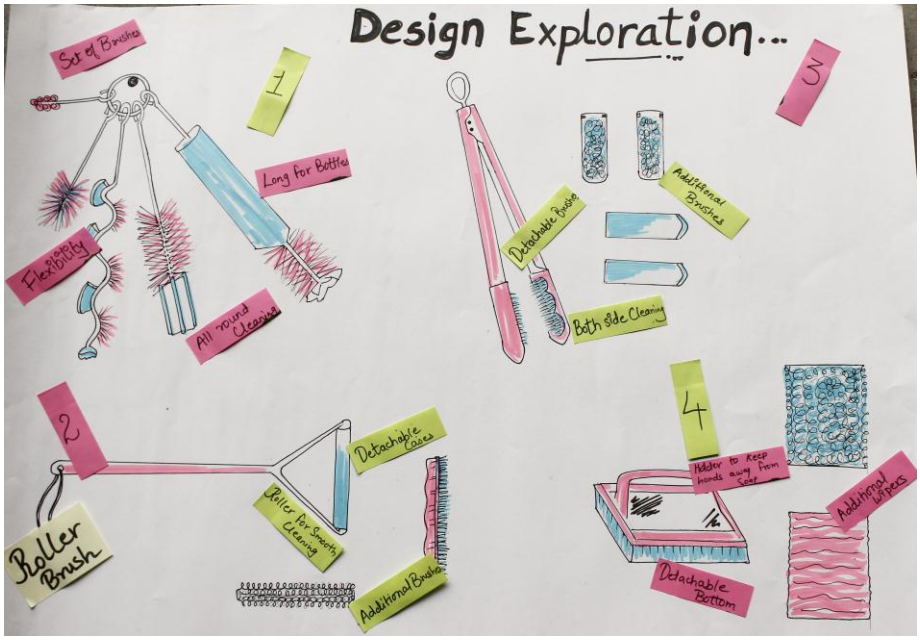


Figure 5.10 Design exploration for multipurpose brushes. Source: Student work. Surpreet, Dhara, Anshu, MDes NIFT 2015

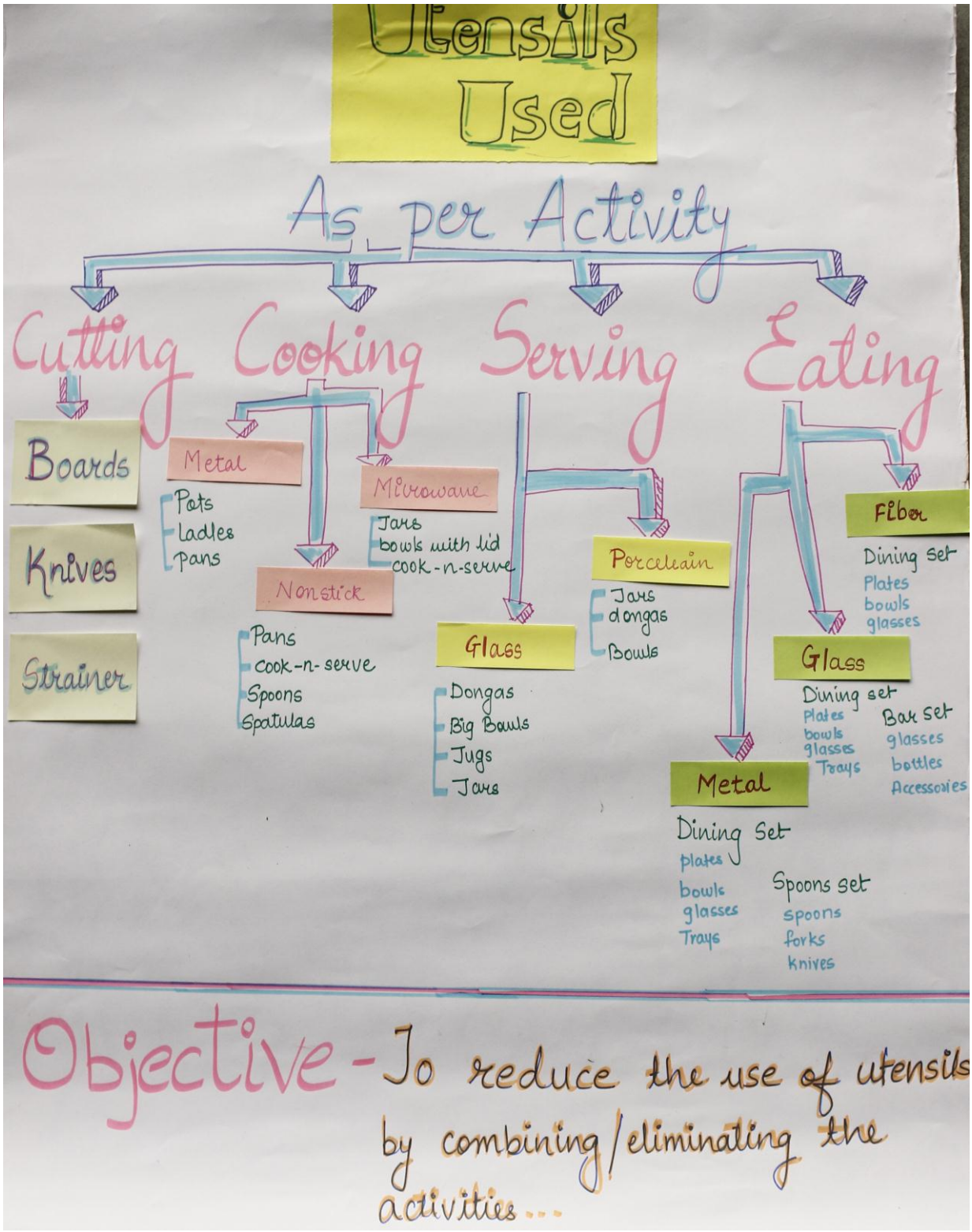


Figure 5.11 Using combining/eliminating activities of washing utensils as primary generator for referent 'reduce'. Source: Student work. Surpreet, Dhara, Anshu, MDes NIFT 2015

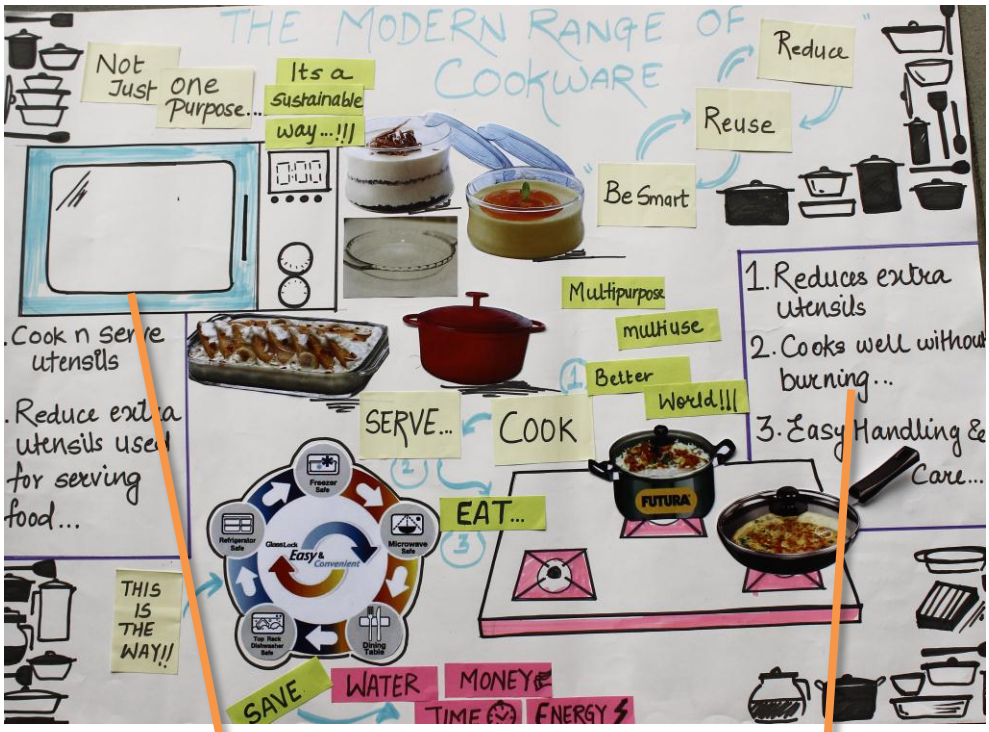


Figure 5.12 Precedents studied within already available utensils in the market. Source: Student work. Surpreet, Dhara, Anshu, MDes NIFT 2015

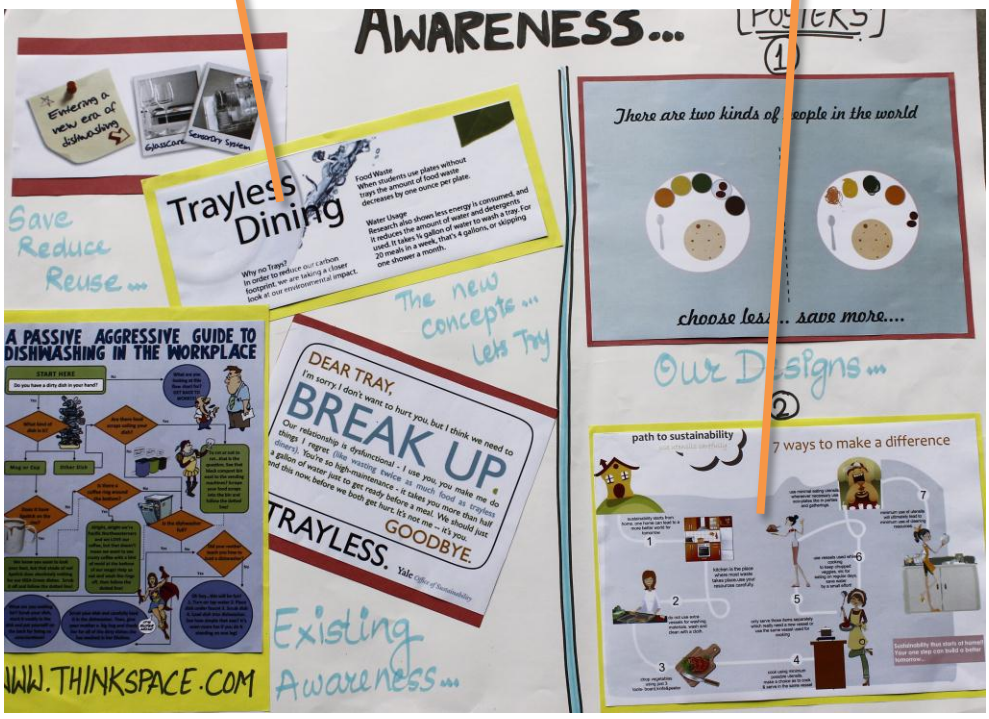


Figure 5.13 Taking forward multi-use utensils as precedent. Source: Student work. Surpreet, Dhara, Anshu, MDes NIFT 2015

There are materials used in the whole system of washing utensils. The students have mapped these.

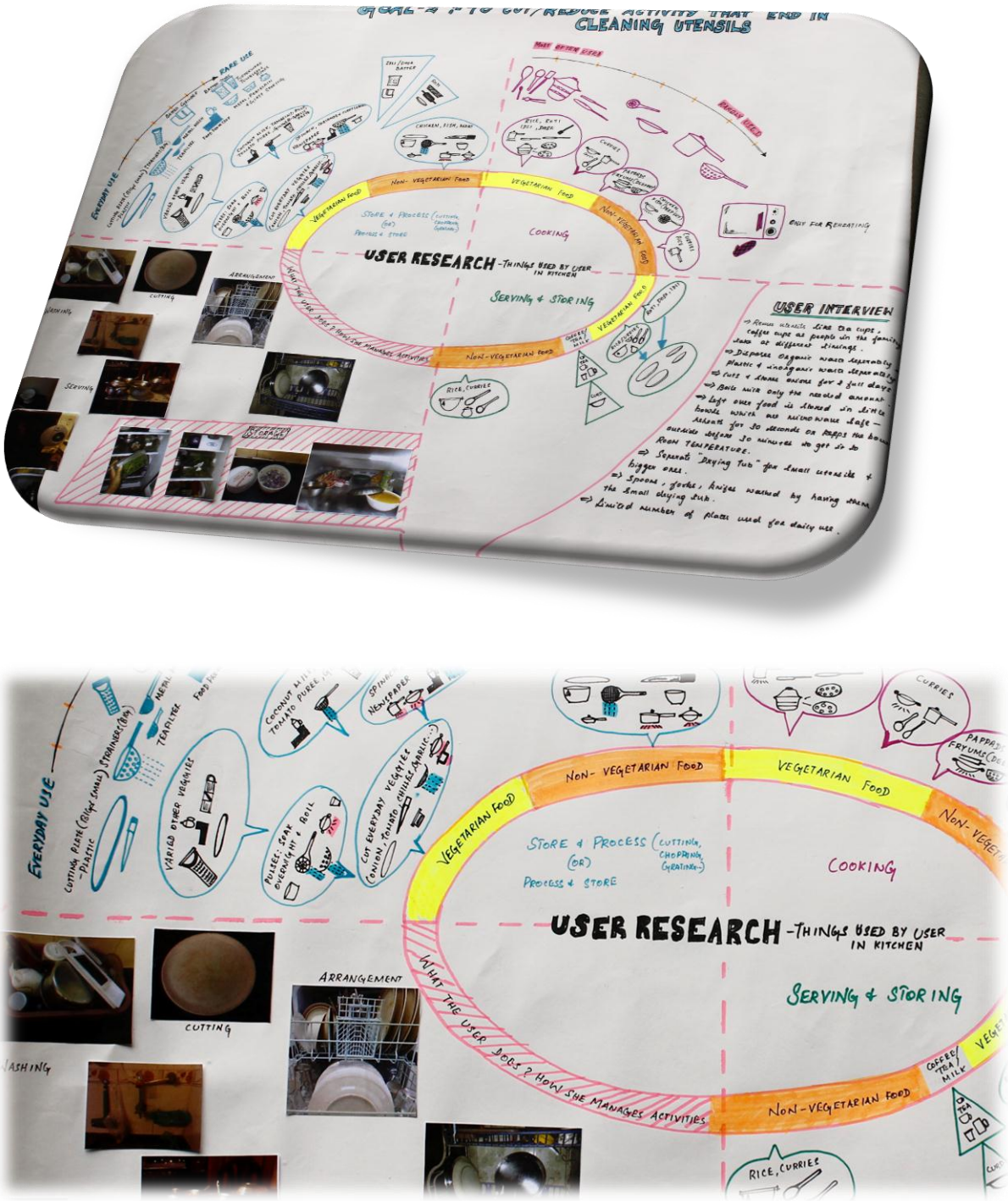


Figure 5.14 Mapping of system of washing utensils. Source: Student work. Surpreet, Dhara, Anshu, MDes NIFT 2015

5.6.2 Buying grocery

Figure 5.14 Mapping activity of buying grocery. Source: Student work. Uday, Apoorva, Tejasi, Vijita, MDes NIFT, 2015

The activity of buying grocery, also made the students realize how seemingly unconnected activities come together. The activities comprised of decisions of

- What to buy?
- Where
- When
- Why and
- How to buy?

In observing the activities the one unsustainability factor they identified was that of expiry date of products in the departmental store. The students looked through relevant literature and found that it is indeed an active sustainability issue in the retail and supply-chain sectors.

The other unsustainability element was time taken to shop. The students found through observation in the departmental store that time could be saved through facilitation of the shopping process. Reduction in both the resources found a common solution in a smart trolley.

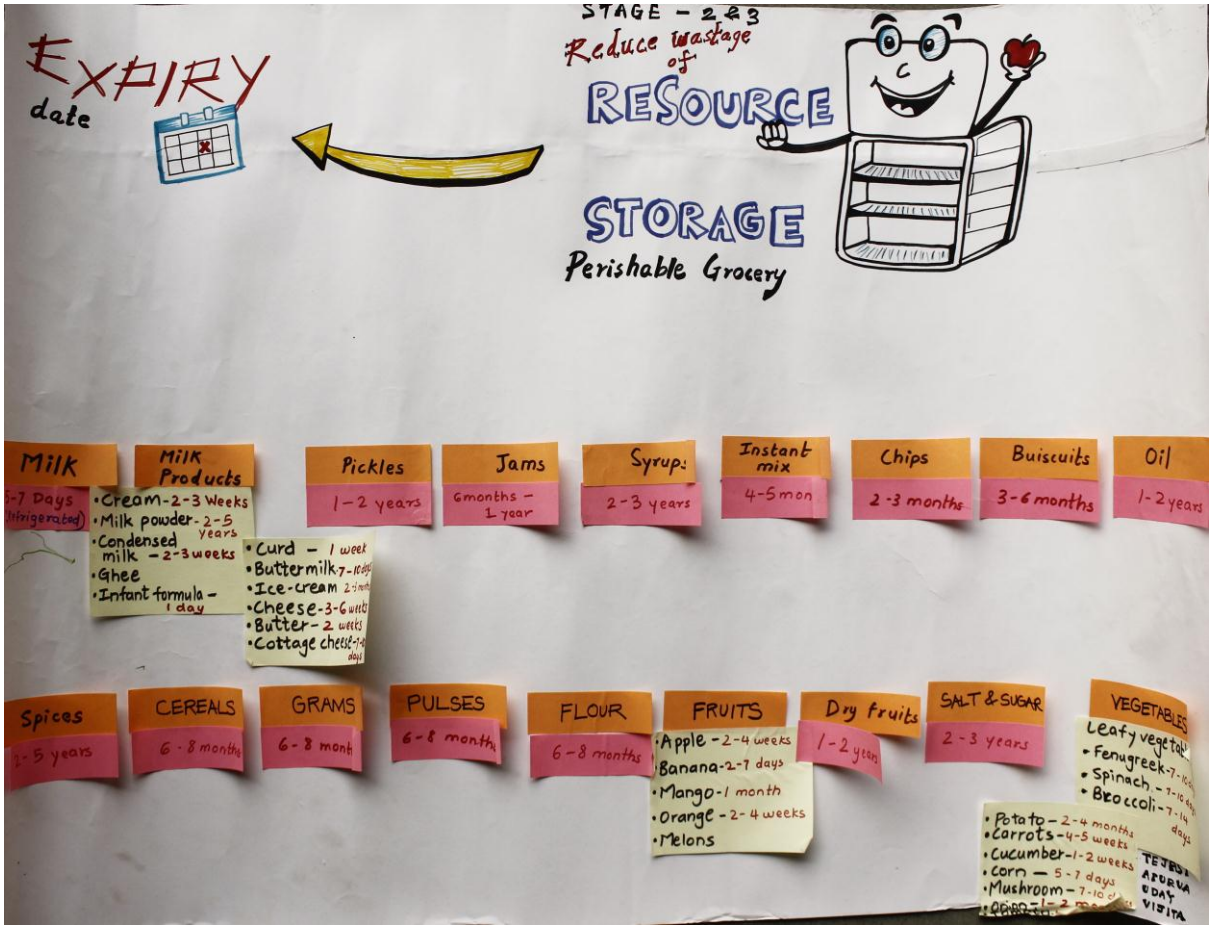


Figure 5.16 Expiry date as the primary generator for reducing storage in the store. Source: Student work. Uday, Apoorva, Tejasi, Vijita, MDes NIFT, 2015

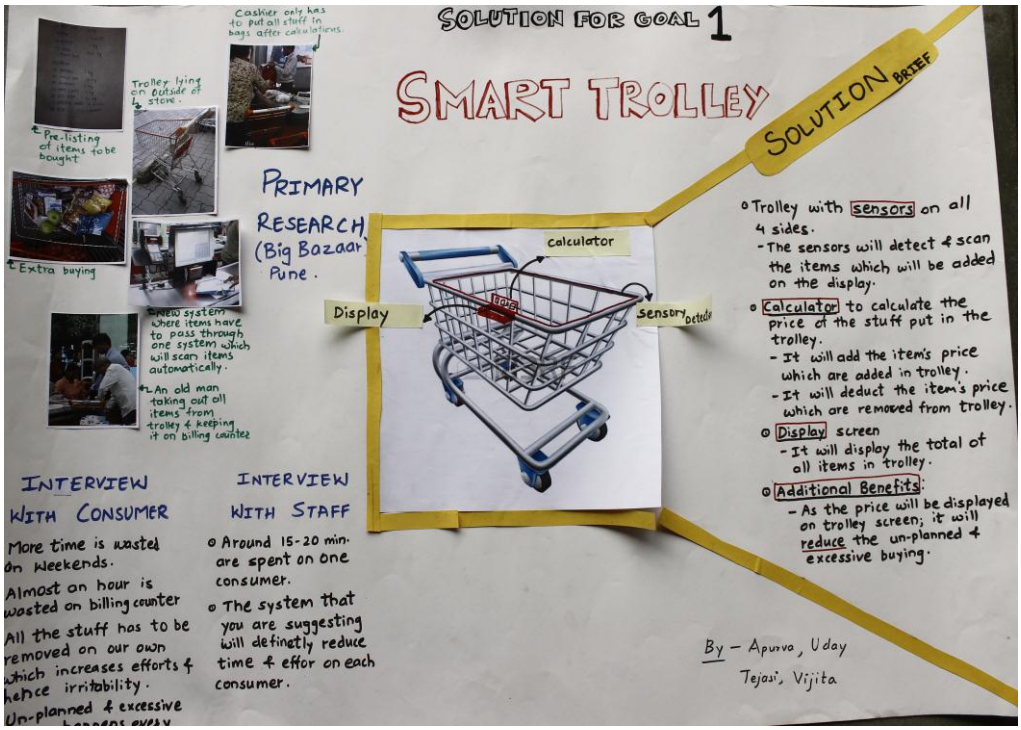


Figure 5.17 Smart trolley as the primary generator for reducing time. Source: Student work. Uday, Apoorva, Tejasi, Vijita, MDes NIFT, 2015

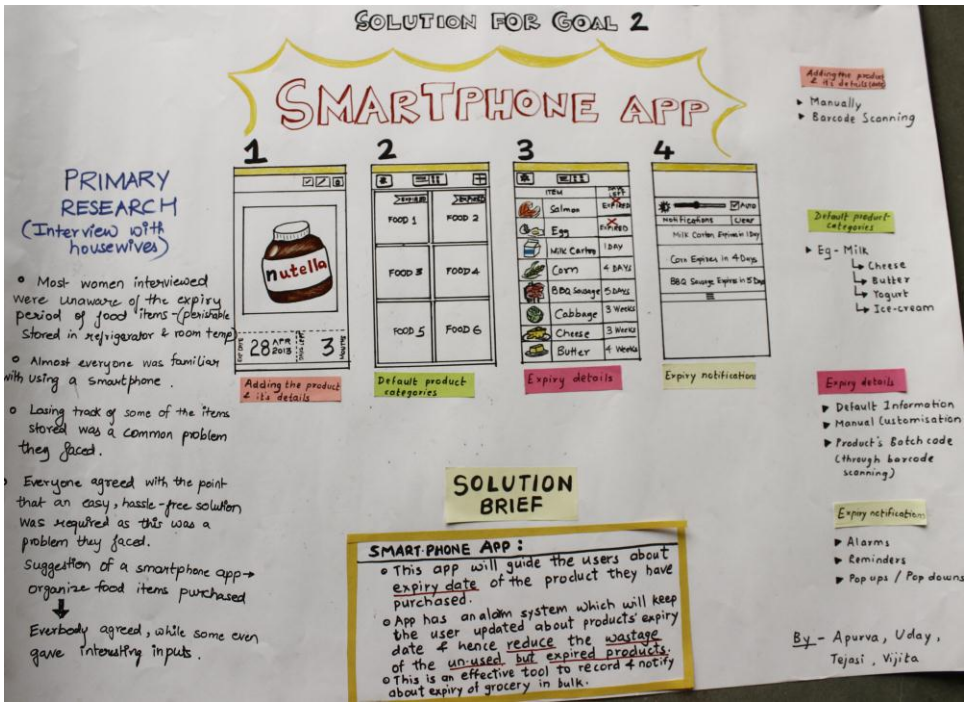


Figure 5.18 Smartphone application as a primary generator to reduce storage due to expiry date. Source: Student work. Uday, Apoorva, Tejasi, Vijita, MDes NIFT, 2015

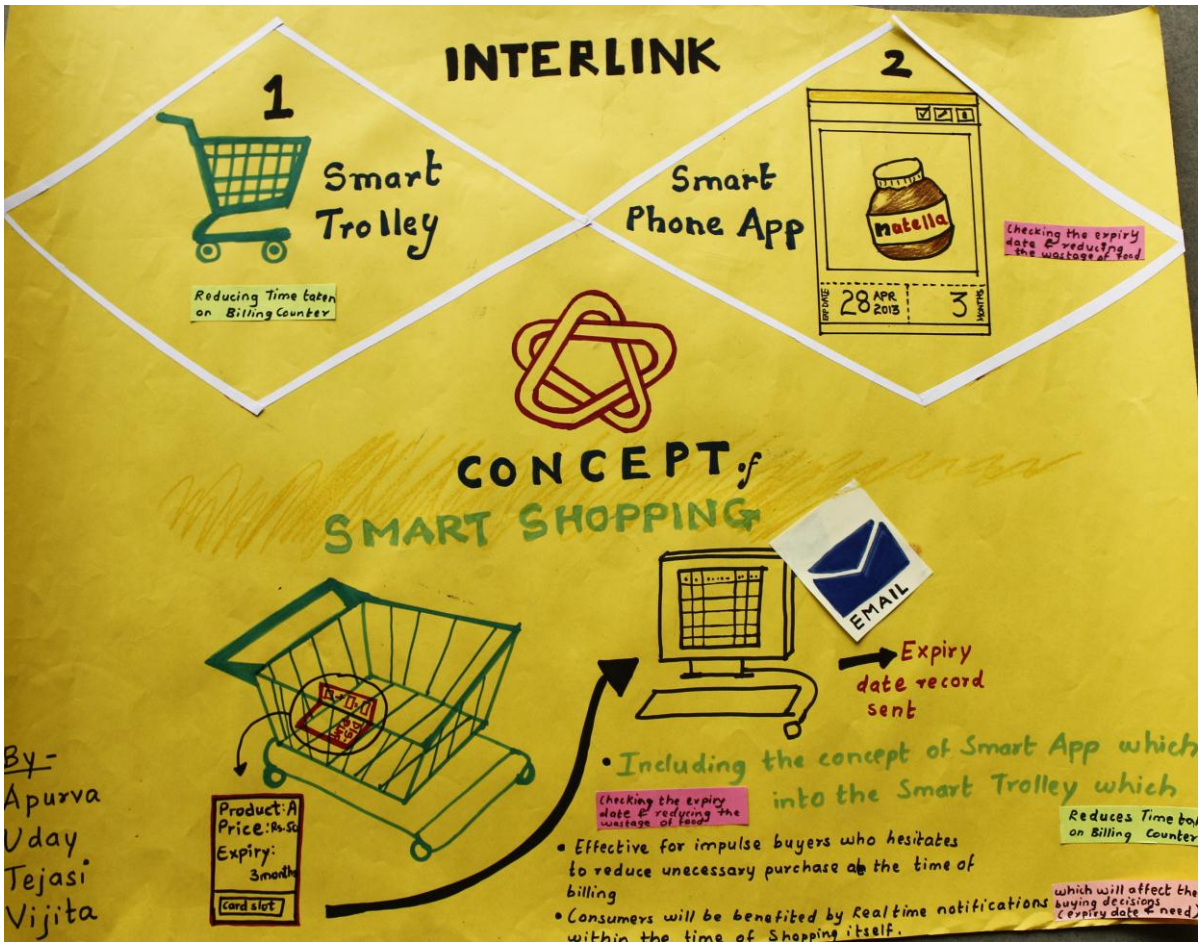


Figure 5.19 Smart shopping with reduced time taken to shop and avoiding expired items.

Source: Student work. Uday, Apoorva, Tejasi, Vijita, MDes NIFT, 2015

5.7 Insights from DE 2a

1. Students started the project with exploring their own personal experiences concerning the activity. This showed episodic behavior like in the previous two observations.
2. The students collected information and got it back to the studio. This had to be matched with the referents given. Even though the list was small (3Rs), the student deliberated on which one matched the unsustainable resource in the information they had collected. They admitted that this added to their understanding of the problem.
3. Applying the referent to two unsustainable resources engaged them in understanding systemic thinking. For example, the group that took up 'washing utensils' identified two resources that needed to be reduced- utensils and water. When they came up with systemic solutions for both individually, they found that in many usage observations, reducing utensil usage resulted in increase in water consumption.
4. We cited the following structure of design thinking in chapter 1;

a. Instead of a problem, we have a state A of a system
b. Instead of a solution, we have a state B of a system
c. The designer and the user are part of the system (stakeholders) (Fendeli, 2001).

But we were not able to achieve converting state A to state B and putting back in the system for two reasons:

a. Paucity of time in a design studio
b. Student projects by its very nature are partially hypothetical. The basic purpose is that the student understands the process and is able to call upon the knowledge when required.

5. Even though the students were not asked to look for a case study, they identified appropriate studies for guiding their design decisions. This shows that using cases are quite regular for design and sustainability thinking.
6. When the problem was introduced, some students raised questions as to whether everyday situations were a good platform to study sustainability. What difference can 'everyday' make on a problem that was so huge. Towards completion of the project they were able to appreciate the impact of the 'everyday' on sustainability issues.

7. Students needed scaffolding to identify unsustainability factors as well. A checklist may be provided to them (Appendix III). The sustainability cheat sheet can also be more exhaustive.

Table 5.4 Relationship matrix for DE 2a

DESIGN / SUSTAINABILITY	REFLECTIVE	ABDUCTIVE	WICKED PROBLEMS
BROADER DEFINITION OF SUSTAINABILITY			
ARTEFACTUAL WORLD		–	
SYSTEMIC	–	–	

After culling out the conjectures in student thinking and projects, the model was generated. On reflection it was found that not only design process can be guided through conjectures but also that conjectures relate the ontology of design and epistemology of sustainability. This has been shown in the relationship matrix. The relationship matrix shows conjectures relating to all the sustainability elements (albeit in the wicked problems category). This is due to the fact that DE 2a has an explicit sustainability focus as against DE 1, which did not. The episodic conjecture is what the students start with to make sense of the artefactual world seen through the lens of sustainability. When they recognize the unsustainability factors they become the starting point of solving the problem. This starting point is the primary generator, which connects the artefactual world and the complexity of sustainability. Case studies and referents are again aids to link the complexity of the problems with the systemic nature of sustainability and its broader definitions.

5.8 Model Iteration 2

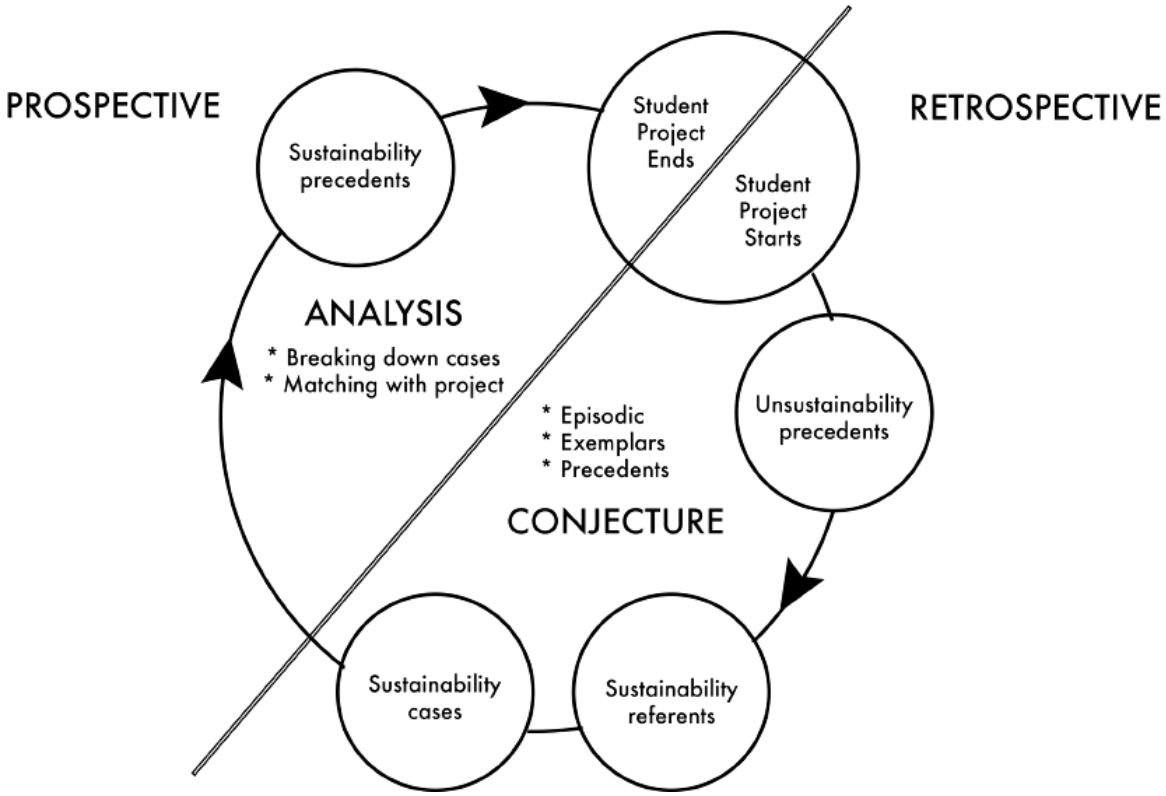


Figure 5.20 Model Iteration 2

The distribution of elements in the model was found to be asymmetric as against the symmetric placement in MI 1. The numbers of elements in the retrospective part of the model were found to be more than the ones in the prospective part. This is because early design stage is being studied here. In Ideology critique and MI 1, the starting point was episodic thinking where the students drew from their own personal experiences (individual) or shared with instructors or peers. In DE 2a, since the design context was situated in the everyday life, it naturally generated episodic thinking. But one of the big insights was that they were not able to progress further to identify referents as suggested by MI 1 unless they were able to identify unsustainability factors (or precedents).

The second step in MI 2 is to match the unsustainability precedents with suitable referents. Three most common referents- Reuse, Recycle and Reduce were given to them. Referents are anything that is used as reference. To do this there has to be a match between

the problem to be solved and the referent chosen. Dorst (Dorst K. , 2006) explains the matching problem in terms of analogies. "Comparison statements of the form 'a' are like 'b' are assessed by comparing features of 'a' with the features of 'b'." The relevant features are extracted through a prior process, in order that" features that are not relevant are excluded, and those that might be relevant are included. In this case we match the chosen unsustainability factors with the chosen referent to solve the problem. This gives the student a hold on the design problem in a sustainability context.

Once the student has reached the stage of deciding which sustainability approach he/she will choose to solve the unsustainability issue, there is still a problem of knowing how to go about it. To do this again matching has to be done with a case study where similar sustainability approach has been used to solve the problem of unsustainability. Since sustainability problems are also wicked, case-based approaches are particularly well suited to teach about sustainability and to build capacity to address the challenge (Sprain, 2012). [19]

Out of the typologies of cases, Illustrative has been used in DE 2a and MI 2. Illustrative cases describe an event or process factually. The students' task is to understand practices that were used and how they were applied, including appreciative inquiry (Sprain, 2012) of what went well in successful cases.

Since the problem to be tackled is a design problem. The cases have to be broken down into smaller parts. Only the relevant part is to be taken forward as a sustainability precedent.

The steps 1, 2 and 3 i.e. identifying unsustainability precedent, matching with a sustainability referent and finding an appropriate case study is the retrospective part of the process where the prior thought is shaped. Taking a part of the case study forward as a sustainability precedent is the prospective part, which is also analytical in nature.

[19] Seven typologies of sustainability cases have been identified by Sprain

1. Iceberg cases
2. Illustrative cases
3. Dialogue cases
4. Application cases
5. Data cases
6. Issue cases

5.9 Insights to be taken forward from Model Iteration 2

1. The fact that episodic thinking can be leveraged into producing unsustainability precedents has been established and has to be taken forward.
2. Unsustainability precedents have to be matched first with an unsustainability referent. This is important to shape the thinking of the student towards sustainability design process. Appendix III (U. Tischner, 2009) gives an exhaustive reference list of questions that need to be asked when faced with a design situation.

5.10 Design Experiment 2b (DE 2b), 2014

Like design experiment 2a, design experiment 2b also was conducted as divergent and convergent action research. It is divergent, because new aspects are introduced to study their impact on use of conjectures. The observation of conjectures remains the constant in all the design experiments therefore is the convergent aspect of the action research. The new aspect introduced in design experiment 2b is the different definition of resources. The accepted definition of sustainability for this thesis is safeguarding resources. It is assumed that resources in the context of sustainability are related with the environment. Here, one is looking at different contexts, where sustainable issues need to be addressed. Some of the issues, which are addressed in this section are: learning history, increasing the life of assignments done by students in a library, maximizing skill utilization in a group, increasing human resource efficiency in a postal system.

The task was to study a system, identify unsustainable factors and converting them into sustainability through a series of steps. All the steps given in model iteration 3 have been followed. It gave rise to some interesting results listed in insights from DE 2a (section 5.8)

This design experiment was conducted with another group of students taking the same course (SS 306) at NIFT Mumbai. The task was to identify an unsustainable solution in their immediate surroundings and turn that into a sustainable brief/solution. Again, an immediate surroundings was chosen so that it generated episodic thinking and a sense of familiarity. Five of the projects have been described below. The discussions between student and teacher (author) were recorded. The students were instructed to present the entire process in the form of a poster. This was done to inculcate reflexivity in the students. The process of conjecturing was more deliberate. This was found necessary since the resources that the students were referring to were abstract and seemingly unconnected with sustainability issues. Seeing all of it together strengthened their understanding.

5.10.1 Learning history as a situation to study sustainability

History is an essential part of the primary and secondary school curriculum. It is clubbed under social studies indicating that it deals with people, their lifestyles, aspirations and events that occurred. Its very nature requires a reflective and discursive handling. But it is taught mostly in the didactic mode. Historical events are introduced 'merely as a chronological sequence' (student). This disassociates the human angle of the event and 'school children usually end up learning it by rote for exams and it is not retained for long' (student). The student working on the 'learning history' project shared this view with the rest of the class and 24/25 students agreed with her. Many of them shared that when they saw a historical film or read a fictional account of history they found it very interesting. This idea was interpreted by the student as a sustainability problem because the knowledge of history does not 'last long' and is 'lost' or 'wasted'. This also stemmed from the student's personal experience where she said that she never remembered anything from her history classes. She thought that history was not taught in a way that it could be retained and taken forward, rendering it unsustainable. She wanted to explore it in a manner that history knowledge is 'not wasted' and is 'durable'. The unsustainability precedent and episodic factor that history knowledge is not retained in the minds of children was also the primary generator. The referent chosen from the cheat sheet was 'upgrade'. 'Upgrade' was viewed holistically on the one hand in terms of creating an effective tool for teaching history and on the other it was

viewed contextually as reviving folk tales. She chose ‘creating effective tool’ to proceed in the project. In order to upgrade the teaching of history, she has chosen storytelling as a tool. Two case studies have been chosen where the referent has been used with same purpose of upgrading teaching/learning experience. Appropriate conjectures were chosen from case studies and taken forward for the final proposal.

Figure 5.21 Story telling as the primary generator for learning history. Source: Student work. Suruchi, MDes NIFT, 2016

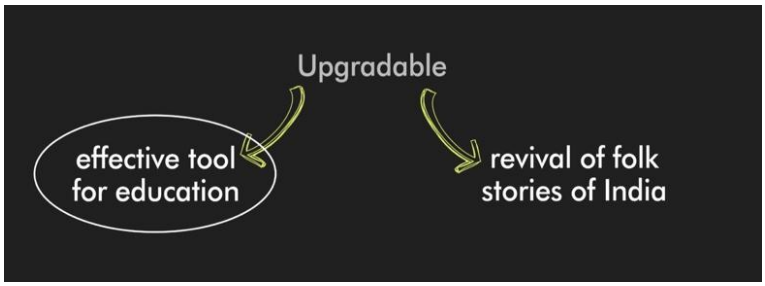


Figure 5.22 'Upgrade' as the referent to aid learning history. Source: Student work. Suruchi, MDes NIFT, 2016

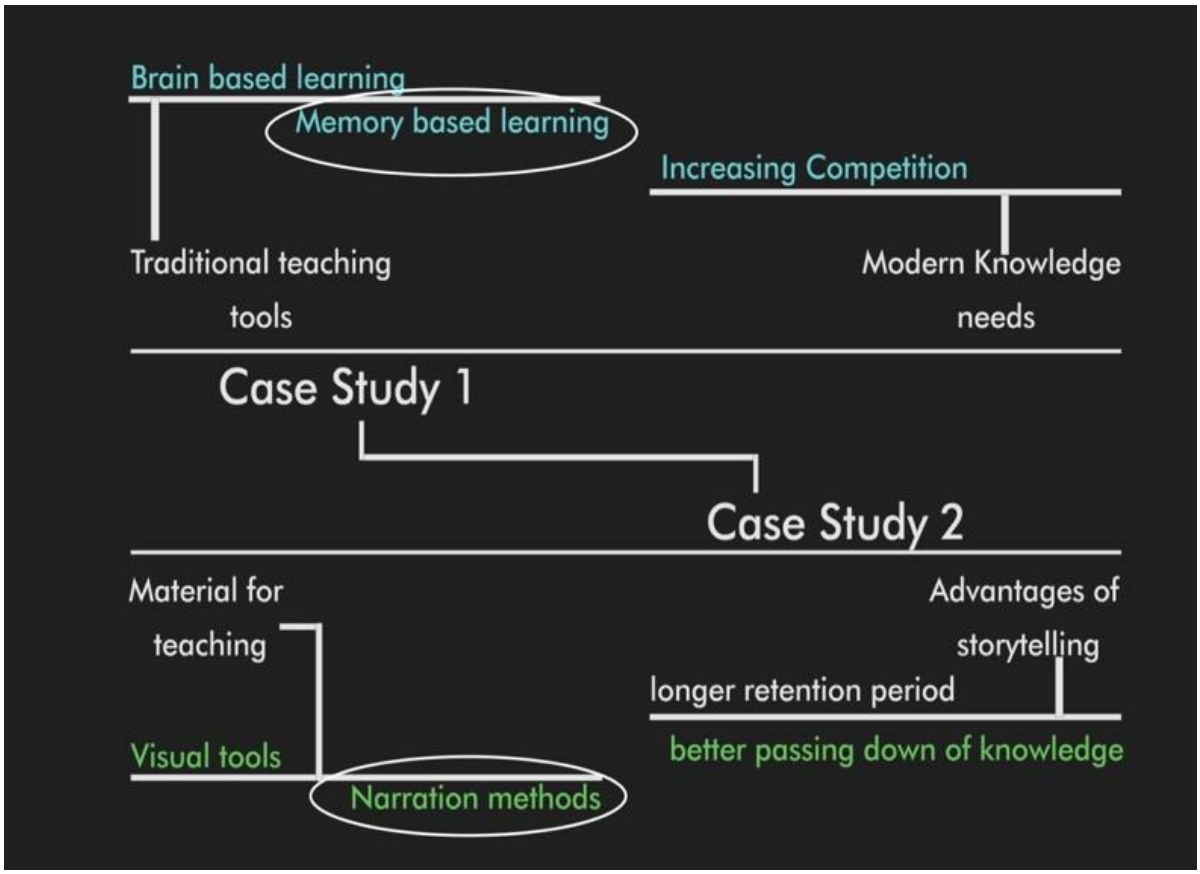


Figure 5.23 Using two case studies of 'learning'. Source: Student work. Suruchi, MDes NIFT, 2016

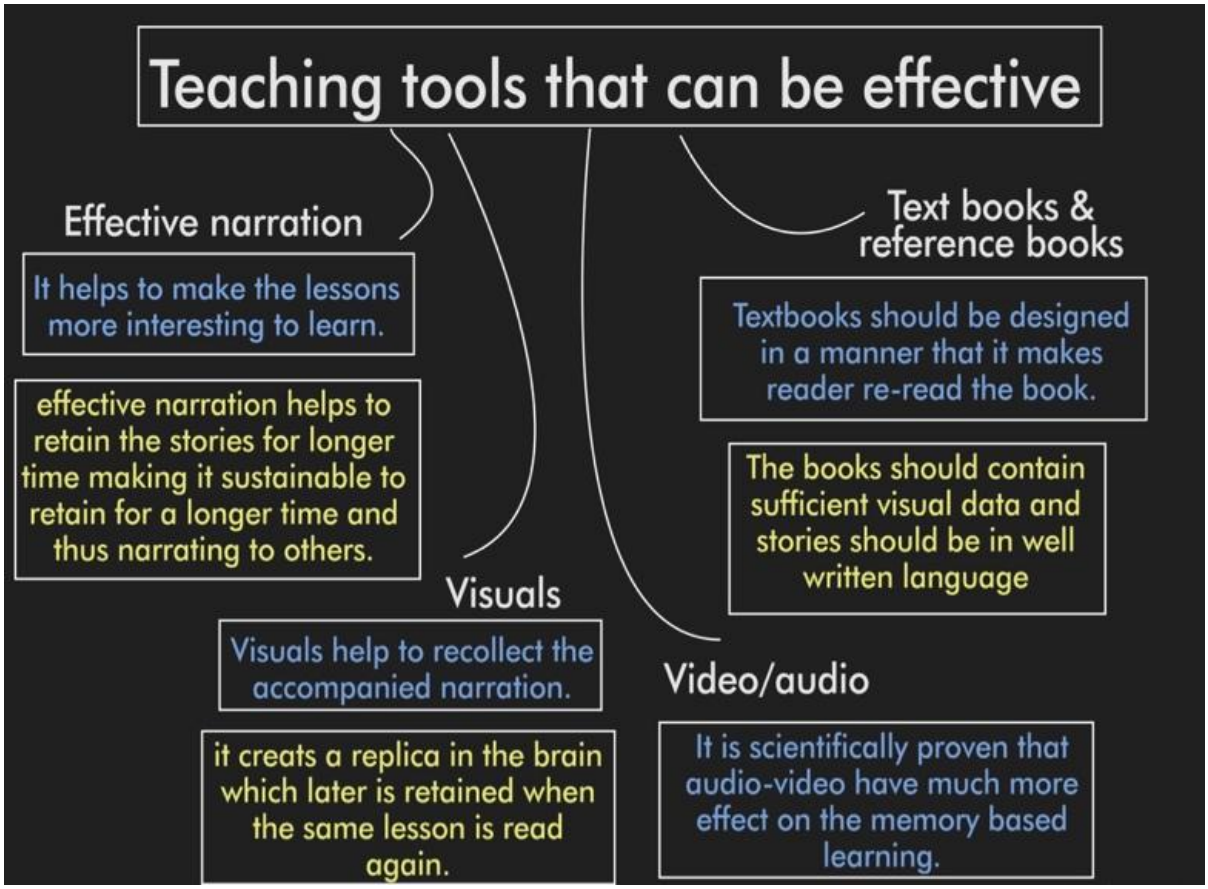


Figure 5.24 Precedents transferred to solve problem of 'learning history. Source: Student work. Suruchi, MDes NIFT, 2016

5.10.2 Library as a sustainable system

This project (Figure 5.25) was about extending the life of assignments that are submitted as a part of their projects in a design school such as NIFT. The resource to be conserved is the knowledge generated through student assignments. Many hours of work and valuable insights are lost after the faculty evaluates the assignment. The library of any institution only stocks published books and other published e-resources and digital records. What about assignments? It was felt by the students that, " some faculty would show us work done by our seniors in class. This was so relatable…more than the work of a famous designer published in a magazine. Sometimes we even reached out to the seniors to discuss what we were doing inspired by their work."

The project began with identifying key sustainability within the library system. Lack of optimum utilization of library resources was then broken into further reasons. These reasons are under four primary categories: space, time, type of knowledge sought and accessibility. After interviewing many students within the campus, what emerged was that assignment completion was the central reason why students went to the library.

The final outcome was to suggest a redefinition of the library as a learning space that utilized the institution's internally generated resources as permanent learning aids and allowed display of how this information is sought. The sustainability referents selected from the cheat sheet were- 'Upgrade' and 'Informationalize'. Several cases of global libraries were studied so as to be adapted to the current situation. The librarian was made the custodian of dispensing this unique knowledge. It was suggested that the librarian should be well versed with the curriculum and take active part in the classroom to tell students where and how to seek information so that the students can complete the assignments efficiently.

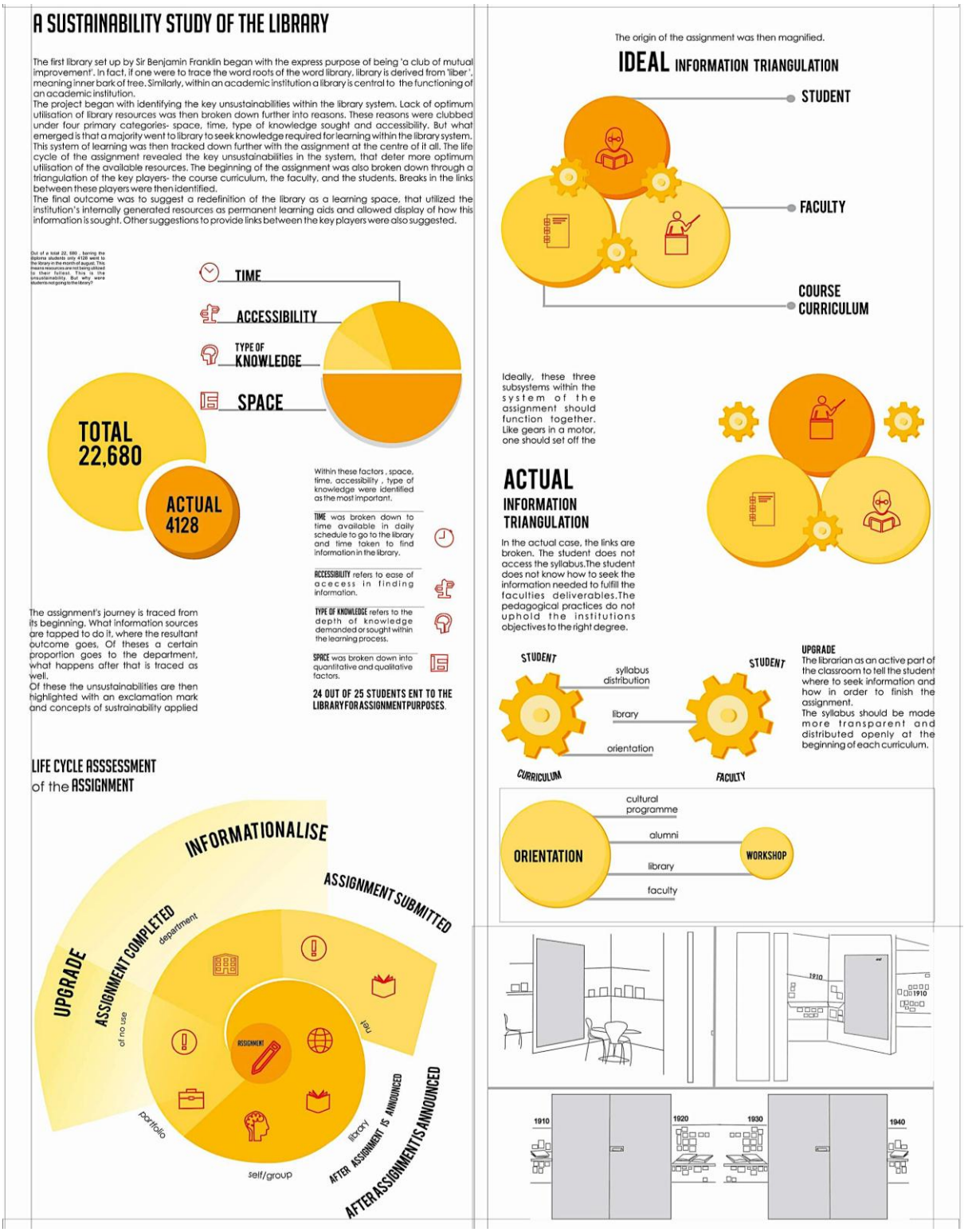


Figure 5.25 Library resources as a situation to study sustainability. Source: Student work.Trina,

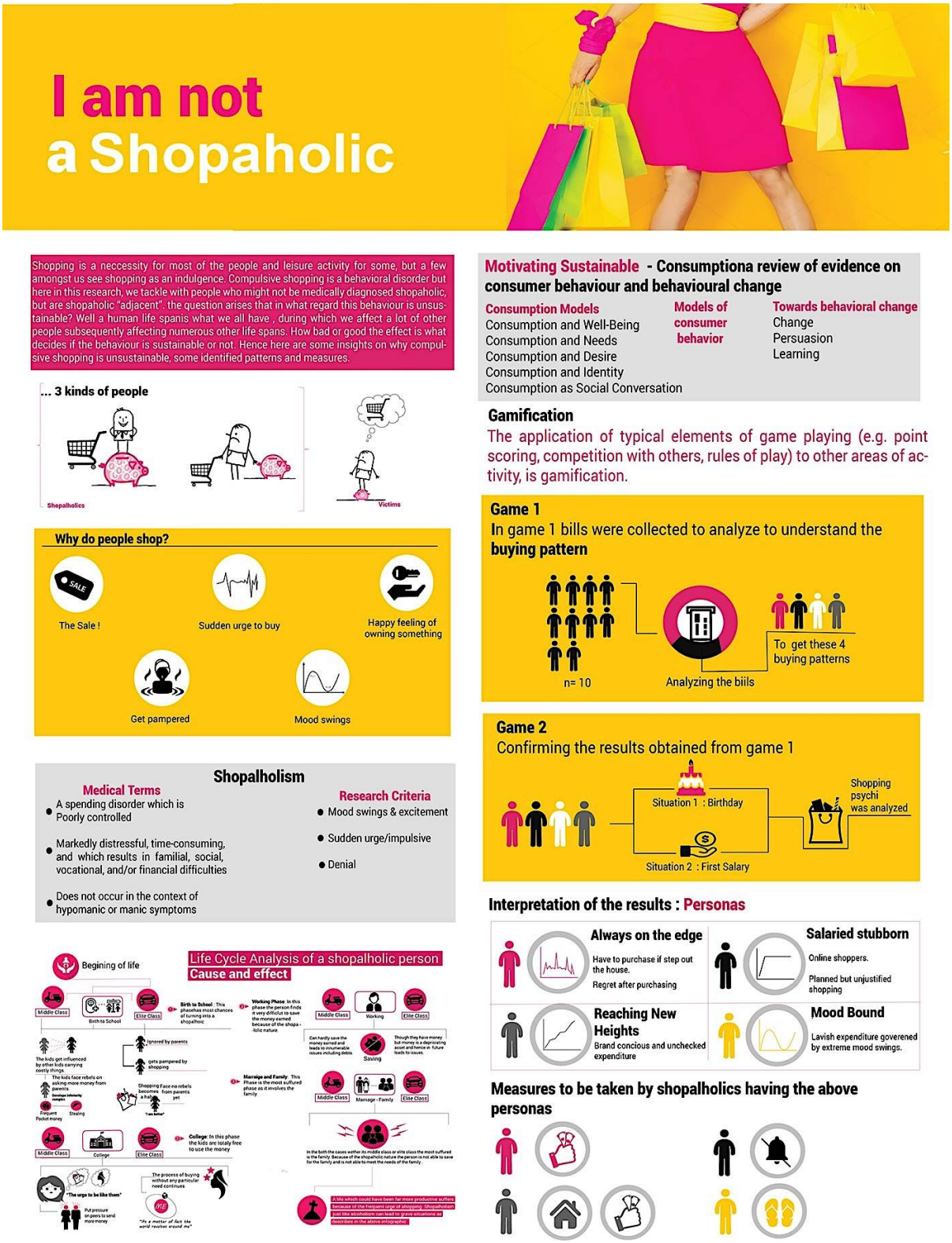


Figure 5.26 Shopoholism as an unsustainable habit. Student work. Source: Shubhshree, Nivedita, MDes NIFT, 2016.

5.10.3 Shopaholism

The third project (Figure 5.26) was that of studying Shopaholism as an unsustainable behavior. The students found themselves surrounded by such behaviours of excessive and binge shopping. They connected shopaholism to consumerism, which is a confirmed unsustainable practice. The referent they chose was – Life Cycle Analysis, because shopaholism itself is just a symptom of an underlying problem. They traced the lifecycle of a shopper and identified the problem area, which tips the balance from shopper to shopaholic. The case studies they chose were from the areas of sustainable consumption and medical domain. From the former they found ways of consuming responsibly. These were given by the instructor (author), which she had collected as literature for the project on sustainable consumption (Appendix1). The medical papers said that shopaholism is just not a behavioural symptom but a medical condition. From these cases the precedent, which emerged was to identify user personas of shopaholics, which might help to understand them better. This direction had a roadblock. People who were interviewed would not admit to their propensity to excessive shopping. The students had to device a creative way in terms of gamification to extract information. On the basis of data gathered, four personas were developed.

5.10.4 Knowledge sharing

The fourth project (Figure 5.27) is also related to knowledge. The lack of peer learning amongst students of NIFT is looked at closely. The project focuses on skills that individual student possesses through their experience. These skills can be learnt from each other, which is not actively practiced, because of which enriching of the whole group does not happen. When knowledge is not used to its full extent or passed on it becomes unsustainable. Case studies indicated that an uninterrupted flow in the knowledge cycle results in creating a sustainable knowledge management system. The students doing this project conducted a small experiment with girls in the hostel where they stayed. The sustainability referents chosen from the cheat sheet were- upgrade (performance and skills), transparency in terms of networking and workflow, reuse of resources, Do-It-Yourself by sharing with peers and substitute formal classroom teaching with informal interactions.

There were two final outcomes of this exercise. One was the idea for a share fair, which was akin to a meet up where peers could share their talent and help others and use help in their weak areas. Thus the student community is empowered. An initiative for NIFT was also proposed which is called Community of practice (CoP).

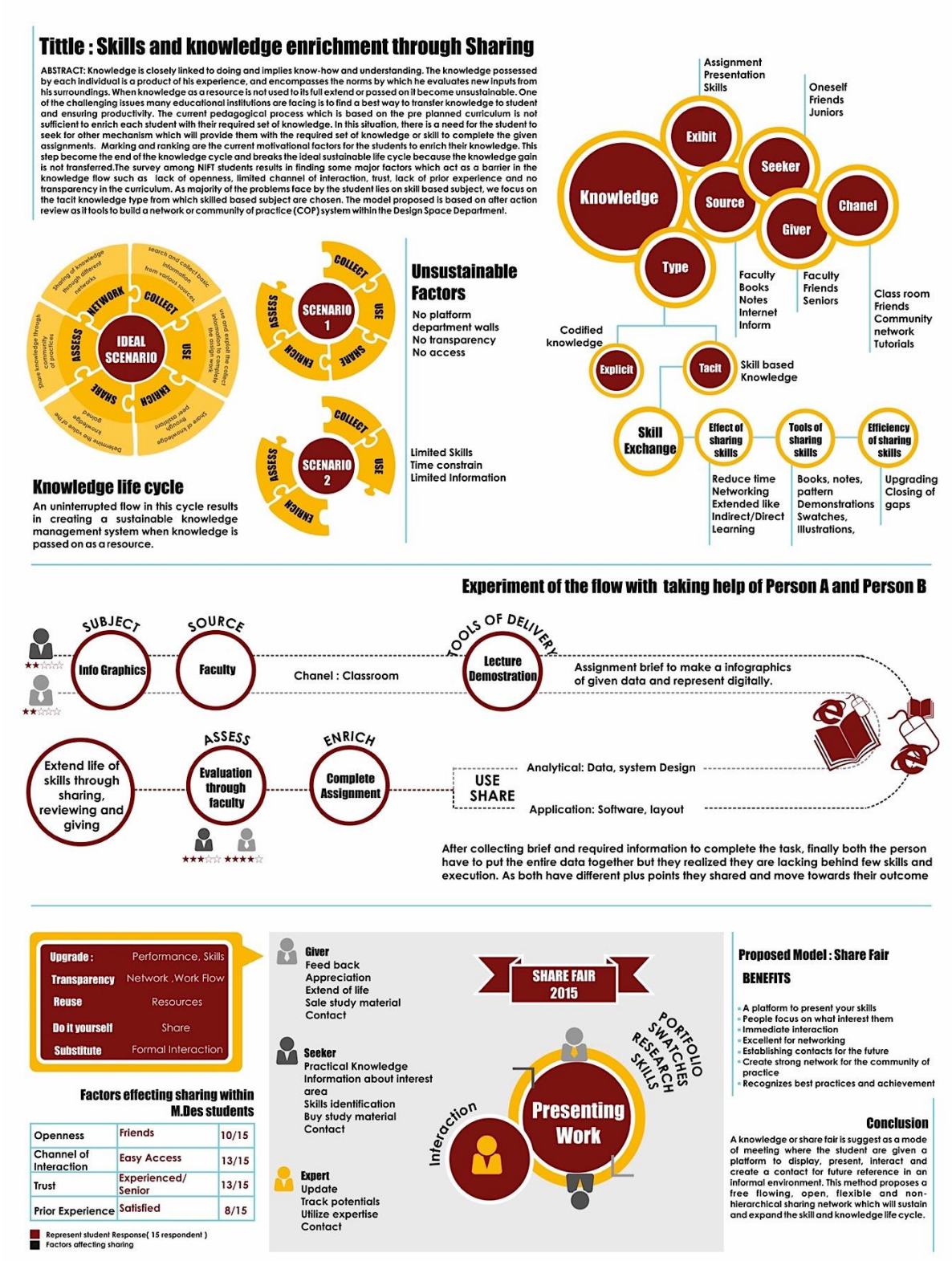


Figure 5.27 Knowledge sharing as a sustainable system. Source: Student work. Elizebeth, Torali, MDes NIFT, 2016

A SUSTAINABLE POSTAL SYSTEM

ABSTRACT

The kharghar post office was studied as a sub system which represents the macro system of the Indian Postal Service. This system was selected out of the curiosity, for the relevance of the post office in the era of digital communication technology and private logistics corporation like DHL, Blue Dart, Gmail, messenger. But, surprisingly it was found, that not only, is the postal service still relevant, but is also relied on by a large chunk of Indian population and organizations too. The Kharghar post office, has to bear the same burden of reliability, when it comes to it's logistics operations. Not only do they get mails on a regular basis, but are overwhelmed by the volume, to the point where, their resources of manpower and time have been stretched thin. The system was studied, to get an overview of it's logistics operations, highlight the problems within it, and to find tentative solutions.

RESEARCH

A package is either put in the mail box (which is then taken to the nearest post office), or directly taken to the post office.The packages are then sorted in the post office according to the areas and pin codes they are to be sent, and packaged according to the sorting. The delivery van takes the packages to different transport mediums depending on their destination and time to reach (roadways, railways, airways etc.). The different mediums of transport, transfer the packages, to the place nearest to their destination. The postage vans, collect the packages from the transport to bring them to the nearest post offices. The bulk packages are then unpacked in the post office and sent off to their respective areas, via postmen (i.e. using the human resource).

Employees

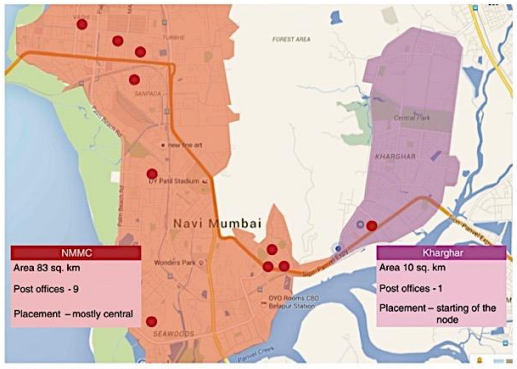
18 postmen (15 permanent, 3 part timers) , 3 clerks, 1 stamping personnel, 1 Postmaster.

Volume of post

1 bulk post dispatch, containing about 30- 35 bags. Each bag containing 500-600 envelopes (200-250 speed post).
Each postman handles 2 sectors, but sectors from 22 to 35 are assigned only 3 postmen. Every postman, delivers about 80 mails each day. The 3 postman that are assigned sectors 22 to 35, handle about 150-200 mails each day.

Official working hours

The official working hours of the post office is 0800 hrs. to 1600 hrs.



Post office distribution

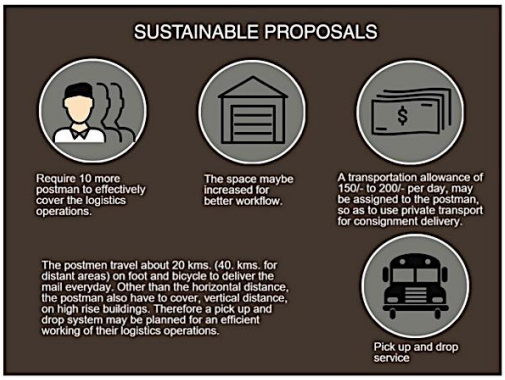
UN-SUSTAINABLE FACTORS

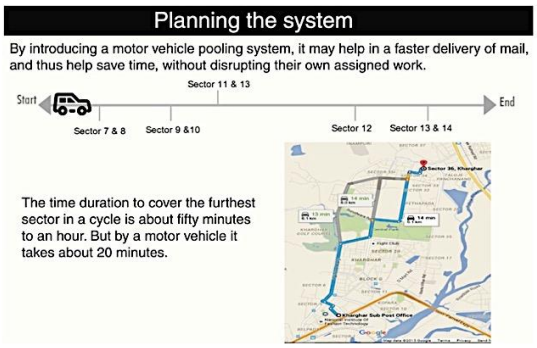
*Small disorganized physical space for the clerical and logistics operations of the post office.
*The volume of the mail is increasing everyday, as compared to the number of employees which is constant.
*The area to deliver the mail is increasing, owing to the increasing population in Kharghar.
*Owing to the constrained manpower, and the increasing volume of the mail, the working hours of the staff are increased from 8hrs. to 12hrs..
*The postmen have their own personal bicycles, on which they deliver all of their mail. They travel about 20 kms. (40. kms. for distant areas) on foot and bicycle to deliver the mail everyday.
*Other than the horizontal distance, the postman also have to cover, vertical distance, on high rise buildings.

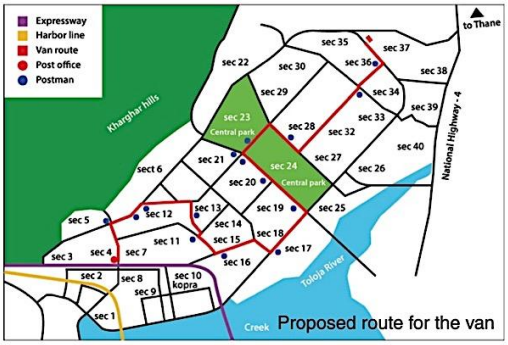
Mail dispatch process (Kharghar)

The Postman's cumbersome routine

Deliverable consignments per postman







Shuchi Agrawal
Kartik Pant
M.Des. Sem III

Figure 5.28 Study of Postal system to propose sustainable options. Source: Student work. Shuchi, Kartik, MDes NIFT, 2016

5.10.5 Postal system

The fifth project (Figure 5.28) relates to the postal system for which the post office near NIFT campus was studied. The Kharghar post office was studied as a sub-system, which represents the macro-system of the Indian Postal Service. Since they hardly went to the post office and all the work was done online, the students went with the presumption that postal service was going out of business. The students thought that the postal service would be challenged due to communication technology and private logistics corporation like DHL, Blue Dart, Gmail and messenger. But to their surprise they found that instead of being out of work, they were actually overburdened with work. Large chunk of the Indian population and organisations relied on the postal service. The post office gets a huge volume of mail regularly, due to which the limited manpower gets stretched. The unsustainability factors were all related to human resource. Small disorganized physical space for the clerical and logistics operations of the post office. The volume of mail is increasing everyday as compared to the number of employees, which is constant. The area in which mail has to be delivered is increasing, due to the increasing population in Kharghar. The postmen are overburdened.

The sustainability referent used is –system innovation. The suggestions were made in the direction of easing the load on the post-office and postmen. Additionally a route map of mail delivery in Kharghar is designed.

5.11 Insights from DE 2b

1. Students understood broader definitions of sustainability. They were looking at social, cultural and economic situations for sustainability problems. The ‘resources’ was also understood beyond physical environmental resources to abstract human resources in the social arena and time and learning as abstract resources as a cultural dimension.
2. All the steps were followed quite seamlessly and the retrospective and prospective steps were found to be present at each step, which matches with the reflective quality of design specified in the ontology.
3. Model has application across design disciplines.

Table 5.5 Relationship matrix for DE 2b

DESIGN / SUSTAINABILITY	REFLECTIVE	ABDUCTIVE	WICKED PROBLEMS
BROADER DEFINITION OF SUSTAINABILITY			
ARTEFACTUAL WORLD		—	
SYSTEMIC	—	—	

5.12 Model Iteration 3

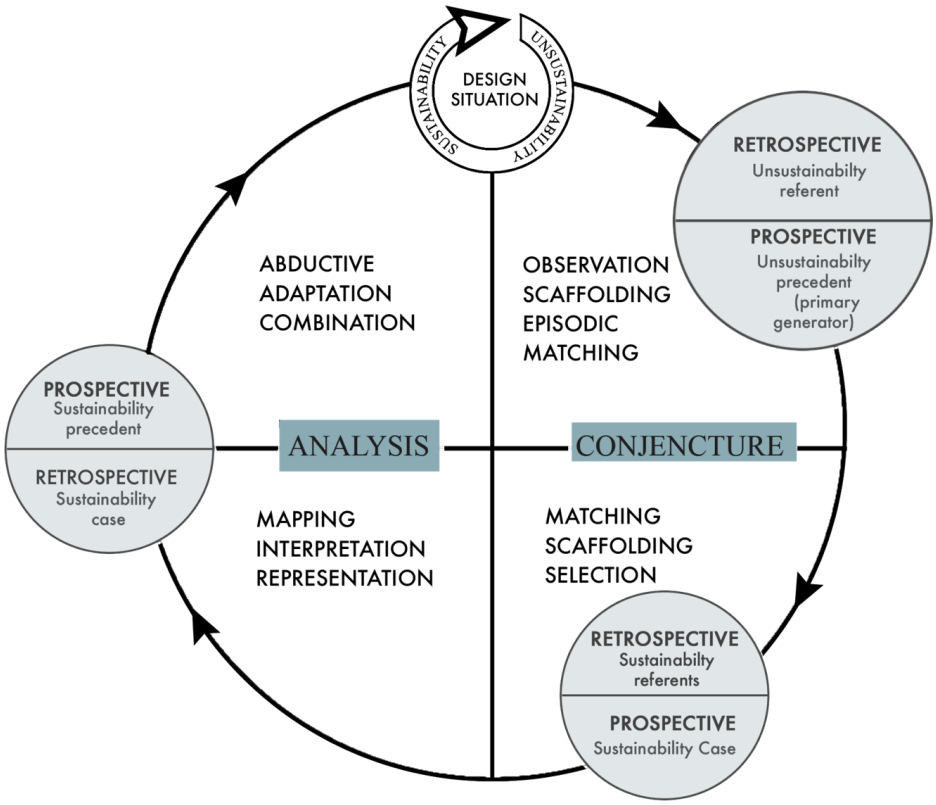


Figure 5.29 Model Iteration 3

The starting node (top) has been depicted as converting unsustainability into sustainability. This is the basis of the model, which in itself represents conjecturing unsustainability in order to convert into a sustainability output. If we trace the distribution of retrospective and prospective parts of the model from MI 1 to MI 2 and finally MI 3, we find that MI 1 has both the parts equally distributed. MI 2 has retrospective taking more space. Finally MI 3 (Figure 5.29) has the retrospective and prospective pairs at each node of the model indicating that it is not one cycle but recurring cycles at each step of the process. In the web of meaning this also indicates reflection at every stage.

The first node has unsustainability precedents, which are derived from unsustainability referents (Appendix III). The unsustainability precedents are now ready to be matched with sustainability referents in the next node. These sustainability referents can be picked from a comprehensive checklist placed in Appendix IV. Subsequently a case has to be found which uses the sustainability referent to solve the unsustainability problem. This case cannot be used as found. It has to be broken into smaller parts. One or more of parts of this case becomes the retrospective part in node 3 where the relevant part/element is used as prospective sustainability precedent in the design situation, completing the conversion.

- At each retrospective/prospective mini cycle there are some processes involved: observation of the situation as the students did in DE 2a and 2b.
- Understanding unsustainability also requires scaffolding that is provided in the form of questions to be asked (Appendix III). When these questions are asked, unsustainability becomes visible.
- Matching occurs at various levels. Matching of referent to a situation in node 1. Matching of sustainability precedent and sustainability referent in node 1&2. And matching of sustainability referent to a case.
- Scaffolding is provided to the student in the form of a list of sustainability referents (Appendix IV). Students are aware of these referents from didactic input given earlier but need help to recall it.
- Selection of the right case. The chosen cases should have the unsustainability situation and the sustainability referent, as in the current project.
- Sustainability case appears in node 2 as the prospective element, which is chosen keeping in mind the retrospective referent. In node 3 case appears as the

retrospective broken down elements to pick the appropriate sustainability precedent.

- This sustainability precedent has to be adopted, combined and the appropriate one has to be abducted into the solution.

5.13 Chapter summary

This chapter describes three design experiments DE 1, DE 2a and DE 2b. The three design experiments are conducted in different pedagogic contexts. The first is an observation of the discussion of two student groups with the researcher as a non-participant observer. DE 2a and 2b are conducted in the classroom with teacher as researcher. They are all conducted in a combination of divergent and convergent modes of action research. With each design experiment a new aspect is introduced and use of conjecture and its typologies are traced. Use of conjecture intensifies with each progressive design experiment. The relationship matrix is also plotted to see how conjectures link ontological and epistemological elements.

Model iteration 1, 2 and 3 are developed through the progressive insights from the design experiments 1, 2a and 2b.

Chapter 6

Flexible application of Conjecture Analysis Model for Sustainability (CAMS)

6.1 Chapter introduction

The model iteration 3 (Figure 5.29) presented in the previous chapter is the final research contribution. This model is called the Conjecture Analysis model for Sustainability (CAMS). The model has taken into consideration student behavior, student needs and instructor's role and inputs in sustainability. The considerations are articulated through conjecture typologies. Therefore it is safe to say that the model has been developed in a phenomenological and contextual manner, yet there is a threat to it being prescriptive. This chapter mitigates the threat by observing the manner in which CAMS has been adapted by three dissertation students to their projects (Design experiment 3, DE 3).

We have taken up the challenge thrown by Jonas to avoid prescriptive structures of design process and adopt 'generative' theories, which will overcome 'learning pathologies in design' (Jonas, 2001). Another motivation for DE 3 is Chris Heape's work in Design Space.

He describes ‘Design Space’ as ‘an unfolding process of inquiry’ as opposed to being a prescribed set of tasks in order to control it’ (Heape, 2007).

6.2 Design Experiment 3 (DE 3)

This design experiment reported is from dissertation projects of final semester students of Master of Design, NIFT. These are the same students with whom DE 2a and 2b was conducted. In the case of dissertation topics, the choice had to be made by the student. This makes it an interesting case. There are three projects described here. The process employed by the student, and the intervention by the instructor, are explained.

6.2.1 Dissertation1, 2014

The dissertation was titled- Best Practices for reducing Muslin fabric waste; A case study on pattern making sessions at NIFT Mumbai. It was a contextual study done by the student at NIFT Mumbai. There are two departments at NIFT, which have pattern-making as a core subject. The two departments are Fashion Design and Knitwear design department. These have laboratory setups where the students are taught to cut patterns for garments. The recommended material for learning pattern-making is muslin. Muslin fabric is spread on the tables and patterns drawn on the fabric and cut. At this stage there is wastage because of several reasons, which are explored in the dissertation. It was deliberated whether this is a valid sustainability project since the kind of waste produced is specific to a fashion school. But the dissertation student found examples of other similar projects giving credibility to her own project idea. Experts were interviewed and they were of the opinion that fashion schools were a good place to instill the awareness of muslin wastage. The students were likely to carry this good practice to the industry hence creating a huge impact. The instructor (author) directed her to do an in-depth study at NIFT Mumbai where she can observe the situation and apply her solution.

6.2.1.1 Episodic

The choice of project has an episodic root. This student observed that in her institute (National Institute of Fashion Technology) there was muslin fabric being wasted specially in

the pattern-making classes. Muslin was used to teach/learn pattern-making as it was ‘a rough and cheap material’. And it was precisely for this reason that the students were insensitive towards its wastage. But she had also came across students and faculty who were ‘aware of the issue of fabric waste and wanted to contribute towards the solution’, but were unable to do so because they were not aware of the ways in which to contribute.

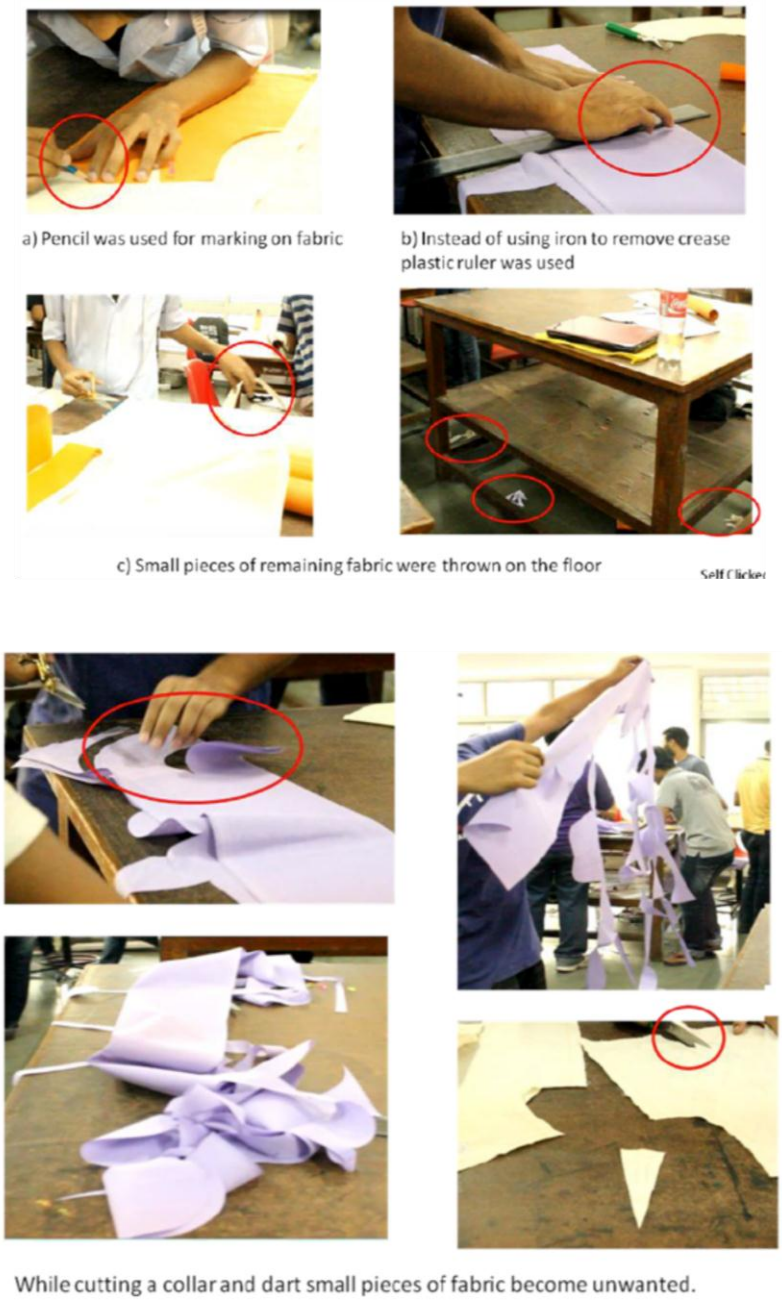


Figure 6.1 Wastage in pattern-making laboratory. Source: Dissertation by Daksha, MDes NIFT, 2016

6.2.1.2 Precedent

Muslin is commonly used for teaching/learning pattern-making for apparel. Muslin is recommended as it is inexpensive, easily available with good draping capability and which mimics the capability of the other cotton based fabrics. The reason for using muslin is that 'it is used to check the fitting of the pattern prior to using expensive fabric to avoid wastage'. Pattern making is where they learn to create two-dimensional patterns into three dimensional ones and check its accuracy'. On the average 20-30% of the fabric that students brought for every session of pattern making was wasted. This waste often landed in the dustbin. But one cannot suggest learning pattern making digitally as one has to learn it manually.

With some planning the muslin can be bought in a lower price from the whole sellers but the students prefer buying it from the retail outlet on campus. This fabric pieces are in lengths varying from 1-2 metres.

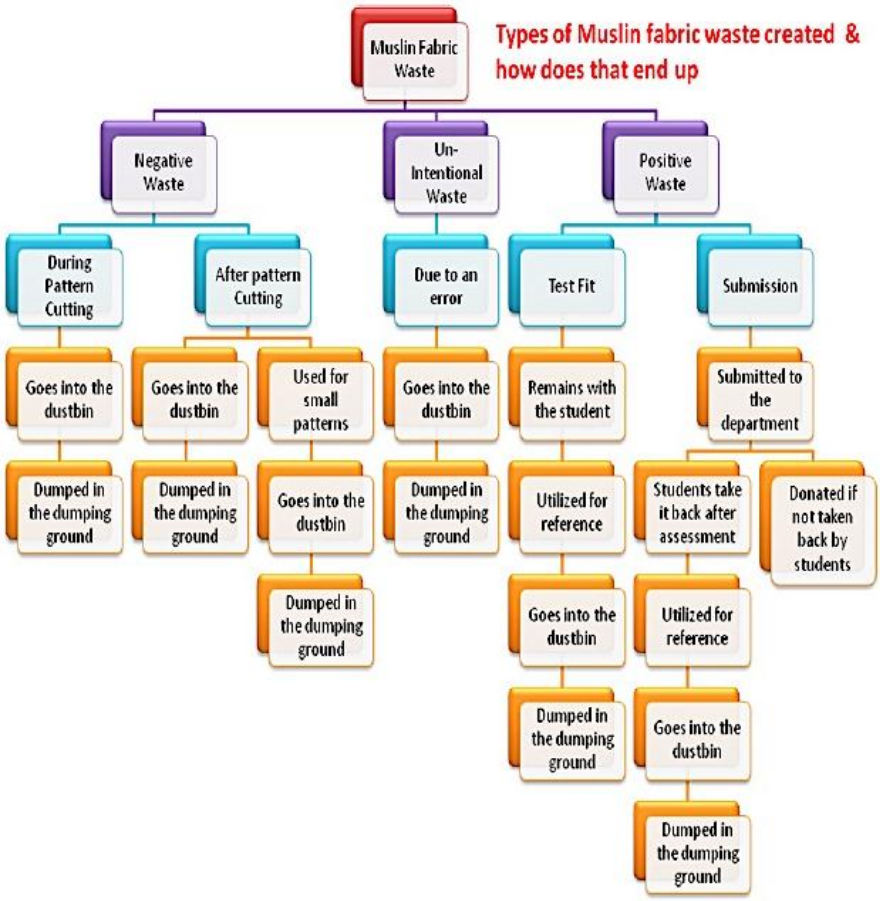


Figure 6.2 Types of muslin waste. Source: Dissertation by Daksha, MDes NIFT, 2016

6.2.1.3 Precedents / Case

Experts were interviewed to capture their experience in the subject. Precedents emerged from their talk.

Some wastage will always occur in a laddering environment and also in design development. Also what works in one institution may not work in another. If using waste internally doesn't work, I would look at the options that you would have locally for scrap. There are specialized machine weaves preventing fabric waste. Other pattern cutting techniques increase efficiency by increasing their fabric consumption. Most of them produce garments that are not vey wearable. They are good concepts but might not work successfully in the market, like by using pleats, tucks, cowls, gathers etc. or can be used as filling agents, shoulder pads, or can be used to create murals etc. There are many ways to utilize waste. I think the process of creativity at university there will be toile waste. The more the student experiment at university there will always be toile fabric waste. The solution is not to try and limit creativity, but by putting in guidelines of how waste can be managed. This for me is key, not that design process should change. Our 1st year studio paper 'Fashion, Body and Form students create a new design from an existing garment (a shirt) and need to record and show how they have integrated each part of the shirt into a new design and show the parts they did not use therefore becoming acutely aware of the waste created through the creative process.

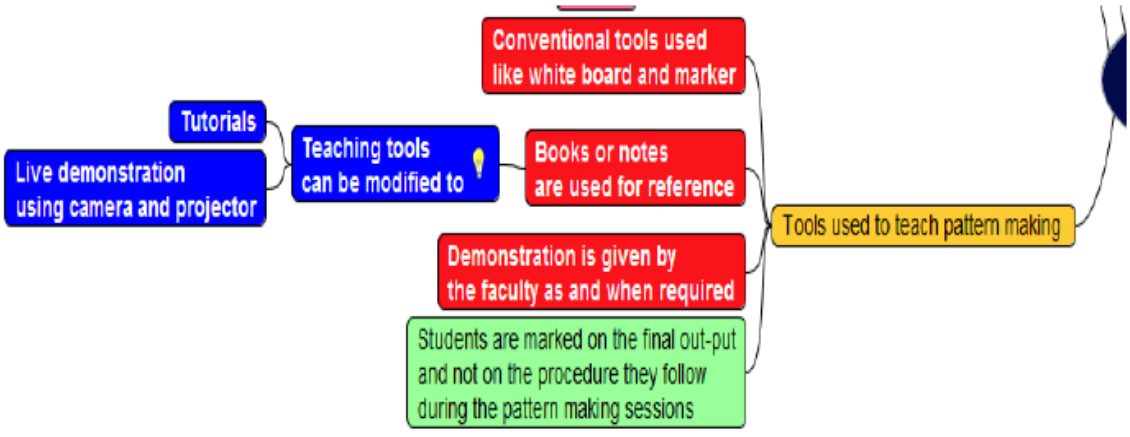


Figure 6.3 Mind map of tools that can be used to teach patternmaking. Source: Dissertation by Daksha, MDes NIFT, 2016

6.2.1.4 Primary Generator

The patterns submitted to the department for assessment formed positive muslin fabric waste, which needed to be taken care of.

The primary generators also came from the cases or expert opinions. Every zero-waste design I have ever done has resulted in some muslin wastage through the toile and fitting processes. At my work we have bins where students can place muslin scrap for students to use. As the fabric used for *toile* does not have to be refined, recycled fabric is maybe one of the most efficient ways of reducing first hand waste at universities. One also has to interact with students and know their way of handling muslin fabric during pattern making session.

6.2.1.5 Referent

As mentioned in the previous section, eliminating waste completely will not be possible. So we look at the next green step, which is 'reduce' and 'fabric management system'. And our aim is to design a sustainable system.

The 'positive waste' can be taken care of to some extent by following the Standard Operating Procedure (SOP) and 'negative waste' can be collected in bins placed in the pattern-making labs.

Figure 6.4 Study of Components of trouser to apply in pattern making workshop. Source: Dissertation by Daksha, MDes NIFT, 2016

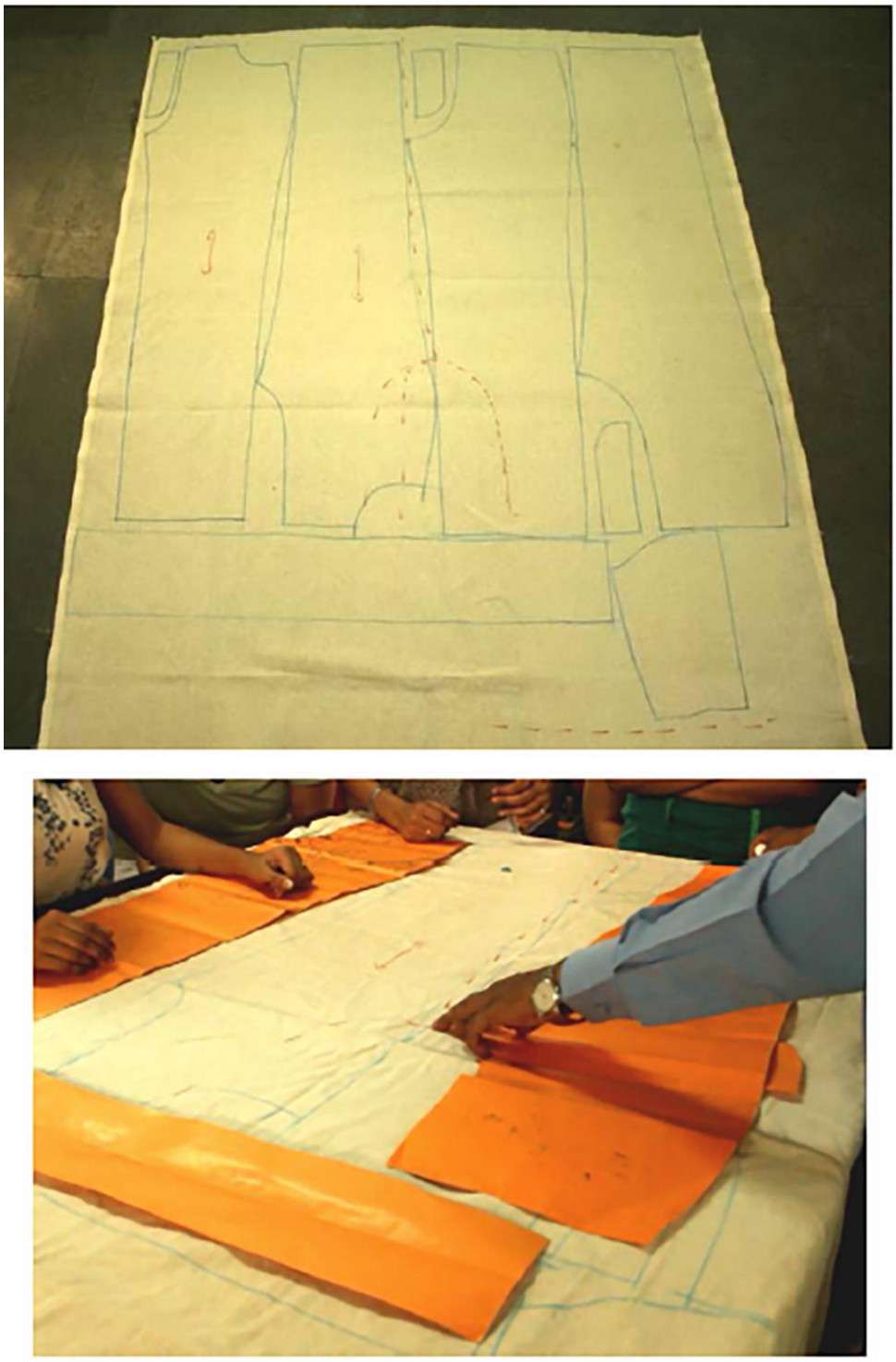


Figure 6.5 Workshop facilitated by student researcher.
Placement of trouser component on muslin fabric to create least waste. Unused pieces are big enough to be reused (above). Faculty demonstrating the tracing and cutting of trouser to students of the sample group (below) Source: Dissertation by Daksha, MDes NIFT, 2016

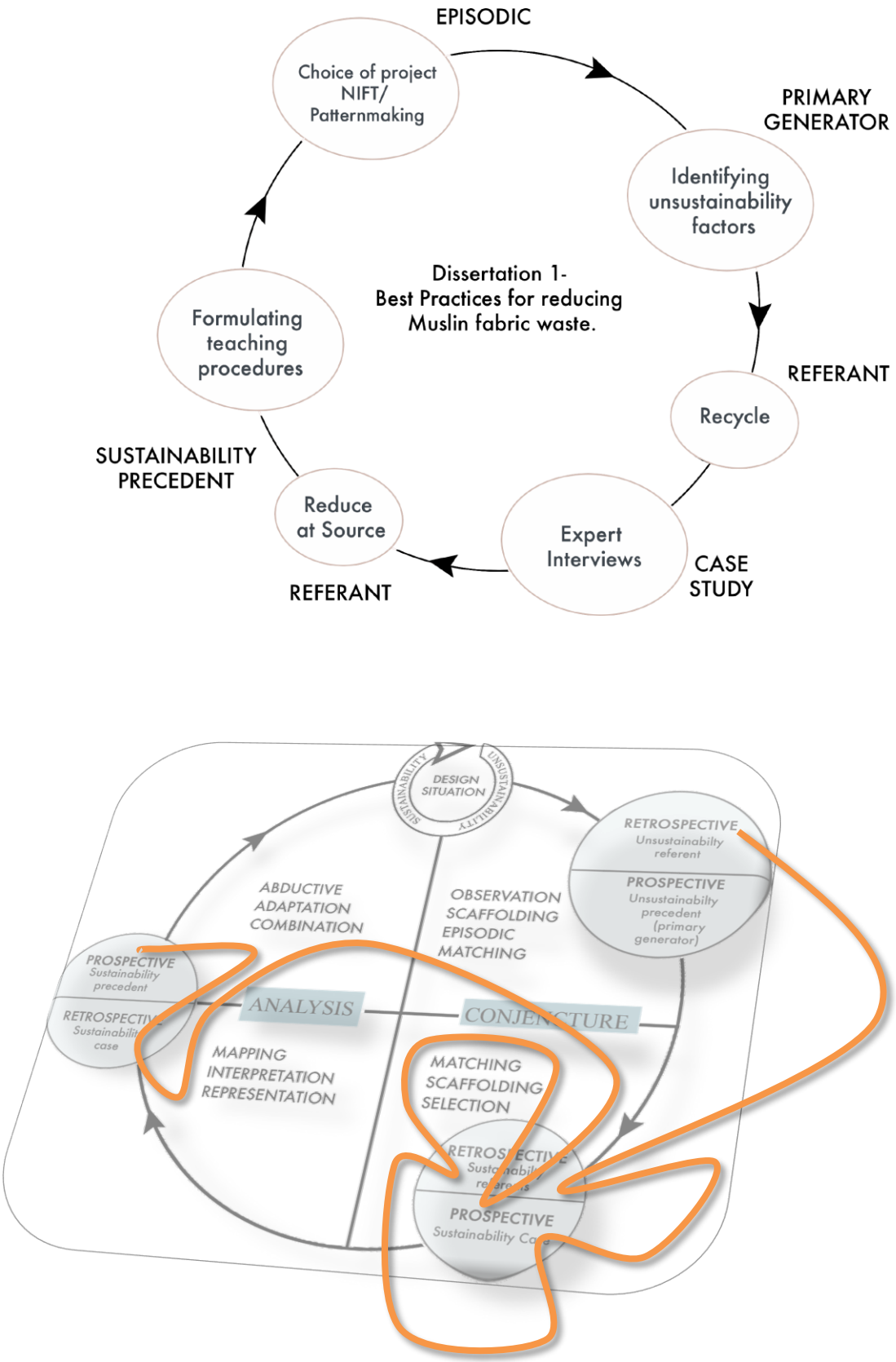


Figure 6.6 Flexible use of CAMS, dissertation 1; (above) stages followed by students; (below) mapping of student's path on MI 3

6.2.2 Dissertation 2, 2016

The dissertation was titled 'Paper Up cycling system design for schools'. This student had done assignments earlier in the area of up cycling. She was convinced that this was the best referent to choose for her present project as well. She did a pilot study in a Mumbai school, but information was not given freely and she was not able to actively work with students and teachers of the school. She decided to work with her own school in Phagwara, Punjab, India. She worked closely with students and teachers to bring awareness about various kinds of paper waste and how it can be up cycled.

6.2.2.1 Episodic

Like the previous project this one was also chosen by her keeping in her mind the familiar experiences of her own school in Phagwara, Punjab, India. Armed with her new knowledge about sustainability when she reflected back on the way paper waste was handled in her school, she felt, she could bring about a sustainable change.

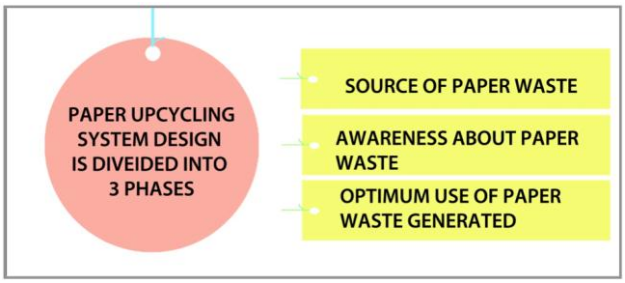


Figure 6.7 Paper up cycling proposal. Source: Dissertation by Pratima, MDes NIFT, 2016

6.2.2.2 Referent

The overarching referent she worked with was ‘up cycling’, where she analyzed the paper waste generated in schools and how the issue could be viewed through ‘up cycling’. She proposed controlling the ‘carbon footprint’ of the school through ‘up cycling’. This would be done through further educating the school students about sustainability referents and questions like- ‘What is waste?, When does it become waste?, Where does it go?, What are

the different kinds of waste? What are landfills? What is the effect of landfills? ‘How can we reduce it?’

6.2.2.3 Primary generator

The referent ‘up cycling’ itself was the ‘primary generator’. The lens to look at the problem was- what were the different kinds of waste generated by schools and how one can intervene to help the school authorities deal with it sustainably.

6.2.2.4 Precedent

This student used more number of precedents than the other two. The precedents included.

1. Precedents drawn from expert interviews
2. Precedents drawn from secondary sources
3. Unsustainability precedents from observation of ‘live case’ of the school she was working on
4. Precedents of the school student and teachers’ feedback on the various stages of implementation of the system, by her.

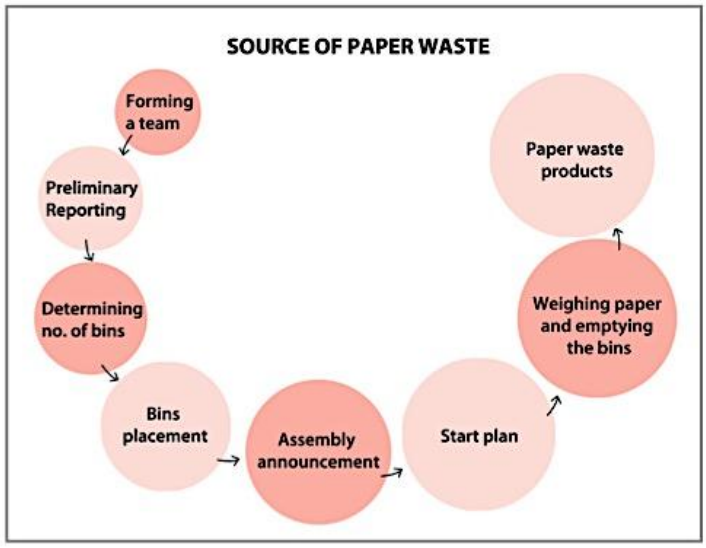


Figure 6.8 Paper up cycling system. Source: Dissertation by Pratima, MDes NIFT, 2016

Excerpts from student's description-

'Main problem, which was faced by all classes, was making of glue as glue making was not explained through demonstration.' This was rectified by conducting the demonstration in home science lab showing details of homemade glue.'

'In the first week of implementation 14 bins were placed. Students started putting their notebooks and papers in the bins daily after a few days. In fact students became so conscious that they carried the 'paper waste' in their bags until the bins were installed in their classrooms.

(b) Large bins installed outside principal's office (c) 2 small bins each places in every classroom with labels (d) Teacher appointed to audit for 3 weeks workshop

Figure 6.9 Implementing the model (Figure 6.7) in the school under study. Source: Dissertation by Pratima, MDes NIFT, 2016

Figure 6.10 Student researcher conducting awareness sessions with students of school under study. Source: Dissertation by Pratima, MDes NIFT, 2016

(a) and (b) Students transfering notebooks and loose papers in large bins

(c) Student discovered new way of folding paper according to his convenience

(d) Each bin filled with notebooks and paper and the third bin for separate waste.

Figure 6.11 Collecting, segregating and up cycling activity in school. Source: Dissertation by Pratima, MDes NIFT, 2016

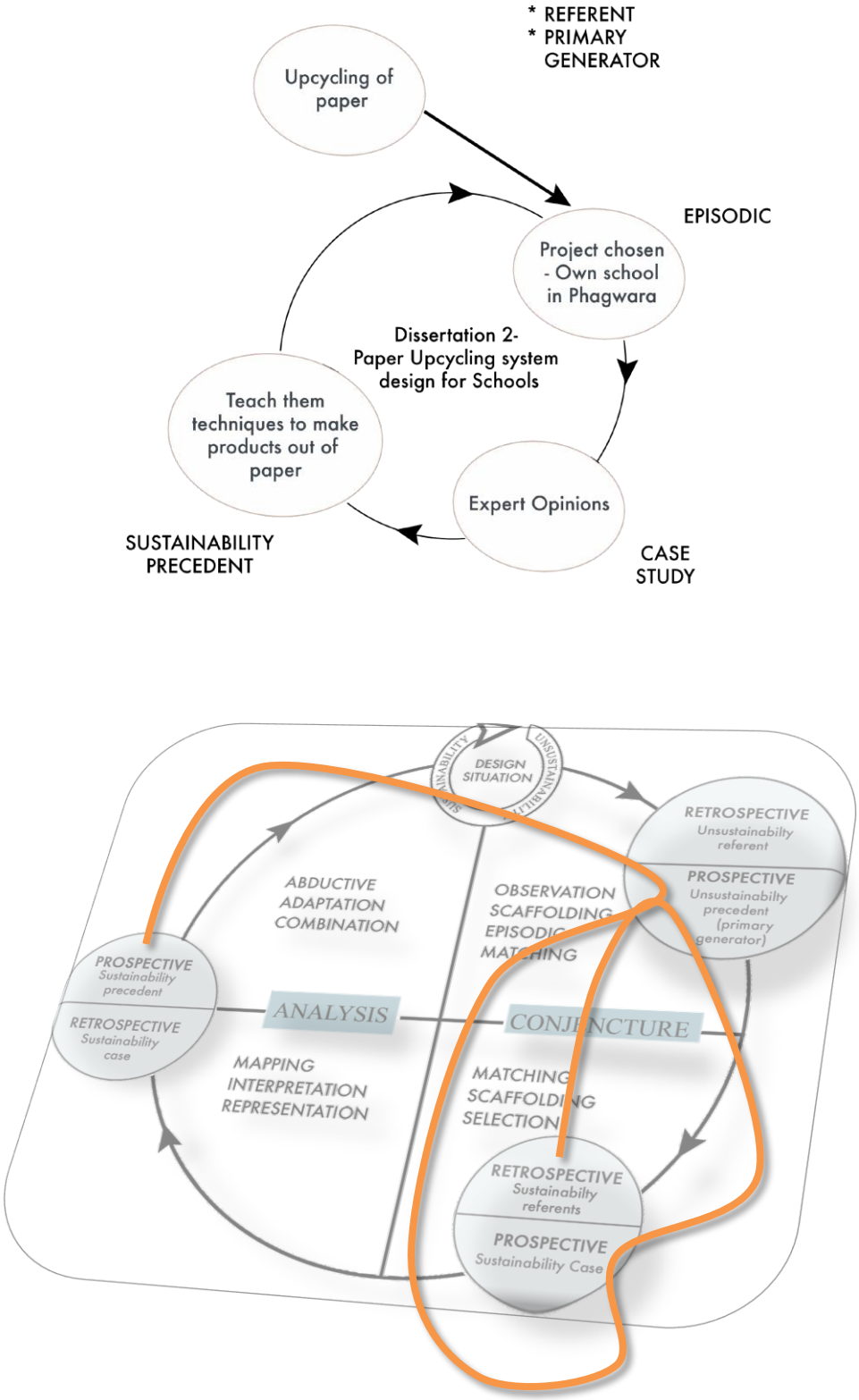


Figure 6.12 Flexible use of CAMS in dissertation 2: Stages followed by student (above), Mapping of student's path on MI 3 (below)

6.2.3 Dissertation 3, 2015

The dissertation was titled 'Towards sustainability by extending 'End of life of products'. This student started with an assumption that the informal sector in India was a big factor in creating a sustainable society, which was missing in the western countries. Interestingly when he did a contextual enquiry with the informal service providers like repairmen and cobblers he found that the scope was limited since people opted to get repair work done by the informal service providers only for inexpensive products. For the branded and more expensive products they still lay their trust on the company services. Company services itself was not without problems. He had to shift to choosing other referents to solve the problem of repairing products to extend 'end of life'. The referent he finally chose was- 'Design for disassembly' and 'Emotional design'.

6.2.3.1 Episodic

The project started with a conversation of the student with the author about 'Jugaad'[20]. The student was reflecting on how the informal sector in the Indian scene such as a cobbler, repair handyman, knife sharpener and 'alteration' tailor help in fixing things so that life of the product is extended. Can this be viewed as a sustainable system? Deliberation on this question was root of this project.

[20] Jugaad is a colloquial Hindi, Urdu and Punjabi word, which has various meanings depending on the situation. Roughly translated, jugaad is a 'hack'. It could also refer to an innovative fix or a simple work-around, a solution that bends the rules, or a resource that can be used in such a way.

https://en.wikipedia.org/wiki/Jugaad

Figure 6.13 Unlike cobblers in formal sector who make footwear, the roadside cobbler repairs the footwear, thereby extending its life. Source: Dissertation by Anurag, MDes, NIFT Mumbai 2015

6.2.3.2 Referent

This student uses many referents. In fact he changes them mid-course in the project and combines two or more referents for solving the problem. Some of the referents he thought about are:

a. Extending product life
b. Eco efficiency
c. Reducing the amount of materials in products and services (dematerialization)
d. Recycling and claiming the product material back
e. Reducing requirement for products
f. Increasing efficiency in product usage phase
g. Product service system
h. Service design
i. Design for disassembly
j. Emotional design
k. Planned obsolescence

6.2.3.4 Precedents

The precedents came from cases.

1. Cases (secondary)- Apple products, Inkjet cartridge, Panasonic, Canon and BMW.
2. Cases (primary)- Observation of informal service providers such as cobblers, tailors and rag pickers.
3. Cases (primary)- Interviews with company (brand) personnel on how warranty and other after sales services work.

6.2.3.5 Primary Generator

The primary generators were the episodic experience of the student along with the referents below.

1. End of life
2. Product service system
3. Design for disassembly
4. Emotional design

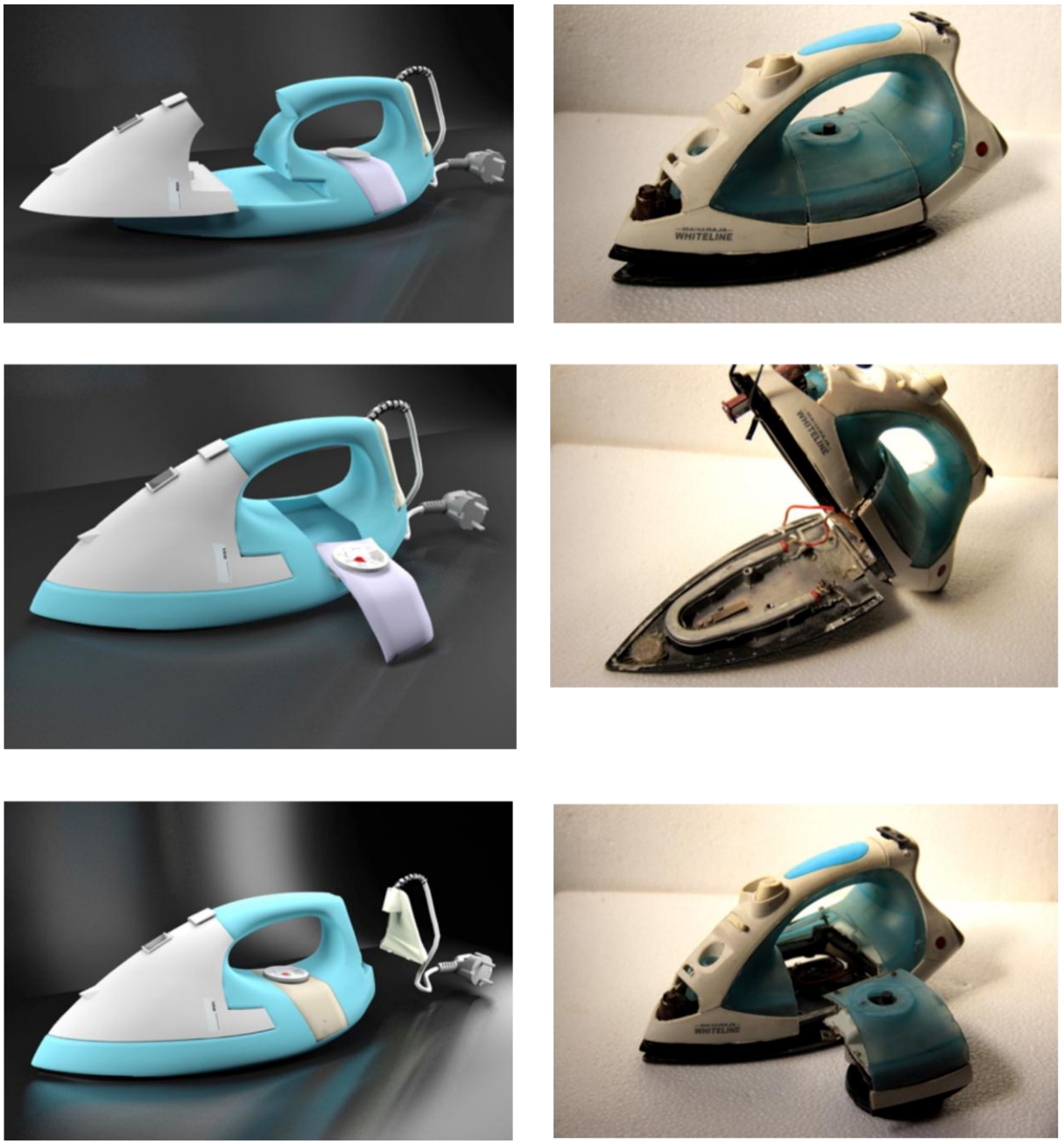


Figure 6.14 Redesign of electric press to increase end-of-life. Source: Dissertation by Anurag, MDes, NIFT Mumbai 2015

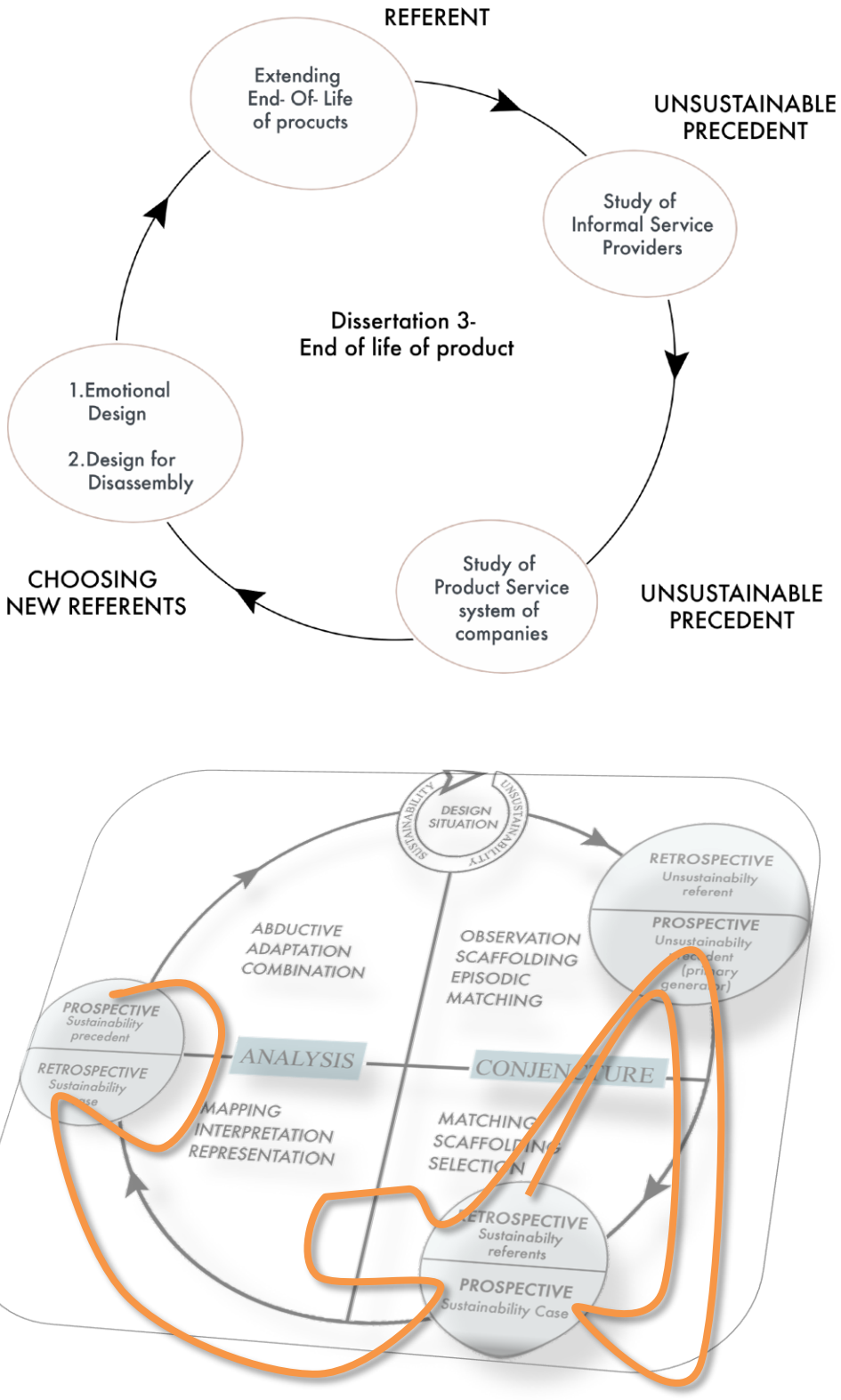


Figure 6.15 Flexible use of CAMS, dissertation 3: Stages followed by students (above), Mapping of student's path on MI 3 (below)

6.3 Insights from DE 3

1. Students on their own choose familiar and everyday activities to base their projects. They feel comfortable as they think they can make a difference.
2. They deal with sustainability in a systemic manner as described in the epistemology of sustainability. The problem is within the system. This is identified, rectified and put back into the system.
3. They are able to choose the appropriate referent. This referent then shapes the entire project.
4. The solution is envisioned within the existing system. The students are also doing action research. (Clune, 2009)

6.4 Chapter summary

This chapter traces the flexible application of the model. Three dissertation projects guided by the author have been described. The use of the model is constructivist where each student interprets the model differently, but the core remains conjectures.

All projects usually start from episodic instances. The first student chooses the academic environment she is in currently. She is part of the stakeholders. But the final beneficiary is the teacher and students of patternmaking at NIFT. The second project's episodic instance was an environment she was a part of as a child in her school. The episodic instance for the third project is the common experience of Indian living- dependence on the informal service providers.

The choice of the other conjecture typologies varies according to the context and preference of the student. The first project has a balanced use of the conjecture typologies almost as proposed in CAMS. The second project used more precedents as the student was actively working in the environment and stakeholders. The changes she suggested were implemented progressively and she could get the feedback and use it as precedents for further implementation. The third project played heavily with referents. Referents were changed mid-course when found unsuitable, combined when necessary and used as primary generator as well.

The constructivist way in which the model has been used in the three cases described in this chapter reiterates the robustness and generativeness. The model is prescriptive until the point of suggesting a framework. The active use of the model can be moulded according to the context in which the project is situated and the constructs of the student and instructor.

Chapter 7

Summary and Conclusion

7.1 Summary of the Research

The compelling motivation, which drove this research, was the author's experience with teaching design and sustainability as two separate courses in a design programme. This experience led the author to question if there were entirely different methods to teach design and sustainability. Literature gave strong indications that this was not so. Thereafter the quest turned towards finding unifying factors, links and bridges between the two domains.

Over the past two decades, the discourse on sustainability is very strong, thus impacting all areas of functioning. Literature on curricula, which have integrated design and sustainability, was reviewed. It was found that design courses either teach sustainability in an abstract manner or get into specifics or ignore it completely. All the three approaches are flawed. Therefore a more fundamental integration was necessary. This led, on one hand, to the path of finding what aspects formed the core of design, and what made design different from other disciplines. On the other hand an attempt was made to separate out issues of sustainability that were relevant to design; or in other words, to find areas of sustainability

where design could contribute. These are the ontological elements of design and epistemological elements of sustainability respectively. Using these elements, a theoretical framework has been structured.

The suitability of conjecture as the epistemic unit and C/A as the suitable paradigm is agreed upon in literature for both design as well as sustainability. C/A therefore becomes the original/existing theory, which this research seeks to expand. On deeper probing one found that there is no visual representation of C/A. So one had to start with giving a tentative visual form to C/A model. This tentative model is built up incrementally through action research. The action research is through theory in action since theories are tested and understood through empirical studies.

The methodology for the study is a nested methodology consisting of Action research, Ideology critique, developing a tentative model and conducting design experiments. Action research is the overarching methodology for this study. The fundamental aim of action research is improvement of practice, which aligns with the main objective of research to improve practice of design pedagogy with special focus on sustainability.

It is very important to critically look at current practice in order to improve it. Ideology critiquing is done through literature, teaching experience of the author and observation of another instructor's studio class.

A tentative model was developed incorporating the theoretical framework and other concepts and theories. Three iterations are discussed. Each version of the model is validated or altered according to the insights gained in the design experiments.

The resultant model is the Conjecture Analysis model for sustainability. Through the process of building the model, five types of conjectures have been identified. These conjecture typologies give a more nuanced articulation to CAMS. Additionally and equally importantly, it demonstrates the relationship between the elements of ontology and epistemology.

7.2 Inferences

The main inferences from the research are:

- Successful integration of sustainability as a meta-objective of design process happens

if a method conducive to design thinking is used. Design students have to adopt sustainability approaches in the design process through a designerly technique, and not by a technique alien to the way designers work.

- Design is, dealing with wicked problems through a series of design decisions, which are taken through abduction and reflection. Wicked problems, abduction and reflection are the ontological elements of design as they define the nature of design and distinguish it from other disciplines.
- To understand sustainability the articulation of unsustainability is very important. There are numerous unsustainable acts that form a part of our everyday practices. Using unsustainability embedded in everyday practices as examples in pedagogy is effective. It helps students to connect better and their motivation to act on it is also much higher.
- In this thesis, sustainability has been defined in two ways. First is-'appropriation of consequences'. This brought in the whole aspect of consequentiality into the sustainability design process. It worked both in terms of designing with consequence in mind, as well as converting unsustainable consequences into desirable sustainable ones. The definition stimulated the idea used in CAMS of converting unsustainability into sustainability.
- The second way that sustainability is defined is- conserving resources. Sustainability needs to be looked at in a multidisciplinary manner. These resources are not necessarily related to environment, they can also have abstract meanings like time, knowledge and learning.
- Conjectured thinking is an integral part of design decisions. As per inference 3 of this section; identifying and articulating unsustainability is important to understand sustainability. Therefore unsustainability is in itself a conjecture for sustainability making conjectured thinking the underlying theme for design for sustainability as well.
- A representation of a model is important as it opens up multiple uses. Once the visual representation of C/A model for sustainability was developed, many issues for deliberation came up.

7.3 Process of answering research questions raised in the beginning

The basis for the first question was fundamental integration of design and sustainability. This was resolved by identifying three features each for design ontology and sustainability epistemology (Figure 7.1).

The premise was that, if we want to make sustainability the meta-objective of design process then a more fundamental search of the two domains was required.

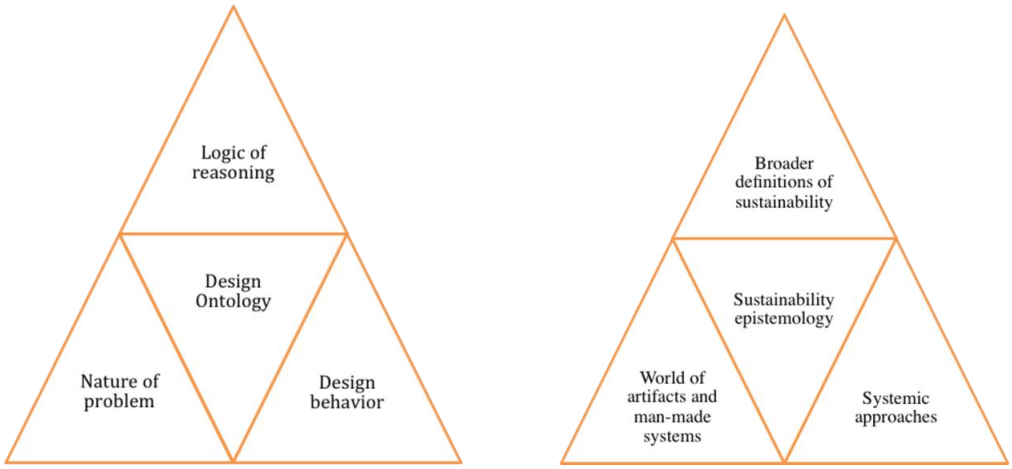


Figure 7.1 (left) Elements of Design Ontology (right) Elements of Sustainability Epistemology

The other premise was that an appropriate model could be developed through which design process can be implemented. After much deliberation it was decided that an entirely new model was neither necessary nor possible, thereby answering the second sub-question. The two existing models in design discourse were examined for their appropriateness- Analysis/Synthesis (A/S) and Conjecture/Analysis (C/A). C/A was found to lend itself to design and sustainability. This was used as the original theory, which had to be expanded. CAMS was given its final shape through incremental revisions. The revisions are made based on insights from action research.

Along with establishing that C/A is more appropriate base model, it also gets established that conjectures are the epistemic units of the model. Which is to say, that conjectures are also entities by themselves. Conjectures, as epistemic units of the model need further articulation. A general definition of conjecture was limiting. And indeed one

found the need (Wood, 1976) with the students. One of the conjectures like referents was provided as 'scaffolding'[21], with the help of which wicked sustainability problems could be addressed. Five types of conjectures have been identified in this research. They are- Primary generators, Episodic elements, Referents, Cases, and Precedents. These conjectures were used to develop the model. These have been mentioned in literature in a scattered manner, they have been brought together and used in the context of the research.

Conjecture typologies not only made the model more articulate but it was found that the different types of conjectures connected the ontological and epistemological elements thus reinforcing the first premise that integration of the two domains of design and sustainability is possible at a fundamental level.

7.4 Innovativeness of this research

Innovativeness is discussed in terms of methodologies used, development of the final model and the versatility of the model.

- Giving visual form to C/A.

  Conjecture/Analysis (C/A) has been chosen as the original theory to be expanded but the theory itself has never been graphically represented. It has only been argued in text. Graphical representation in a model is a useful and necessary tool. It is a commitment to a particular interpretation of an idea.
- Using C/A for sustainability

  C/A is a known theory but its use in design is limited and its application for sustainability solutions is new. The innovativeness is also seen in development of a dedicated model for sustainability.
- Generative model

[21] Scaffolding is support that is placed outside a building, which is being built. As soon as the building can support itself, the builder removes the scaffolding. This metaphor is extended to teaching. Teachers support learners to develop new understandings, and withdraw support, when skills are acquired. (https://en.wikipedia.org/wiki/instructional_scaffolding). It was used the first time by Bruner, (Wood, 1976), as a metaphor in the learning context. In the context of this research, scaffolding is used in terms of providing templates and guides' of sustainability referents.

New solutions and sub-solutions are generated. Since it is a generative model, use of conjectures does not replicate the solutions but provides newer solutions and sub-solutions.

- Harvesting information from different sources (Eilouti, 2009)

  In a global world of today there is information related to design and sustainability, which has worked well in a remote area but can very well be adapted as a technology solution in an urban milieu. This contextual processing can happen through the use of different conjectures in the proposed model.

- Temporal shifts are possible

  Through the use of CAMS, quarrying conjectures from different geographies is possible (as mentioned in the earlier point). Additionally it is also possible to quarry conjectures from different points in time. Information, for example, which has relevance to a craft practice, can be applied to contemporary design.

- Using theory-in-action

  Action research is usually used in education, to improve or measure practical considerations. This research uses action research as theory-in-action where validation of the model is when the theory works. Further, each teacher or instructor will have the opportunity to test his/her own theory through this model.

- Design Experiments

  Use of a method called Design experiment was very beneficial to the researcher. Design experiment is mainly focused on ecology of learning where it does not isolate variables for testing but takes into fold all the factors acting in and on a learning environment. Further, this method has not only provided openness within one design experiment but also allowed observations across pedagogic conditions like discussions within students, design studio with all students and one-to-one critique of student work by the instructor.

7.5 Research Contributions

1. Conjecture Analysis model for sustainability (CAMS) -This model has been developed through multiple iterations of theory in action (Figure 7.2).

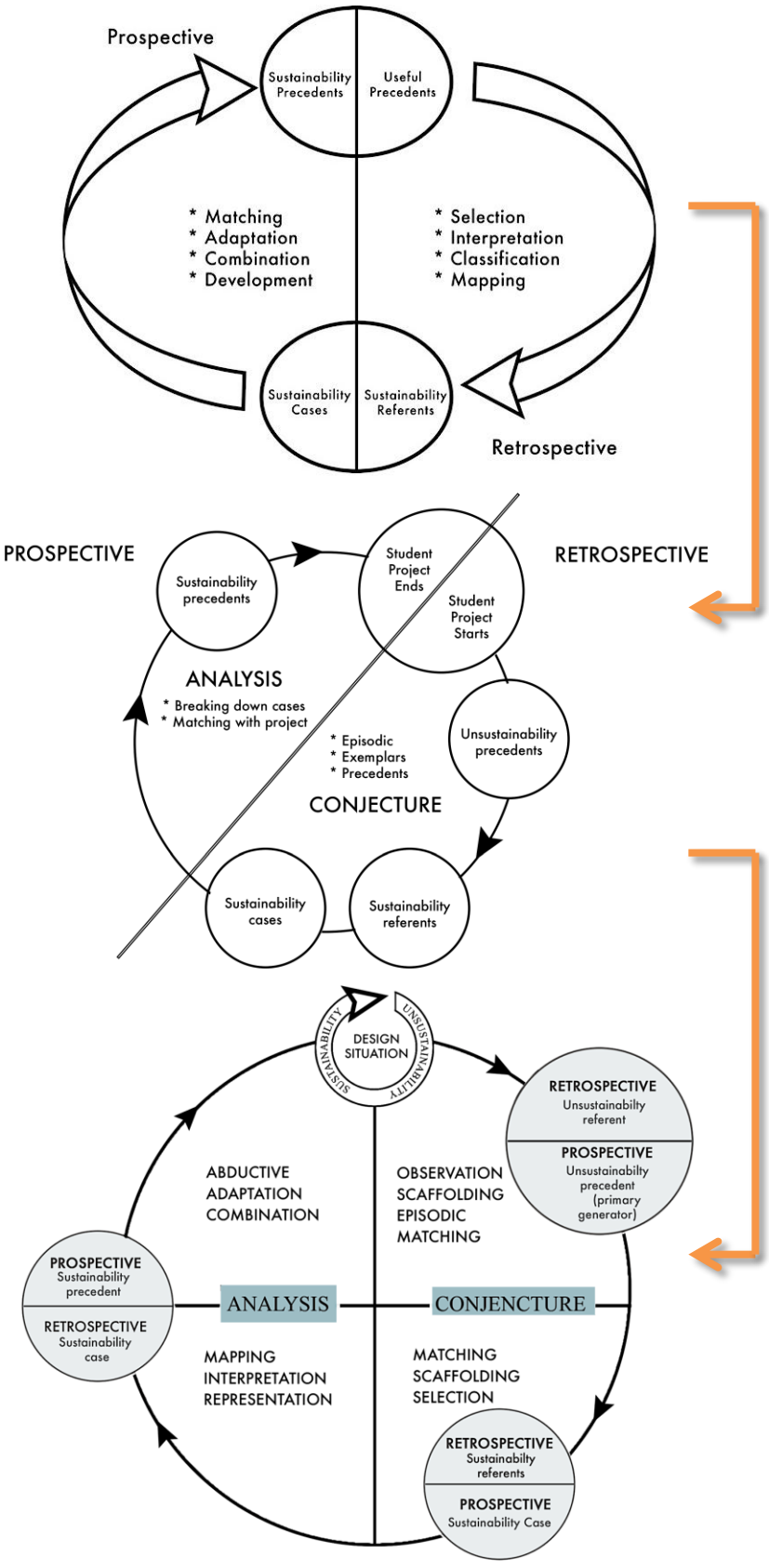


Figure 7.2 Refining CAMS through stages

Not only is the final model a contribution to further research in the area of sustainable pedagogy but the iterations are also contributions to the design discourse.

2. The flexible use of the model is also a demonstration of pedagogic patterns that can be generated in future. These pedagogic patterns can be shared and used by the community of design educators.

3. Typology of Conjectures (Table 7.1)- The typologies are gleaned out of various sources of literature (Oxman, 1997) (Eisentraut, 1997) (Goker, 1997) (Goldschmidt, 1997), and matched with the current context of enquiry. These typologies become the repertoire of conjecture. Using them helps in articulating the nuanced meaning of conjecture for design pedagogy. Below is a representation of the five typologies.

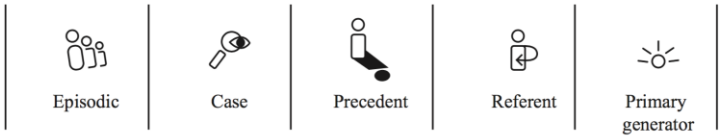
Table 7.1 Typology of conjecture

				
Episodic	Case	Precedent	Referent	Primary generator

4. Demonstrating the relationship between ontology and epistemology- the relationship matrix connects the elements of ontology of design with the epistemology of sustainability. As one sees in the compiled matrix, some cells are not populated or sparsely populated. While some have many elements in one cells, with repetition. In this study the relationship matrix is the result of the experiment and observation of student behavior. In future, the relationship matrix can first be mapped with the desired relationships. This may then be administered to the students.

Table 7.2 Relationship matrix combining DE1, DE2a and DE2b

DESIGN / SUSTAINABILITY	REFLECTIVE	ABDUCTIVE	WICKED PROBLEMS
BROADER DEFINITION OF SUSTAINABILITY			
ARTEFACTUAL WORLD			
SYSTEMIC	—	—	



7.6 Implications for sustainability pedagogy

Literature shows that both instructors and students of design are inclined towards sustainability, but do not have suitable tools at hand to guide their design process towards sustainability. The proposed model will be a usable tool for both instructors as well as students. The model has the flexibility to be applied to any area of design like product design, graphic design, interaction design, fashion design and others. The model also has flexibility of newer concepts and approaches of sustainability into the model increasing the shelf life of the model. The new concepts of sustainability can be easily added to the referent list, which will be referred to during the design process.

One of the problems faced by students is that they do not have a language to discuss sustainability. CAMS allows discursive elements of sustainability to be available to them, which brings ease of handling the subject. Another important implication for sustainability pedagogy is that the students and instructors are able to pursue sustainability as a creative rather than a technical or clinical process.

Multidisciplinary approach to sustainability is not a new idea but this research has added more elements of multidisciplinarity for sustainability in design. Abstract elements like time, knowledge and learning has been added as resources to be conserved, therefore enriching the vocabulary of sustainability.

7.7 Implications for design pedagogy

The design community can be comfortable in its shoes of using previous knowledge to add to the present situation. This was anyway being followed but CAMS just formalizes it. CAMS fits into Nelson's description of 'Ultimate particular' (Nelson H.G & Stolterman, 2003) very well. Design, he says, does not deal with the universal truth but with the particular, which means we are not dealing with abstract reasoning but with the real, which is a result of action and intention.

Each time the instructor guides the student through the model of converting unsustainability in sustainability through a series of actions, a particular problem is solved. These solutions, if saved in a case repository from a cross-section of studios or in a given studio over time can become a powerful pedagogic instrument (Akin, 2002).

The proposed model and conjecture typologies give a more systematic way of teaching sustainable design. The instructor and student are aware of the rationale behind the instructors teaching methods hence they are more receptive. It tackles another major problem faced in design pedagogy, that of bridging prescriptive and procedural knowledge. Prescriptive knowledge is given by the instructor in the didactic mode, usually in the beginning of the design studio. By the time the student has to apply the prescriptive knowledge to their projects, they are not able to match or recall the information. Scaffolding techniques have been suggested in the model, which deal with this issue.

7.8 Implications for design practice

Practice can now borrow from case-based repository of conjecture to apply to a project. This approach will put pedagogy and practice on equal footing. If the design community gets comfortable in its shoes of using conjectures in a systematic way, it can add to its tools of design thinking, which other domains such as business and management are borrowing from.

7.9 Future work

The model proposed is a theory-testing model. Each of the theories can be rigourously tested further.

This thesis has chosen to follow the C/A model to guide the student through the early stages of design for sustainability. But there are evidences to show that A/S model might be suitable for later stages of design. By this time the problem has been defined and a particular direction has been chosen. Therefore an integrated model incorporating A/S and C/A might be explored as further research.

The C/A model for sustainability design pedagogy has been proposed for and appropriated for pedagogical use, but it can be altered wherever necessary, for use of professional designers.

The research project is a 'cross-case study', as it gave a structure and means of appreciating the various experiments as part of a larger whole. Now that a generic model is in place, it can be tested for specific cases. This thesis concludes and projects a broad-based use of the model where it can be applied in any discipline of design. However, a specific discipline of design might choose to observe the design process for a more focused enquiry.

Sharing among the pedagogic community is the strong desire of the author. In fact it may very well be taken up as a future project by the author herself. The observations, thoughts visual documentation and dialogues between student and teacher, will be very valuable information. This information when shared sets a healthy communication amongst educators, which will enrich practice. Documentation of teaching and learning practices are called pedagogical patterns. Pedagogical patterns are highly structured, succinct descriptions of practice that can be made/used to enhance teaching within a community of educators. They are abstractions generated from successful experiences, with just enough detail added to enable replication and improvement. Goodyear (2006) as in (Derntl, 2006) argued that pedagogical patterns are particularly useful in representing, sharing and putting into practice, knowledge about educational design. Derived originally from architectural patterns (Alexander, 1977), these descriptions represent a bottom-up approach to educational design, since the patterns are derived from successful practice. This is in contrast to theory-led approaches, such as traditional instructional design, where

practice is inferred from general principles. Pedagogical patterns are particularly powerful in setting up rich dialogues in professional teaching communities.

As mentioned earlier, each time the model is used, it can be treated as a case, which can be documented. Merseth (Merseth, 1991) points out that, in management studies case writing itself is recognised as a legitimate research endevour, which is not the case at the moment in design. If case writing is appropriately awarded in career advancement, it will motivate design educators to take up this activity.

In this research it was only possible to broadly connect the conjecture typologies to ontology and epistemological elements. For further study, each relationship between ontology and sustainability in the relationship-matrix can be explored further.

APPENDIX I

This was a short study conducted by the author with 14 respondents (sustainable consumers). This gave an insight into how people relate their personal belongings (everyday objects) and activities to sustainability. The insights from this study helped the author to structure the sustainability assignments described in DE 2a and DE 2b (pg.113-147).

Understanding Attitudes and Values of Consumers concerning sustainability

Abstract

This study is an attempt to find the attitudes and values of people towards 'Sustainable Consumption'. The method adopted was an in-depth interviewing technique of 'laddering'. The respondents were chosen through a judgmental sampling approach, to identify 'Responsible Consumers'. The respondents were taken from a material level of attributes of a product to a higher level of abstraction of their values. This is a qualitative and exploratory study to gain insights into people's ways of thinking. These insights may lead to some patterns for consumer attitudes and values, which could then be used to create instruments for further study.

It was found that, the respondents started the discussion with ecological conscious views, and it meandered towards personal benefit factors. Many of the concerns for sustainability were more socio-cultural in nature. There was also a perceptual difference between consumer behaviour and consumer attitudes. Behaviour is more apparent at the time of buying; and attitude is reflected at the time of using the product; and values come into play at the time of disposing or reusing a product.

1.0 Introduction

A survey of works on the topic suggests that sustainability is a multidimensional concept with a number of interrelated aspects or dimensions, including ecological, environmental, economic, technological, social, cultural, ethical and political dimensions. Most commonly Sustainable Development is understood as positive change lasting over time, which ensures that the well being of the present generations does not lead to a decline in the well being of the future generations. Skirke, Kleizen, Barber (2003)

The scale of unsustainability the world is faced with, is gloomy. But some thinkers like Prof. Ezio Manzini and John Thackara see a lot of promise in collaborative-networked efforts. They have shown this through their own work on 'Sustainable Everyday project' and 'Doors of Perception' respectively.

Their work also paints a picture of what the sustainable world of the future would look like. This visibility makes dealing with it more comforting. People either neglect the appeal for sustainability because it is too cumbersome or because it will require them to give up lifestyles, they enjoy. Manzini, says, therefore, that the effort of designers should be to enable people to live, as they want to while moving in the direction of sustainability.

Ever since Club of Rome published its report called 'Limits to Growth', where it was proposed that the huge strain on the ecology was the fact that growth was taken as the measure of human progress. If we shift the focus to physical, emotional and spiritual well being of the human as the goal, the means to achieve it will also change.

Today, we know that the present mainstream idea of well being, the one based on western standards of living -product-based well being- has to change. This is clear when we consider that its promise of individual freedom and democracy of consumption has not been fulfilled, but it can never be fulfilled, either now or in the future, because this product-based well being, extended to a worldwide scale, is proving to be intrinsically unsustainable: the

planet would not be able to support the weight of the 6-8 billion people approaching western standards of consumption. Manzini (2007)

The task ahead for Designers and Design researchers is recognizing the fact that design is the interface between consumers and the activities of consumption, therefore has the potential to influence the environmental and social impact of products and services to contribute towards the goals of sustainable development.

2.0 Objectives

- To find the concerns, attitudes, norms and values of 'responsible consumers'.
- To learn and apply the technique of 'laddering' to achieve the above objective.

3.0 Background

Identifying values of well-being within people through the products they consume is the area of investigation of this study. This investigation will be conducted through 'Sustainable' or 'Responsible' consumers who consume sustainably. This is because they are the people who have the power to influence the larger populace.

3.1 Sustainable Consumption

In terms of individual initiatives, sustainable, responsible consumption may be expressed through the following elements (Marchand et al. based on Hansen and Schrader and Cooper)

1. *Absentation*: refraining from consumption or, in some case, consuming less;
2. *Attitude*: seeing consumption that exceeds one's basic needs as negative;
3. *Awareness*: choosing products on the basis of their broad-based ecological qualities;
4. *Alternative*: identifying substitutes to traditional consumption (e.g. switching from product to service)

3.2 Sustainable Consumers

Sustainable consumers are the people who are prepared to make lifestyle transitions to sustainable consumption and assume behaviour patterns that emphasize the quality rather than the quantity.

3.3 Previous Research

Environmental policies have been targeting the behaviour of consumers, but it has been found that attitudes and values people hold in relation to products of consumption are more enduring. It may do well for policies to target the attitudes that inform consumers' behaviour.

The research [by] Anne Marchand, Stuart Walker (2007) shows a clear desire amongst the interviewees to evaluate their attachment to possessions and to invest emotionally in a few carefully chosen objects. More specifically, they were seen to have a close and, simultaneously, distant relationship with the world of goods. In addition, they generally tend to consider the object more as a means, for what it allows, rather than as an end in itself.

As part of this research, Anne Marchand, Stuart Walker (2007)[conducted] in-depth interviews among people who consider themselves responsible consumers …The objective of the interviews was to gather insights about the way sustainable consumption might modify our relationships to the material world and the ways in which we experience objects. Eighteen individual interviews, each of one to three hours duration, were undertaken with 14 respondents.

Young. W, Hwang. K, McDonald. S and Oates C.J (2008) have studied the 'attitude/behaviour gap' or the 'value/action gap'. According to them, 30% of UK consumers report that they are very concerned about environmental issues (Defra 2006). But they struggle to translate this concern into green purchases.

Tanner. C and Kast. S.W (2006) examined the influence of distinct categories of personal factors (such as attitudes, personal norms, perceived behaviour barriers, knowledge) and contextual factors (such as socio-economic characteristics, living conditions and store characteristics) on green purchases of Swiss consumers.

Hirschl. , Konrad. W, Scholl. G (2005) studied strategies of use intensification and useful life extension in their study and came up with four broad user typologies:

1) Ownership oriented- Private ownership bias
2) Open-minded- Little reservation towards private borrowing
3) Consumption oriented- Inert to extended use
4) Low interest- Not willing to take commitment

3.4 Conferences and Expert opinion

- Indo-US workshop on Designing Sustainable Products, Services and Manufacturing Systems. Indian Institute of Science, Bangalore, August 2009.
- International conference, 'In a planet of our own'. Industrial Design Center, IIT Bombay, November 2009.

Collected key concerns and issues as elicited by experts at the conference.

4.0 Methodology

- The responses of the consumers will be analyzed to derive patterns 'ways of thinking' and for gaining insights. This is non-numerical measurement approach hence is a qualitative study.
- The study is exploratory hence does not have a fixed hypothesis

4.1 Sampling

From the population of the city of Mumbai, a sample of people who have the following description were chosen.

- Should be aware of the term Sustainability.
- Should incorporate some sustainable activity in his/her lifestyle
- Should be a decision maker in terms of shopping.
- Should be well educated

From the sample frame, the sample size of 14 respondents was selected, as the 'Sustainable consumers' through judgmental sampling approach.

4.2 Method

4.2.1 Laddering

"Laddering refers to an in-depth, one-on-one interviewing technique used to develop an understanding of how consumers translate the attributes of products into meaningful associations with respect to self, following means-end theory" (Reynolds & Gutman, 1988, as cited by Tânia Modesto Veludo-de-Oliveira, Ana Akemi Ikeda, and Marcos Cortez Campomar).

The laddering technique emerged in the clinical psychology area introduced by Dennis Hinkle (1965) in order to model the concepts and beliefs of people. Hinkle's work, a PhD dissertation at Ohio State University, although awarded, was never published, but was treated extensively by Bannister and Mair (1968) who coined the term "laddering".

Gutman (1982) defines MEC as,

Means are objects (products) or activities in which people engage (running, reading). Ends are valued states of being such as happiness, security, and accomplishment. A means-end chain is a model that seeks to explain how a product or service selection facilitates the achievement of desired end states.

MEC links sequentially product attributes (A) to consequences of product use (C), and to individuals' personal values (V). An A-C-V sequence forms, what Gutman (1982) called, the means-end chain or ladder. The set formed by various ladders is represented on the Hierarchical Value Map (HVM), which indicates the relationship between all the attributes, consequences, and personal values relative to a product. A HVM is a tree-like graph that illustrates the major means-end connections people perceive between attributes, consequences, and values. These attributes typically are perceived as a means to achieve a set of specific consequences, which in turn aid the individual in achieving a smaller set of specific personal values. Hence, the graph illustrates how the large number of attributes essentially funnels into a small set of personal values through the consequences of product usage.

4.2.2 Appropriateness to the Mini project

The 'laddering' method has been successfully been used in the area of consumer research and

organizational research. A qualitative method to unravel the minds of the respondents was required to attain the objectives stated in section 2.0. Therefore this method was chosen for conducting the study.

4.3 Data Collection

4.3.1 Initial Interviews

- Based on brand research conducted by the company 'Third Eye' in 2008 to find the brand gap for Bournvita drinkers, the initial interviews for this study were designed. Placards were made with Attribute, Consequence, Value-sequence and placed before the respondents. The interview was based on identifying links between the statements on the placard through the interview. This turned out very distracting for the respondents. They would read instead of talk. It was realized that probably the brand study required many stimulants to be introduced at the same time but, for the 'concept analysis of Sustainability', stimulus had to be introduced one at a time. The whole structure of the interview was to be based on the respondents answer.
- The interview format was then rectified. The interviewer had the cue cards for the initial questions and some points which should not be missed out. The respondents were left free to talk uninhibitedly.
- Sitting across the table with the interviewer and interviewee facing each other was found to be the most conducive arrangement.
- The structure of the ACV was to be borne in the interviewer's mind and not to be revealed to the interviewee, for a smooth interview. Otherwise the respondents felt pressured to perform.

4.3.2 In-depth interview

Wansink (2003) sums up the main points that should be prioritized in a laddering interview (a) ask questions that can reveal personal reasons, (b) ask questions that lead the person to think and answer with a sentence, not just responding with a 'yes' or 'no', (c) keep asking 'why', (d) question people's reasons for their answers, (e) allow the questioning to flow, (f) ask questions that give respondents' free reign to answer

the question as they feel is more appropriate, and (g) watch people's facial expression as they answer the question and listen to the tone of their voices.

For the Mini project, in-depth interviews of 14 respondents were taken. The interview began with the introduction to the project. A 'word mapping' exercise was conducted by asking the respondents to think of words related with their idea of sustainability. Some respondents were able to think of some words, while some needed assistance. In both cases a set of cards were set in front of them with some terms relating to Sustainability. Sometimes there was an overlap with the terms presented on the cards. They related to some of them more strongly. These were separated and along with the words suggested by them, the respondents were asked to think of a product which in some way related to the words the had picked in the context of Sustainability. This product had to be something the respondent owned. With the mental picture of the product in mind of the respondent, further questioning was carried out.

Each interview took between 20-45mins. The respondents were allowed to talk of larger perspectives and their opinions on the subject, before the interviewer would pull them back to the subject at hand- that of product-value matching. This interview was audio recorded with the permission of the respondents.

4.3.3 Format of an in-depth interview

Q. Are you aware of the term Sustainability?

A. Yes.

Q. What words come to your mind when you think of Sustainability?

A. Durable, Lasts long, Organic.

Q. Do you integrate any of these in your lifestyle?

A. Yes. In whatever I consume- food, clothes…

Q. I will now ask you to think of a product you own. It should broadly agree with the words you used to describe Sustainability. They are- Durable, Lasts long, Organic.

A. An old pair of shoes…Woodlands.

Q. What are the things you like about the shoes?

A. Its good, comfortable….

Q. What is good about the shoes?

A. Individual parts are not worn out, can easily repair, and reuse.

Q. Why is comfort important?

A. I have grown with it. I can use it roughly without being too careful.

Q. What is not being too careful?

A. It is like a habit.

Q. Why is it important to be habitual?

A. I don't have to think/worry about it. I don't want to let go of it as long as possible.

Q. What will you do when you have to let go?

A. I'll think of ways to extend the use/reinvent. If I have to buy a new one, I'll buy something like the previous one.

Q. What will happen to the old one?

A. I'll give it away to the maid or someone who can use it.

Q. Why do you give it away?

A. So that someone else can make use of it. I don't like throwing anything in the garbage bin.

4.4 Data Analysis

Based on Gengler and Reynolds (1995), we can summarize the laddering analysis and interpretation steps as follows.

- Data reduction (data conversion into separated phrases);
- Content analysis of the elements selected in the previous step;
- Summation of relations in content codes, resulting in an implication matrix of all paired relationships; and Construction of a diagram to meaningfully represents the main implications of the study, the HVM.

4.4.1 Data Reduction

As indicated above, the first step is the reduction of data originated from interviews into separated phrases. These phrases are basic elements in which the subsequent analyses are based. This involved transcribing the audio files recorded during the interview.

4.4.2 Content Analysis

Harold Lasswell, formulated the core questions of content analysis: "Who says what, to whom, why, to what extent and with what effect?" Ole Holsti (1969) offers a broad definition

of content analysis as "any technique for making inferences by objectively and systematically identifying specified characteristics of messages."

With the above guidelines the transcribed data was analysed. The separate phrases were nominated as Attributes, Consequences or Values (A,C,V). These nominated phrases were then collected under separate categories of A,C,V. A summary ladder(s) was then created out of this categorized collection according to the links made in the interview.

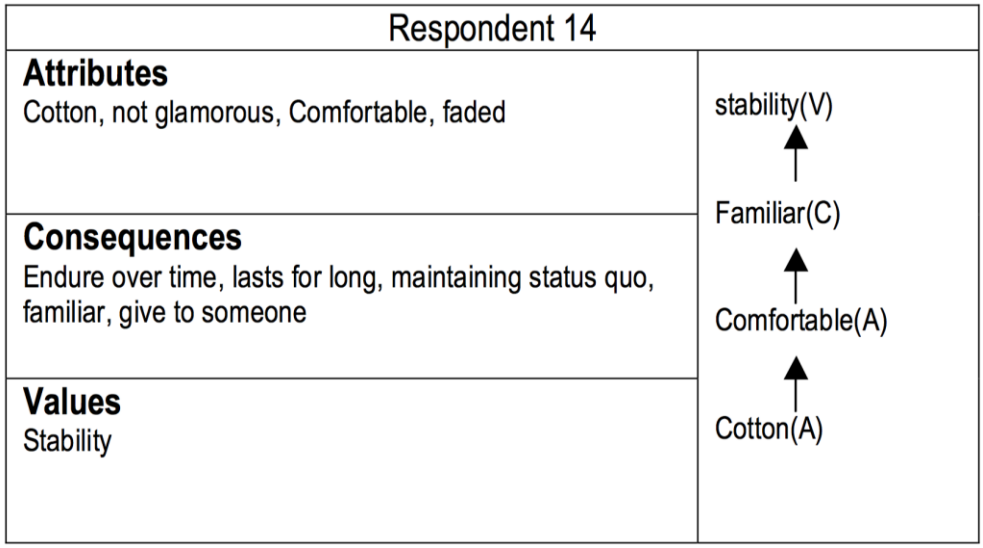


Figure 1 ACV ladder. Above is a representative table. This was done for all 14 respondents

4.4.3 Summation- Implication Matrix

A list of all the A-C-Vs that appear on the summary ladders in Figure1-14 were collected and again clubbed together wherever a similarity in concept was found. These set of ACVs were codified (Figure 2).

	01	02	03	04	05	06	07	08	09	010	011	012	013	014	015	016	017	018	019
01		0.0	0.0	0.0	0.0	2.0	0.1	0.1	0.0	0.1	1.0	0.0	0.1	1.0	0.1	0.0	0.0	0.0	0.2
02			0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
03				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
04					0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0
05						0.0	0.0	1.0	1.0	0.0	0.0	2.0	0.0	0.0	0.0	0.2	0.0	0.1	0.0
06							1.0	1.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.1
07								0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
08									0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0	1.0
09										0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
010											0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0
011												1.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
012													0.0	1.0	0.1	1.0	0.0	2.0	0.0
013														0.0	0.0	0.0	0.0	0.0	2.0
014															0.0	0.1	0.0	0.0	0.0
015																0.0	0.0	0.0	0.0
016																	0.0	0.0	0.0
017																		0.0	0.0
018																			0.0
019																			

Figure 2 Implication Matrix

Attributes	Code	Consequences	Code	Values	Code
Cotton/Organic/Natural	01	Familiar/Habit	07	Stability/rooted/traditional wisdom	015
Handmade	02	Reuse/recycle/extend use/flexibility	08	Caring/Emotional bonding/Active involvement	016
Precious	03	Less things/simple/time investment/economical	09	Contribution	017
Unusual/Uniqueness	04	Help craftspeople/protect art&craft	010	Continuity/reinvent/Legacy of green values	018
Multiple uses/ease of use/functional/easy to maintain	05	Legacy/traditional	011	Self esteem/appreciation/inspiring others	019
Comfortable/Strong/ Quality/Tough/Fit	06	Retain/lasts for long/Durability	012		
		Feel/look good/confidence	013		
		Knowledge of product/brand/trust	014		

Figure 3 Coding the elements

The Attributes, Consequences and Values, which were codified as above were tabulated in a square matrix with the same 19 elements on both axis to get values of paired relationships. These paired relationships are both direct and indirect. Direct relationships are indicated on the left of the decimal and indirect are indicated on the right of the decimal point. This is called the Implication matrix that shapes the final Hierarchy Value map (HVM).

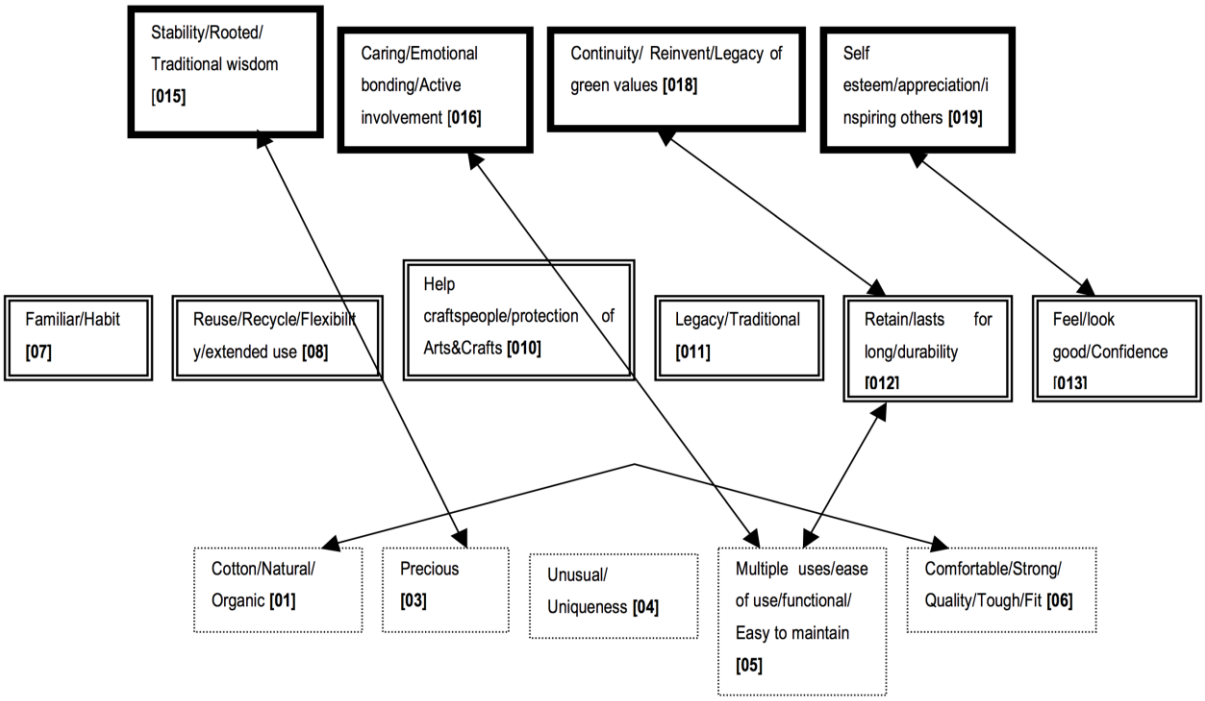


Figure 4 Hierarchy Value Map (HVM)

4.4.4 Hierarchy Value Map

The HVM is the conclusive indicator of the entire exercise. The laddering results are summarized in the HVM across the chosen sample to represent dominant orientations and "ways of thinking".

The HVM is derived from the Implication matrix. The cut-off for the frequency of relationship occurrence is kept as 'above 1'. Any value above 1, whether a direct or indirect relation is mapped on the HVM. The cut-off is applied to increase clarity of the HVM. At the lowest row are the attributes (A), the middle row are the consequences(C) and the highest row are the values (V).

5.0 Conclusion

Usually the relationships on the ladder are between A, C and V but sometimes there might be a relation within the horizontal as seen between Cotton/Natural/Organic (01) and Comfortable/Strong/Quality/Tough/Fit (06).

The strongest ladder is rung (05) to rung (012) to rung (018). The in-depth interviews revealed that the attribute of multiple uses was what gave the flexibility to retain and make the

product last longer with them. The multiple uses lent itself to reinventing and harked back to the Legacy of green values handed from parents and grandparents. Two of the well-travelled respondents mentioned that this was a unique feature, which finds a resonance with the Indian psyche. This trend is not so predominant in the west.

The other direct connection is between Attribute (03) and value (015). In these cases jewellery was the chosen product. This also has cultural references of jewellery being viewed as the safest investments. Therefore the values unraveled were 'rooted' in 'traditional wisdom' and 'stability'.

The Attribute (05) and Value (016) are directly connected due the factor of ease of use and easy to maintain. Respondents found that this quality of the product got them more involved with the product; therefore the sense of caring and emotional bonding was high.

The half ladder between consequence (013) and Value (019) is not very relevant in the context of discussion on Sustainability but it has shown up as a strong relationship because of the category of personal clothing and accessories that the respondents had to choose from. Those who chose clothes would ladder it up to look/feel good to appreciation and self esteem.

The study showed that people lived sustainable lifestyles not only because of ecological consciousness but find a more direct connection to perceived personal factors or benefits.

6.0 Further Research

The findings from the present qualitative study can be surveyed more intensively for quantitative data. Some other interesting insights might emerge from the quantitative study; moreover it can form the basis of identifying user typologies amongst sustainable consumers. This will be useful area of Design Research as designers can target these groups for their sustainable design solutions and predict with some certainty that it will trickle down to the rest of the population.

References

1. Webster Frederick E., Determining the Characteristics of the Socially Conscious Consumer, The *Journal of Consumer Research*, Vol. 2, No. 3 (Dec., 1975), pp. 188-196 Published by: The University of Chicago Press
2. Marchand Anne, Walker Stuart, Product development and responsible consumption:

designing alternatives for sustainable lifestyles *Journal of Cleaner Production* 16 (2008) 1163e1169

3. William Young1+, Kumju Hwang2, Seonaidh McDonald3 and Caroline J. Oates4 Sustainable consumption: green consumer behaviour when purchasing products
4. Skirke. U, Kleizen. H, Barber.M, Increasing the rate of sustainable change: a call for a redefinition of the concept and the model for its implementation. *Journal of Cleaner Production* 15 (2007) 525e537
5. Modesto. T Veludo-de-Oliveira, Ikeda. A, and Campomar M.C University of São Paulo, São Paulo, Brazil , Discussing Laddering Application by the Means-End Chain Theory, *The Qualitative Report Volume* 11 Number 4 December 2006
6. Carsten Stig Poulsen, Hans Jorn Juhl, Klaus G. Grunert, A new approach to analyse data from laddering interviews
7. Tanner, C, Promoting Sustainable Consumption: Determinants of Green Purchases by Swiss Consumers. *Psychology & Marketing,* Vol. 20(10): 883–902 (October 2003) 1994 X(2) 206-223
8. Walter H. Corson , Changing Course: An Outline Of Strategies For A Sustainable Future Ecological Economics 50 (2004) 135– 153 Institutionalisation of sustainable consumption patterns *Journal of Cleaner Production* 11 (2003) 873–881 New concepts in product use for sustainable consumption
9. Michel. R(ed), *Design Research Now (2007),* Birkhauser
10. Jordan. P. W, *Designing Pleasurable products,* Taylor and Francis
11. www. socialresearchmethods.com
12. www.sustainableeveryday.com
13. www.doorsofperception.com

APPENDIX II

The setup to record the discussion of two groups of students was done by the author at NIFT Mumbai. Protocol of the two groups of students was analysed to derive conjectures detailed in DE 1 (pg 97-110). Placed below is the entire transcribed material.

Protocol analysis, NIFT Mumbai, 2011- Group 1

Student participants Moby and Abhishek

M- (Cough)…Ya…

A- We were discussing…like…how, like, the need of Barbie doll because recently we saw that there was a very, very down decline in the sale of Barbie's, recently, so they like were shutting all the Barbie companies in Japan, because only Japan was selling Barbies.

M- You know probably the reason why Barbies sale has gone down is that there is a new set of Barbie dolls kind, they call My Scene dolls. And from whatever I know that I have come across, seeing my cousin and stuff, that they have shifted the whole idea of girls is shifting from that very pretty looking doll to a very hep sort of a thing…so…those, those Barbie dolls, they come with bikes and not like brushes and make-up kits they come with bikes and dogs.

A- Ya, more chic.

M- And skates and stuff like that so but ya…but that's secondary…the problem is that…

A- But here the problem is that…the problem that we are discussing is Barbie that…uh…uh…the younger daughter of some parent is insisting on…uh…on like getting Barbies to her and her parents are in a problem with it.

M- See its like…uh…the same issue is that with the Barbie itself, its not just the Barbie, buy the Barbie, buy her chariot, you buy her house, you will be compelled to buy her make-up kit, you buy her doctor kit and stuff like that so its these other additions, these extra things that they make around it, which may very well be fit to any Barbie so every kid wants every bit of it.

A- Ya, and then generally…like…it is a collection so…so they are like I want this…

M- Ya exactly (emphasis)…exactly so now what we have to see if that is a problem (silence)…lets think about it (silence).

A- We want the question once again.

M- If the kids want more Barbie things around, the different things you get for Barbie…What I think is the way you can make a change in Barbie improve is that we make Barbie less pretty looking thing and more like…no, no, I'm not saying ugly, but like how these new set of Barbie that come, they're not with hairbrushes, they're with roller skates…I mean I've seen…

M- They're more of a …very modernized…so

M- Ya so(emphatically)…exactly….so, so, you give a child, say its first, if I give a child a sofa, he will want a pet table too, you know, that sort of a thing, but if I , if I, so if I give a child something that nothing can be…well of course things can be added to it, but not necessarily, but if a child is definitely is buying a bedroom set, she definitely wants the left things that definitely don't come in the packet, so maybe we can change little bit the image of Barbie, so that kids don't look at it as a collection.

A- Ya…collection, as in…

M- (Taking over)Ya…uh…they kind of idolize their Barbie, you know, if not, if they can't do those things themselves they at least do it to their Barbie, basically.

A- Ya exactly…the need of a child is…all girls, you know, a lot of desires which they cannot do so they like, they create, the Barbie is their child and they act like a parent, they marry them or, you know, treat them as 'go-to-school' and things…

M- Ya, so here…that's a good solution to the fact that you make Barbie the less pretty thing and more of a girl thing, like, Barbie is not exactly a girl child, you know, she's a, if you look at it, she's a pretty grown up lady, sort of a thing, you know, so you get the little fun element into it, people will look at Barbie in a much more light hearted manner. Right now if you see you, you throw a kid's Barbie, you know, she'll come and hit you for it, you know, so its good the kid is attached to the thing but say if the Barbie comes with a like a, like a like helmet and say instead of a tiara she comes with helmet and instead of a gown she comes with a jacket, you know, the kid would obviously, like…it definitely affect the kid's perception also.

A- Ya, a bit, you know, like…uh…like see the child's mind is very sp (unclear)…they're very soft, whatever they see, they perceive and they try to become…like with this generation we see that most of the girls, they're more tomboyish, like they want to wear jackets and they want their hair to be cut.

M- (interrupts) I would say that a set of, sort of kids probably, but eventually, ya, very few of them are of the kind who want to be like tomboy, (coughs) what I'm saying is, like a good thing would be to get kids out playing instead of inside the house with Barbies, kids are outside the house.

A- (Trying to say something)

M- How these Barbies can be, uh, less princess and more of a fun girl sort of thing. Obviously you do get influenced by it if I have, say, if I am a girl, if I have a Barbie which has these killer skateboard and say roller skates and has a nice backpack and would obviously encourage me to pick up. Because I idolize it, you know, so I want to do things outside the house too, you know, so, it's a whole difference that you can give a personality change to Barbie.

A- Trying to say something

M- Since the kids are going outside I'm sure they…their needs, it like, say I want to do this, I want to go out of my house, I need my roller skates, okay, I will…but if instead of a princess I have a tote and…I need everything around it to build a story.

A- Ya, the whole thing

M- And, where I think one, one, one place where everybody needs…uh…where these manufacturers, they cash in, is that there is a…see there's a movie release…Alice in Wonderland is released, I should bring out that doll.

A- Ya, so that collection should be there

M- I want a Alice in Wonderland doll, you know, so triggering a need, you know, forcing someone to want something is one thing, but here what is happening is that they are tempting, they are making use of …uh…making use of the opportunity

A- (Trying to say something)

M- They are making use of the opportunity of course, if it was going to, I'm going to watch Alice in Wonderland and I see Alice in Wonderland right outside, in the stall, it is like, 99/100 kids want it and 100/100 girls would definitely want it

A- Will definitely want it

M- I think we're going a little off, so think maybe we can give…uh…Barbie a little a personality change.

A- A different look. Not altogether a dreamy-dreamy but more to a practical girl

M- Make her more like a fun girl, like how a kid should be, so you now, obviously, that mentality that thinking that you…uh… our main purpose, our ultimate purpose is make kids step out of the house and…

A- Not stay within.

M- So that not to become like me, you know, so they should step out of the house and play outside, you know, rather than having, because mostly you see, they're all sitting inside. They go to from one house to another house. They all take their Barbies, like how you said, you know, get them married, ya its in its own way, its in a way its cute little girl thing to do, but at the end of it you do want people to…

A- Move a little bit.

M- Ya, step out and also, say, my Barbie is on roller skates I want to be like her, I would want the roller skates, so I'll…

A- So…

M- So I'll have lesser time to think about, oh! now what can I do to it? Now I have a house set, my bedroom is perfect so I should make a bathroom, have a kitchen for it you know, then the whole set.

A- Ya, just thinking ahead…

M- Comes with certain…I mean, that's probably why we should give Barbie a little personality change.

A- And then they can also do with Barbies, they can come up with, like you know, products…like a bigger size of the skate with and accompanying skateboard for you as well. Like for kids, if they want to aspire also, like Barbie so that they can go out with the Barbie and roam around.

M- That's a good idea, ya obviously, see at the end of it, Barbie is not a game, it's a toy which doesn't jump, doesn't walk around much. You can dress her, you can just…

A- Ya.

M- Just comb her hair but doesn't interact with you as such. You move around her hands. Somewhere we need to give kids certain toys that probably help them, help them in way that probably…

A- More…towards others, I think a little IT and technology can play little role in it. Probably you said that it can talk, like you know if…

M- There are talking Barbies

A- Yes we have. But if they have its good for more interaction. Is there and then, you know, parents can generally, you know, like kids when they are with their toys they are isolated so much, generally we see, kids come to their house, throw their backpacks and go to their room and start doing something or the other according to their…And if the Barbie is there, so they can, you know, more interact with, you know, kind of parents, like I don't know, if it is possible but if, you know, if parents can just record the things and Barbie kind of thing and then if they can interact, then kids and then parents can get feedback, you know, small kids are little…they have something in their mind, they generally don't speak at all. So the parent can, you know, if there is an interaction between them and Barbie and they know what is there on the child's mind. Which way it's going.

M- But you know, but you know, like…uh ya…that is there but, no you tell me, say you've a sister at home, parents are working, you know, parents cannot devote time and that's the reason why kids become addicted to these things. Like I, I, I, I mean from the time that I…

A- With friends

M- No, no from the time that I was a kid, from the time I see my cousins as, you know, we didn't, we needed games…but we couldn't do, do, do without toys, because mums have started working now, like there were lesser mums working before. So there was someone at home, so when the kid is idle, sitting idle, he doesn't know what to do so he picks up probably these things and then he gets into the whole thing, now his world gets contained within the Barbie. For myself, I didn't…talking about myself, there was a time when I was obsessed with GI Joes, they didn't solve any purpose, you know, I would buy them, they were expensive.

A- Same with hot wheels

M- I had to beg my parents, I had to like plead, steal money and do what not to get them and but somewhere I think…uh…I know I fell for it, I fell for the whole thing, you know I want a tank, a chopper, I want…

A- Ya, you want more and more.

M- I want everything around.

A- It is your world, you build your own world and everything around. Had GI Joes been more fun guys and not serious with guns and all, had it been more you know…

M- Ya…its, its, see now it depends upon what kind of image or personality your toy has. If you want superman, I buy a batman I don't want Robin maybe, I can do without the Robin but if I buy a GI Joe torpedo, I want the…

A- You want the whole army

M- Ya, ya, exactly, you know, its about the personality. We should make Barbies that are more self sufficient with the whole little box. They don't need things around.

A- They are, you know, more normal way they can do with. More of you know, a family

M- A little, a little bit like the whole skate thing and then a bicycle or a dog thing a probably a…little more light hearted…less tiara pretty princess thing, so obviously, that's probably, there would be a way to probably cut down this whole thing that kids get into.

A- Ya, there would be you know

M- Because you take a toy and you move outside the house just that when you have the toy in front of you and you're bored, you don't know what to do, and now you're out of this thing, okay, what can I do, you know. I have gotten her married, I brushed her hair, now what do I do, I should get her a friend

A- Ha, then…

M- So, you want another Barbie, you get her a friend, you get her a chair, so we should make Barbie we should make these personalities, so that the toy is self sufficient, like how a Batman is a Batman, he doesn't need his car around, he has a very strong identity, so maybe if Barbie has a very you know, the thing is that all Barbies look alike, maybe if there are different kinds of Barbies.

A- They can segregate…

M- They can segretate and give them a distinct personality of style Barbie and think something like that is there…

A- Ya, on the guitar on all its there

M- in a few places but not with Barbie but there are these other, I'm not sure of the brand but Barbie as such has a very…uh…you cannot distinct one Barbie from another Barbie without the clothes, they just look the same, their hair is the same.

A- Same, same, same…

M- Everything's the same, so you somewhere need to give a personality

A- Ya, a different…

M- …To Barbie. A kid identifies with one, picks it up and is happy with it. Her Barbie is bland like after a while she's bland, she doesn't now how to stand, she can't even bend her own legs, you can't make Barbie stand straight, I mean.

A- It goes like that

A- So something like that maybe somewhere there's…that's the way. Okay fine, that's probably one way to, probably make the situation better, the thing to do is the personality. Now what can be the next thing if there is another problem, lets see…

A- I think, seeing it from the parent's side if they are having like a it's…I don't think there is, there should be a problem with parents, you know, parents worried so much about Barbie, do you think it's a problem? I don't think, its only a matter of money, you know, probably more.

M- It is a very big thing…

A- Money…that is only what would be a constraint over here, otherwise…M- But you know what I would think, I would, this is from my personal this thing that my parents were never too happy seeing me playing with GI Joes but they were happier to see me playing with Uno, you know, coz my mind was getting worked, my mind is used somewhere, so somewhere I know it sounds a purpose for toys not to like, a kid wouldn't want a toy that said A for apple B for boy but somewhere in a very nice way if you incorporate certain things that the kid can learn something.

M- Ya, exactly, that's what I was saying, for the impractical things for Barbie, if they are there they can you know, they can mould their skill building, interaction in that way. They can probably, they can have according to that age level have a kind of quiz. Parents can just help them in things. Ya…one more thing parents can do is taking you know how lives of the kid and Barbie, you know how they can just come, like Mom if you're not working, if they are working in the evening just can you know like what do you want new and what do you have you learnt today, like sort of that, then you know, the kid will not be like Barbie, Barbie but the mother coming back and talking, because that's the way how kids do.

M- That is one thing we cannot influence, we cannot. See, a product I Barbie, we can directly in contact. Hey, sorry, not directly, indirectly is in contact with parents as parents buy. The problem with influence, it influences the child more so, that will vary from parent to parent, whether parent is ready to spend time, whether the parent is the kind who would want to spend time with the kid and Barbie. So that in some way is little out of our control. But..uh…we can…maybe…

A- Or maybe if the costs is a big thing then you know, that's a very manufactures' based thing you know, cost cutting and then…probrably…but then…generally I have seen my cousins down the line and generally, they are like, my cousin, they want Barbie every time they go, they want a Barbie for birthday and after a week or something its gone, its there in the almirah, all packed up, because it gets spoiled and stuff. It happens.

M- And also the toys will not run after you, you can't run after the toy, the toy will just be in your hand, if you have to make anything you've to lift a hand to make something happen…

A- Exactly...it happens with toys.

M- So maybe somewhere with the kid interacts with the toy, the toy interacts with the kid, not just the kid interacting with the toy.

A- Ya, so arm kind of thing, you know, you need to go there

M- We need a little improvement in…uh…

A- More technology

M- Ya, if technology is a way to it, well and good, but then, maybe the toy should be a bit more interactive. It is too quite its, its, its difficult to comment as to how can that be done, you know, but somewhere, the toy needs to interact with the kid, that's the reason why the kid gets bored of it and he wants an extension to that toy. So if the toy is entertaining enough I do not need more toys. So if my design is, if my toy is the toy that the child wants in life, he doesn't want more toys then.

A- Then he can…

A- Because we as kids, we have, we get attached to certain things and its, if we get passionate then no toy will come and allure us and we'd want to move on to, its just that somewhere there is satisfaction of owning that Barbie is not there, you know, she's just sitting and cannot stand straight so generally just a chair, so somewhere make Barbie more…

A- More user friendly and you know, they should be more, you know, the child can, you know that attraction thing is really nice, if they make the kid, like, if they all lead a life like Barbie also. Probably they can also give Barbie you know like, if they are giving that skateboard kind of thing, a story kind of thing, like animated movies, there are there, and

they can you know, what she did, they also wanna do sort of, you know and more skill building, you know, they, if Barbies are shown doing this, many, many girls do copy Barbie, you know, then life is Barbie, ultimately their friends are also like that only so they can…

M- You know, sorry, sorry for interrupting. I've seen this recent phenomenon of Hannah Montana.

A- Ya.

M- Like that was an idol, now its on every bag, every pencil, every T-shirt, every roller skates. Its just the same thing, so and if you see that kid is not just, she's not a princess, she's a…

A Normal girl

M- No, she's a rock star, it definitely shows that there is a way to build up such a personality for a cartoon that people are happy with it, you know what I mean.

A- Ya, its quite evident, every article has it and then people still want it, like…

M- But again, there also is a little this thing, is that you want a Hannah bag and Hannah bottle and a Hannah…but that is something you cannot control, you know.

A- That's obvious, exactly…

M- What you can…in terms of toys, but you would not want to have three different Hannahs. So there is not an option to have two different Hannah dolls, because Hannah is such a strong personality that they can have only one Hannah doll. Right now, our issue, these are the…

M- This the kind of thing that we can do, you know that a single character in Barbie probably they come out with a different altogether with styling and all and then you should, people can put a lot of publicity in one thing that every person wants only one because that's their idol now, kind of thing. Like if it's a rock star. Then you know, but we have, like, every child is not the same, probably out of 10, 5 don't like a rock star.

M- Ya, so that's why I'm saying that there should be a variety, not a mad variety, like a few options for the kids to pick up characters. I think its time we should go ahead from the princess thing and probably give a little more realistic personality, to the toy so that the toy…

M- Ya…

M- …is more relatable to either, child can relate to the toy more and its content and is satisfied with the toy. So our solutions is, what I think is first is the personality lift giving a more specific, more realistic personality with…uh…ya, second is the interaction where the toy interacts with kid and the kid doesn't get bored of it and wants an extension to the toy. Why an extension to the toy and why not a new toy because the kid is attached to the toy so doesn't want to give it away but at the same time, wants to do something more with it.

A- More with that toy

M- With that toy and not someone who so looks for a hairbrush and so looks for a dressing table. Somewhere an interactive toy, somewhere a toy, which satisfy the needs, is entertaining the kid. It looks more like the kid s entertaining the toy. Where as it should be the toy entertaining the kid.

M- Those are our two solutions. Do you agree?

A- I do.

Protocol analysis, NIFT Mumbai, 2011- Group 2

Student participants Shruti / Riddhi / Suhas

(Silence)

Prompt- What are you thinking?

R- No, we were sort of reading…

SU- Barbie's needs…let's see that…

R- Ya, I mean, there is like a direct relationship between the child's desires and Barbie's needs.

SH- Ya

R- It's also concerned with awareness, or you know, what like I said, like, I mean, they're evolving and children's needs are growing.

SU- Awareness, I won't say…

R- Awareness, I mean TV and all of that.

SU- Through that…

R- Ya, through that, also peers, I mean.

SU- She's getting these ideas through all that.

R- Ya, I mean, you can't really stop that, that can't be really…

SU- You can't restrict them.

R- Ya, so, ya, that, like I said, that you know,…uh…I mean, children now as in my cousin, she would want to match her shoe her dress with her shoes, her clips and maybe a bag, so you know, I mean, in the horizon is like broadened for little children to…

SU- Basically, there're influenced by what they see. The elderlies do that.

R- Right.

SU- Elder, elder girls probably…

R- Ya, absolutely, ya, right.

SU- Is doing so she wants to do that. You can't stop her from seeing that.

R- Obviously, yes

SU- You explain it to her, she won't understand, she's small, counseling will not help much.

R- The thing as in, the point about Barbie's needs is, I mean like, …uh…Barbie as a doll is sort of translating a culture, as in, in a way, like how or maybe in lots of other things that are happening, like,…uh…there would be one doll which does horse riding, you know,

you would have the paraphernalia with the doll, or, or, there would be a you know one school going doll.

SU- Ya

SH- ya

R- So they have their entire, you know, what all they need, sort of thing happening, I mean, I like, it says uh…demand a solution to reduce Barbie's needs and therefore the child's desires.

SU/SH- (Chorus) The child's desires.

R- And I mean, Barbie's needs, I don't know how one can do that…

SU- Just the way we can get down to the child's desires, because she is more attached…

R- But, do you think that the actual way to solve this…

SU- That is one of the methods…

R- One, ya

SU- The main thing we want to do out here is reduce the child's desire.

R- Ya exactly, through Barbie.

SU- Ya through Barbie. We can do it anyways.

R- Ya. As in so I don't know, after like reading it, do we think that its basically, what we need to, the problem really is curbing the child's desires. I don't know, I'm still confused. Maybe, that could be like the starting point, because, it is basically, like, like a lot of families, there are some kids, who don't ask for a lot but then there are these others who would demand.

SU- Who are very adamant on it or…

R- Ya, so, it is also how you know, you have nurtured. There's a lot going on you know, its not just about this but, there are layers to this.

SU- The kind of environment she's in, kind of…uh…the kind of responses she gets everything.

R- So lets see, the child's desires, basically stem from how the child is nurtured, the upbringing maybe….

SU- Hmm…the environment she's been brought up in

R- Ya, absolutely and, that also comes with the peers and you know the amount of, what do you say, like, I don't know like the time she spends with, on maybe TV or, or…things like that could also, could also have an effect. (Writing) We're sort of sorting out where

these, these desire's sort of stem from, right, because, like I mentioned, whatever, some children don't ask for much.

SU- So that is, that depends on how they've been brought up, and depends on all things.

R- Right…

SU- Restricting the child's desires is not a solution but…

R- Maybe…okay...also I feel that Barbie can be an aspiration to little girls…like…

SU- That's what…they see themselves over there…

R- Ya, its also said that she became the child's identity.

SU- Exactly

R- So maybe if the child thinks like I would want to like I want a bathtub in my house to whatever so she…

SU- …can't get it so let the Barbie get it anyways.

R- Ya, I mean, but obviously, I mean, we can't like, all our whims and fancies cannot really be satisfied, or, parents can't really get the world for us, there are limitations, so maybe the parents, first need to understand that its not really the child who has those crazy desires but its actually, sort of, grounding them would help, rather than you know, making, or reducing Barbies needs. I know that…

SU- Grounding them…

R- As in, you know, maybe…maybe, think smaller joys. I don't know how that would work but like you know, when we were…Parents would sort of need to explain to their children that …uh…you know…

SU- Kids don't understand that, counseling doesn't help in the case of children…kids

R- But, but is there really a need for a bathtub when a shower or a bathroom really does it for you, or whatever, you know. If there's something like that because, maybe they could be a little more rational.

SU- Ya, it depends on that also.

R- It like..uh..uh.. you know, you've, you can make it more interesting for the children. Because there is a lot happening. There's no water, I mean I mean, there's shortage of water, and a bathtub is totally wasting water so maybe you know, you can add rationale or logic to how you explain to…

SU- So probably some kids would be impressed by that and would make over their minds.

R- Ya, but you're right, they're all sorts of…

SU- The stubborn kinds…

R- I think we should like sort of …Have we identified the real problem?

R- Lets jot down all this, right.

(Silence writing)

SU-First of all, the kid portraying her needs is through the doll, that's not actually a problem. The increase in needs

R- Ya, right, right, that could be, that is a problem.

(Silence)

SU- And also its happening in such a short duration like a week's time.

SH- A bathroom and a bedroom for Barbie.

R- Ya, that could happe,n it could also happen because she thought of it because she said, like if a child is playing…

Su- Her friend probably got a bedroom.

R- Ya…it could be anything.

SU Or her elder sister got a bedroom for herself…

SH- Its like Barbie is a living person, has certain desires.

R- Ya that is what is happening.

SU- The attachment basically, the attachment of the kid and Barbie.

R- We could also like take a child for example, and you know, maybe like, understand how they would react to a situation, we've been through it and I don't know, I don't know. I'm sure you had Barbie when you were a kid. I had tons of them with all sorts of clothes and shoes.

SH- I never had much of Barbies.

R- We've all been through…guys goes through this car stage and everything.

SU- Ya.

SH- Ya.

R- So, ya, I mean, I want to like go back and think why did I really do this, I mean.

SH- Today, also when I see Barbie's movies which come I feel like its so beautiful, such things should happen in my life also, so I mean, kind of…

R- Ya, there is, like this aspirational value attached to…

SH- That is happening in a much more stage in this child's life…

SU- Ya, its happening a bit before time.

R- Well, I'll tell you something…uh…when I was a kid, I had a lot of Barbies. They were usually gifts or I got clothes I mean, I don't remember I used to ask for clothes because I was fashion crazy or whatever, but not really the other paraphernalia, with the bathroom and the bedroom was happening. I would get them as gifts. If I take the example of my cousin, like she's five years old, like I mentioned like hundred times before but my Mami (aunt), she really, she doesn't think twice before buying her anything. She goes, it costs, its very expensive, you know, seven hundred (Rs.) or sometimes like a thousand (Rs.) too.

SU- absolutely

R- So every birthday, they get her something new. It actually happens you know, in a house and she has all sorts of things. Everything attached to a Barbie doll and pink is her favourite colour because, well, its all over, so you know, I don't know. I would just like to compare this with because my parents…

SH- That can be one bedroom why the child's desire is increasing.

R- Ya because…

SH- Because of the parents influence.

R- Exactly, right, it can be that, I said that earlier also. So there has to be this…the parents would have to explain to their children in a language that they understand and attach rationale to it, I mean logic to it because, I mean…

SU- Ya.

R- Everybody understands that.

SU- Ya it's how they…conveyed.

SH- Ya, depicting their big desires…that is.

R- Ya, exactly. So, I mean, how could…

SU- Parents, basically need to convey this rationally, right?

SH- Ya.

R- Because I honestly feel that, that's one way that this problem can be solved.

SU- That is one solution…

R- No, external influence you can't really help that, but if, if, if, if…

SU- You can't restrict certain things.

R- But if the child has that…um…uh…I don't know maybe strong understanding of that, its not really needed.

SU- If the child understands that, then the external influence will not have such an impact on the kid.

R- Right, right.

SU- Every time an ad comes up you can't shut the eyes of the kid, right?

R- Ya, obviously, ya.

SU- If you've explained it to her, she'll probably see the ad, she'll be like okay, then she'll remember that no mommy said this.

R- It does work.

SU- It does work, it does make a difference.

R- I mean lot of times what parents do is that they'd say that this is bad for you or sometimes they just say that, 'Nahin, yeh', like for chocolate, they'll just tell you that no, you're not gonna have it. If you have like a strict, whatever, approach to it then maybe the child will still want to do it but if you go down to their level and tell them that you know what have, or maybe, have one, have one and you'll see that, you know, teeth get bad or whatever, maybe talk like that.

R- Right, right but maybe also, if they show them examples, like flicking through a magazine and there's like this bad teeth, whatever, like this teeth whitening sort of ad and you could tell them that you know what, this is what will happen to your teeth if you eat chocolate, or, you know, things like that help.

(Silence)

R- Uh…in the case of the…Barbie doll and the things she needs.

SU- The counseling of the parents, that's one way out, I mean, the parents explain that to the child. That's one way out over here.

SH- Umm…

R- Ya, also like if the child is adamant and is stubborn, so like, parents usually, you know, slowly wean them out of some things or like, you know, like…

SU- Its done either harshly or else…

R- Or you go slow, there's a process.

SU- Either go around them, gonna take a week or so.

R- Or they sort of reduce, like they, I don't know if that really works, like parents they say that um.. okay I won't buy you this, I mean, I won't buy you the car…

SU- If you do this I will give you this.

R- Ya, maybe not the car because maybe because the car is out of price range or whatever but maybe something smaller I mean that could work initially when they're trying to explain the child, and also the need related things, like you know, uh…I don't know how, like how can I relate a doll to needs.

SU- For kids, if you have your meals in time, we'll get you a new Barbie next month or something.

R- No but that's wrong. Giving them temptation. I don't know.

SU- That is wrong , in one way.

R- No, I'm just saying that if a child is standing in a store and they start, sort of pointing at a thing and like I want this then like that, maybe you could, they could start at something smaller and say that you know, and explain to them that, maybe you know, and explain to them that, maybe this makes sense right now but a car really doesn't matter or whatever and also explain to them that there will be a phase in their lives where, they'll get over these things soon. But then, you can't then really take away their joy of playing.

SU- Ya

R- With dolls and…

SU- That moment when the kid actually wants that, its really difficult to convince him that…In the store if he's pointing out, its, not that easy.

(Silence)

R- Identify and structure the problem (Silence)

R- okay fine, uh…the structure basically is we start from the…like the major problem was or solution rather is to…uh…to explain and add logic, that's what it would be.

Su- To convey.

R- Ya, right, what I mean what's right or wrong can't be the solution to this but…well make sense.

SU- Rational explanation basically.

(Silence)

R- And so accordingly to us like, this is out of question, reducing Barbie's needs because…

SU- Somehow you're gonna reduce the attachment between the kid and Barbie

R- Right, right exactly.

SU- That is more important.

R- And also maybe, idolizing uh…I don't know.

SU- More important things to be idolized rather than a Barbie.

R- Ya true.

SU- To show the actual importance of the other things.

R- At the end of the day its an inanimate object. Right, Its just a doll and it can't really uh… sort of, like a Barbie is something one should aspire to be or identify with.

SU- It's a doll, only a doll.

R- Ya, so, that's the parents should also do, right. And its just meant for recreation where you know, children play, they do I know that sort of different kinds of Barbies and friends little girls play with each other. But, that is, just stay to that maybe…and...

SU- Because the attachment will really help. If you remove the attachment it will really help.

R- Ya, because, because its really like increasing. There are like Barbie clothes and Barbie bags sort of maybe like…

SU- Even the kids clothing will be getting into…

R- No, no that's what the clothes t-shirts that kids wear would have like a Barbie doll whatever print on it. Ya, that is something that sort of…uh…making this…I mean, this, the whole becoming the child's identity. And they shouldn't maybe the parents shouldn't encourage that of it, I mean, the doll should just be, those to play around and that's it.

SH- The problem is how they should explain it to the child.

R- Right, but that…explanation here is important and every family has their own way of explaining but the whole strictness would not work or like a strict 'no' wouldn't really help.

SU- You need that counseling, basically.

R- And also, like all children want is the truth and if said in a very understandable manner, I mean if one says that you know, if they say uh…'*Hum yeh tumhe nahin kharidh ke de sakte kyonki abhi hamare pas paise nahin hain*' (We can't buy this because we do not have money for it now), they might just take it in a wrong way. Instead maybe, one could explain it saying that you know that we'd rather do this, we'd rather take you for an actual horseback riding next summer, than buy you a Barbie's horse, you know, I don't know, something like that you know, if we say that *hamare pas abhi iske liye paise nahin hain*.

SU- Again you're tempting the child right?

R- No but isn't that maybe on the plan, maybe that's there on a family plan to actually take the child on a horseback riding or to a trip or whatever.

SU- But aim is that you're tempting the kid.

R- But then there's nothing wrong with this temptation because its actually gonna happen.

SU- I'm not saying that is not true but…

R- Ya, true.

SU- It is temptation.

R- Ya true.

---The researcher prompted the participants to think of designers' role in the scenario.---

SH- We actually listed a lot of points- Environment.

R- Ya, right.

SU- Exactly, ya…Space.

R- You said (to Suraj) nurture and conveying to the child is communication

SU- You don't need to convey it verbally, ya actually, if you give a space, I guess.

R- And also if involving them in activity is like drawing or whatever, things that they like or reading stuff like that and also, then again, like uh…

SU- So you can probably have a small play area in her room itself which they could keep on changing every week or a month or so, that would help that way she would not move towards the Barbie or other things. More into one thing, better things more physically active stuff than playing with Barbie dolls. That'll help in the growth eventually also.

R- So you're saying that a space, an interactive space or…

SU- Play area of something, a treehouse, anything of that sort, like probably in the garden, in the lawn. A treehouse, or probably in her bedroom so she'll have small sand pit where she could make sand houses., something of that sort, creative stuff would, actually she'd be more interested into that than a Barbie doll, that's for sure

SH- Different activities but we are giving it to the child.

R- Ya, so we're sort of saying that, like one solution could be to involve or make the child busy into more

SU- Ya, to give her options rather than just a Barbie doll.

R- Ya.

SU- You give her options in a place where she is. She'd be more into those things than playing with a Barbie doll. Because it is a bit monotonous for a kid, but because she's got no place, she's probably just in one room, she's got a TV, she's got a video game.

R- Absolutely.

SU- At the most and she'll sit in the bedroom, on the bed and do something.

R- Right.

SU- That's it, sketching fine. I mean, you just have one more activity, right.

R- Right.

SU- She'd not be totally dedicated towards that. That'll really help. Play area, tree house, things of that sort.

SU- The kind of interiors in the room, colourful, bright.

R- And also making the room colourful can be an activity in itself, where the children can…

SU- She can have a wall for herself where she can paint.

R- Ya, they could paint it themselves, right and you know while they are at it, I mean, the parents could talk about or communicate the more important thoughts or things that'll you know make the child grow or, you know involve or get her busy into other things.

SH- Basically, there's not only one thing which can, I mean, reduce the child's desires.

R- Right.

SU- Coz, she's influenced by everything, everything, the clothes she wears, the things she sees, the place she stays, the bed, everything, so, increasing the number of activities, the options she has, that is the solution.

(Silence)

R- So…um

SH- Its like, they should not get obsessed with just one particular thing.

R- So as like maybe, uh...like a communication design solution could be for the parents where how, where and in what medium do they use to sort of explain to their children, you know about such aspects. Well like you said, you know, while…

SU- It does not have to be verbally, it is not necessary.

R- And if they're enjoying and both of them or whatever, the parents are involved in activity with the children and they're making the most of it, that is quite evident where you're just playing with the doll alone and this makes more sense.

SU- Its because she's all alone, that she doesn't have anyone to talk to or play around with. Then they move on to doll, if they had the options, they would probably not go down to playing with just dolls.

R- Ya, obviously

SU- If she had a sandpit, she'd have friends to come over and play with her, so that, it's the Barbie doll is basically a figure which is with the kid all the time so she has a partner or something, she has something or someone she can look up to, she can do something with, do something when she doesn't have anything else to do, if she has other options I mean, that'll be more fruitful for her.

APPENDIX III

The following tables are reproduced from a document- Module C- Product-Service Systems and Tools and Cases published in a joint collaboration between UNEP and TU Delft University. The whole set of tables that were given to students for reference is available in (Tischner, 2009). This was the scaffolding provided to the students to ask the right questions and expands their understanding of unsustainability (Unsustainability precedents as mentioned in MI 2 and MI 3)

A) Environmental dimension	Questions	Priority?
A.1 system life optimisation	Are disposable systems used? Are disposable products packaging or support products used? Do parts of the system tend to be technologically obsolete? Do parts of the system tend to be culturally/aesthetically obsolete? Do some parts of the system tend to wear out easily (than other)?	High Medium Low No
A.2 mobility reduction	Is there any heavy transportation of goods? Is there any heavy transportation of semi-finished products or by products? Is there any heavy transportation of people? Is there any un-useful (empty) use of transportation means?	High Medium Low No
A.3 resources reduction	Is the system consuming in use high quantity of energy? Is the system consuming in use high quantity of natural resources? Is the system absorbing high quantity of consumables? Are products, packaging or support products of high materials intensity?	High Medium Low No
A.4 waste minimisation/ valorisation	Is every waste going to landfill? Is the system at the end of its life producing high quantity of waste in landfill? Is the production of system products, packaging and support products producing high quantity of waste in landfill?	High Medium Low No
A.5 conservation/ bio-compatibility	Are all the energy in use from fossil flues? Are all the energy form exhausting resources? Are most of materials for products, support products, packaging, infrastructure exhausting and/or non-renewable?	High Medium Low No
A.6 a-toxicity	Are the resources used toxic or potentially toxic in production for the workers? Are the resources used toxic or potentially toxic distribution? Are the resources used toxic or potentially toxic for the user? Are there any toxic or potentially toxic effects of the products, support products, packaging or infrastructure for any end of life treatments?	High Medium Low No

B) Socio-cultural dimension	Questions	Priority?
B.1 Possibility of customers to consume socially more responsible *(Sufficiency)*	Does the consumption in the system (use phase) cause major environmental or social problems?	High Medium Low No
B.2 Health and safety *(of employees, customers, stakeholders...)*	Are there any health and safety problems in the supply/ the value chain, i.e. from raw material production to use, recycling and disposal)?	High Medium Low No
B.3 Living conditions/ quality of life *(customers/users perspective)*	Are there any problems with customer/ consumer acceptance? Are the customers unsatisfied with the offer? Are there any needs of the customers NOT met through the current system? Does the offer contribute to the 'enrichment' of life of users (by giving learning opportunities, enabling and promoting action rather than passiveness,	High Medium Low No
B.4 Employment/ working conditions *(employee perspective)*	Are there any problems with the quality of work in production and supply chain (Supportive environment, enriching the life of workers by giving learning opportunities, social aspects like child labour etc)? Is the workforce shrinking in the current system?	High Medium Low No
B.5 Equity and justice/ Relation to stakeholders *(society/global perspective)*	Are there any problems with intra- and inter-generation justice (equal wealth and power distribution between societal groups, North-South, not postponing problems to the next generation, etc.) in the current reference system? Are stakeholders and public media NGO's etc. satisfied with the offer, or do they criticise the system? Has the company/ offer a	High Medium Low No
B.6 Respect cultural diversity *(society/local perspective)*	Are cultural values, cultural identities diminishing in the current reference system? Does the current system offer only one solution/ few varieties for all regions and cultures? Does the current system have a negative impact on social well being of communities, regions etc.?	High Medium Low No

C) Economic dimension	Questions	Priority?
C.1 **Market position and Competitiveness**	Do you have a weak market position in the current system? Are there possibilities to improve your market position that you do not use at the moment? Do you see current and future threats for your market position?	High Medium Low No
C.2 **Profitability/ Added Value for companies**	Is the profitability of the current system low for your company and other external partners? Is there anyone producing better offers than you in a cheaper way? Are there missed opportunities to create more value in the whole value chain/ system? Is somebody else using this opportunity? E.g., selling your products second hand?	High Medium Low No
C.3 **Added Value for Customers**	Is the profitability/ value low for customers/ consumers? Do you fail to offer concrete, tangible savings in time, material use etc. for the customer? Do you fail to offer 'priceless', intangible added value like esteem, experiences, etc. for which the customer is willing to pay? Are competitors creating more value for money for the customers? Does it solve real customer needs and socially acceptable demands? Are there any negative social impacts related to the offer in the existing system?	High Medium Low No
C.4 **Long term Business Development/ Risk**	Are there any threats in the current system for your business in the longer term? Do you foresee that the customer's needs for your offer will disappear? Are there any major risks from external sources (clients, government, legislation, NGOs…) for your offer? Is your offer more a short term business, will it disappear soon? Is your offer threatened by technological or fashion changes? Is your financial background sound?	High Medium Low No
C.5 **Partnership/ Co-operation**	Is your market position in danger? Do you have a weak market position that you want to improve? Can you use strategic partnership and co-operation? Are your competitors co-operating and therefore have a better market position? Are you missing competencies internally that you need today and in the future?	High Medium Low No
C.6 **Macro-economic effect**	Are there problems on a macro economic level, e.g. disclosure of participants in economy, monopolistic structures, rebound effects...?	High Medium Low No

APPENDIX IV

Cheatsheet

This list was given to students in order to choose the right referent which matched the sustainability issue they were dealing with currently. This has been developed by the author.

	Referent	Short description
1.	Expanding product Life cycle	A product has a life-cycle both as a designed product as well as a marketable product. Both these can be extended to make the product last longer and hence reduce new production and marketing.
2.	Cradle to grave	The life-cycle of a product from raw material through production, use and finally disposal.
3.	Cradle to cradle	The cyclic life-cycle of a product from raw material back to raw material to create renewed product.
4.	The 3R approach Reduce Reuse Recycle- Up cycling, Down cycling Refuse	Most common sustainability strategies, which have wide application. It can even be practiced by a layperson in their daily lives.
5.	Life cycle thinking	Not being focused on one aspect of the product but thinking systemically of the various stages a product goes through.
6.	Product Improvement	Improving an existing product with incremental changes for the better.
7.	Product Redesign	Redesigning an existing product such that the weaknesses are eliminated making the product more efficient.
8.	Function innovation	Sometimes the product is aesthetically good but the function is inappropriate, therefore innovation in terms of function of the product leads to sustainability.

9.	System innovation	Every product is situated in a milieu or a system, so the solution lies in system innovation rather than in just a product or function.
10.	Biomimicry	Mimicking or imitating biological forms or phenomena has a great leaning toward sustainability.
11.	Modular	When products follow the concept of modularity they can be manufactured, assembled and disassembled and stored easily.
12.	Multifunctional	When a single product has multiple functions the number of products used, bought, produced is less.
13.	Upgradable	Embedded ability of a product to be upgraded without being replaced.
14.	Innovative Material	A good knowledge of material will enable basing the entire design on appropriate usage of material.
15.	Lighten design	Reduce the material with which product is made.
16.	Mono-materialistic	Making all parts of product with single material so that it reduces cost of manufacture and easier to bio-degrade.
17.	Transparent	If assembly of product is transparent the disassembly or repair is also easier.
18.	Do-it-yourself	A huge trend amongst people to not depend on service providers but to repair, redesign and recycle oneself.
19.	Substitution	Substituting of a more sustainable material instead of an unsustainable material for the same end purpose.
20.	Localization	Sourcing locally available material so that transportation and supply chain costs are reduced.

21.	Informationalization	Very often unsustainable behaviours are because consumers are unaware. Giving information to people about product or service so that they can act on it.
22.	Design for durability-emotional design	Emotional connect with product can avoid use-and-throw approaches.
23.	Slow design	Slowing down of production, manufacture and marketing of product as against the race to be faster and therefore more wasteful.
24.	Design for Disassembly	Parts of product can be taken apart easily so that disposal is easy.
25.	Close the Loop	In a sense cradle-to-cradle
26.	Design for Effectiveness	Looking at the whole life-cycle and deciding where to intervene rather than one-size-fits-all approach.
27.	Design for system	Not looking at things in isolation.
28.	Product Service System	Shifting focus from only product and replacing with thinking in terms of service.
29.	Customization	Standardization and mass production leads to waste. With customization smaller batches are possible hence less production.
30.	Experience design	Designers have the option of designing experiences rather than tangible products.
31.	Social design	One of the three pillars of sustainability is society therefore design in the social sector most definitely contributes to sustainability.

APPENDIX V

Chapter 6 is a descriptive account of the interaction of student and mentor (author) along with instructor observations. Following is the content analysis of Dissertation 1, 2 and 3 written document

Dissertation 1

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S.No	Segment	Conjecture category
1	muslin fabric which is inexpensive, easily available with good draping capability & which mimics the capability of other cotton based fabrics is recommended.	Precedent
2	The significance of using muslin is that it is used to check the fitting of the pattern prior to using expensive fabric in order to avoid wastage.	Precedent
3	preventing the muslin fabric waste during pattern making is not possible	Episodic
4	so as per the waste management hierarchy next step, which is reduction, should be considered	Referent
5	They learn terms like “Green Fashion” and “Sustainability”	Referent

6	but, these terms were not visible in their practice.	Precedent
7	fabric management in pattern making	Referent
8	come up with a sustainable system	Referent
9	to reduce muslin fabric waste	Referent
10	academic fashion institutes: Case Study- NIFT, Mumbai	Episodic/Case
11	how muslin fabric wastes can be reduced at the academic institutional level	Precedent
12	Students and the faculty are aware about the fabric waste issue	Episodic
13	want to contribute towards its solution	Episodic
14	due to unavailability of précised direction to the thinking	Precedent
15	learn how to create a two dimensional patterns into three dimensional one & to check its accuracy	Precedent
16	In due process a substantial amount of muslin fabric waste was created by students	Precedent
17	varied between 20-30% of the fabric that students bought for every session of pattern making	Precedent
18	This waste often ended up in the dustbin.	Precedent
19	students have a mindset of considering muslin fabric as a rough & cheap fabric	Episodic
20	Even after being guided to use fabric…...they tend to create muslin fabric waste.	Precedent
21	not possible for any student to use it without learning pattern making manually	Precedent
22	the patterns submitted to the department for assessment formed positive muslin fabric waste	Primary Generator
23	which needed to be taken care of as nothing was being done with it.	Primary Generator
24	Most of the students bought Muslin fabric in pieces varying from 1 meter to 2 meters	Precedent

25	from the stationary inside the campus as it was convenient for them	Precedent
26	They did not mind paying extra to the retailer (stationary) instead of spending less to the wholesaler	Precedent
27	located far from the campus) from whom they could buy the same fabric in bulk.	Precedent
28	Some wastage will always occur in a learning environment, and also in design development.	Precedent/Case
29	Every zero-waste design I have ever done has resulted in some muslin wastage through the toile and fitting processes.	Primary Generator/Case
30	I don't think waste elimination is possible there, so managing the waste becomes key.	Referent/case
31	At my work we have bins where students can place muslin scrap for other students to use;	Primary Generator/Case
32	not everyone uses these bins however and most of the waste still goes to landfill.	Precedent/Case
33	Also, what works in one institution may not work in another.	Precedent/Case
34	If using the waste internally doesn't work, I would look at the options that you would have locally for textile scrap.	Precedent/Case
35	Has developed a technology…	Case
36	specialized machine weaves only the pattern designed	Precedent/Case
37	preventing fabric waste completely.	Precedent/Case
38	is called DPOL (Direct Panel on Loom)	Referent/case
39	Other basic pattern cutting techniques increase efficiency by increasing their fabric consumption	Precedent/Case
40	'DPOL' increases the fabric utilization by reducing the wastage by 15%-22%.	Referent/case
41	There are several ways to produce zero waste patterns	Referent/case
42	most of them produce garments that are not very much wearable	Precedent/Case

43	are good as concepts but might not work successfully in market,	Precedent/Case
44	there are other ways of achieving zero waste	Referent/case
45	like by using pleats, tucks, cowls, gathers etc.	Precedent/Case
46	for the waste produced, it can be recycled into papers	Referent/case
47	or can be used to create as filling agent, shoulder pads, or can be used to create murals etc.	Precedent/Case
48	there are many ways of utilizing wastes	
49	I think in the process of creativity at university there will always be toile fabric waste	Precedent/Case
50	the more the student experiments or perfects the more waste there would be	Precedent/Case
51	the solution is not to try and limit creativity by putting in guidelines of how waste can be managed	Precedent/Case
52	I remember after my final university year having to carry huge bags of toile to recycling bins.	Episodic/Case
53	This for me is the key, not that design process should change	Precedent/Case
54	but that what happens with toile's	Primary Generator/Case
55	and the waste of cutting the pattern is managed more effectively	Primary Generator/Case
56	If the university puts in place a recycling scheme then they can manage that waste	Referent/case
57	they could send all there muslin waste to a textile recycler creating recycled muslin fiber and fabric	Referent/case
58	in a way creating a loop where the textile is used at university, recycled and then reused at university	Referent/case
59	As the fabric used for *toile* does not have to be refined	Primary Generator/Case
60	recycled fabric is maybe one of the most efficient way of reducing first hand waste at universities.	Primary

		Generator/Case
61	Our 1st year studio paper 'Fashion Body and Form' students create a new design from an existing garment (a shirt)	Precedent/Case
62	and need to record and show how they have integrated each part of the shirt into the new design	Precedent/Case
63	and show the parts they did not use therefore becoming acutely aware of the waste created through the creative process.	Precedent/Case
64	a recycle bin is in place in the studio where students set aside remnants of fabric (reasonable size), which can be used by other students.	Referent/case
65	I collected toile from 4th year students a couple of years ago to develop a project	Precedent/Case
66	I use these as example for drawing or explaining approaches in other papers.	Primary Generator/Case
67	I also try to encourage students to work half scale where possible- to reduce amount of cloth used in their prototypes.	Primary Generator/Case
68	To make students aware about best practices that can be followed	Precedent/Case
69	in pattern making sessions in order to reduce muslin fabric waste	
70	To interact with students and know their way of handling muslin fabric during pattern making session.	Primary Generator/Case
71	every student was asked to describe the method or procedure they follow to cut a pattern	Primary Generator/Case
72	attributes were considered to evaluate their process:	Precedent/Case
	• Tools & material used by students	
	• Muslin: Source + Width + Quantity + Cost	
	• Standard operating procedure is followed or not	
	• Pattern layout: Planning about how muslin fabric will be cut in order to consume optimum quantity of it.	

	• Quantity of the muslin fabric after pattern is cut.	
73	: To explain them various steps that can be followed during pattern making session in order to make optimum use of muslin fabric.	Precedent/Case
74	The guidance was give in terms of:	Precedent/Case
	• Tools & material used by students	
	• Muslin: Consumption	
	• Standard operating procedure	
	• Pattern layout:	
75	how muslin fabric will be cut in order to consume optimum quantity of it.	Referent/case
76	It was shown to students how they can first calculate the quantity of fabric	Precedent/Case
77	which will help them buy adequate quantity of muslin fabric eventually reducing muslin fabric waste.	Precedent/Case
78	Quantity of the muslin fabric after pattern is cut.	Referent/case
	• Utilization of the remaining muslin fabric	
	• Some guidance on reduction of muslin fabric waste and utilization of muslin fabric waste created in pattern making session	
79	it was observed that students were more concerned about the end product which in their case was traced & cut pattern pinned on the body-form	Precedent/Case
80	evidence from this study suggests that if certain steps are involved in the standard operating procedure	Precedent/Case
81	which can be followed during pattern making sessions in fashion institutes	Precedent/Case
82	can eventually lead to reduction in muslin fabric waste created by the students	Precedent/Case
83	Buying muslin fabric only after calculating consumption	Precedent/Case

84	• Considering width of muslin fabric that will be used.	Precedent/Case
85	Following standard operating procedure (SOP).	Referent/case
86	• Pattern layout is an essential factor, which should be planned properly before tracing.	Precedent/Case
87	students should arrange all the pattern blocks together keeping in mind the grain line.	Precedent/Case
88	Separate bins for different types of muslin waste created should be placed and maintained.	Precedent/Case
	Mind mapping all possibilities	
	Identifying green steps to come up with solutions for the problem(green step 1-6)	Referent

Dissertation 2

S.No	Segment	Conjecture category
1	To study and analyze paper waste generated in schools	Referent
2	and to come up with sustainable system to reduce and utilize paper waste	Referent
3	which can be followed by any school.	Precedent
4	To study all types of paper waste which is generated in schools	Precedent
5	treatment done to notebooks, papers and other kind of paper waste generated by students and school authorities	Primary Generator
6	To make proper utilization of paper waste within the school premises through up cycling	Referent/ Primary Generator
7	To conduct awareness campaigns, workshops in schools regarding up cycling of paper waste	Referent

8	provide and insight on how to reduce paper waste	Referent
9	and how children can learn about paper waste issues	Precedent
10	educating students about paper waste issues and up cycling	Referent
11	controlling their carbon footprint will contribute school efforts	Referent
12	The sample selected for the study was 6^{th} class, which was altered according to school preferences.	Precedent
13	Only 6^{th} class teaching won't give impact to the whole school as the system will be continued even after the implementation of study is done	Precedent
14	sample selected was changed and was made broader. 6^{th} – 9^{th} class students were given as the class in which workshops would be conducted.	Precedent
15	the system designed consisting of 3 phases	Precedent
16	For three weeks bins will be placed in the entire school for the collection of old notebooks and other kind of paper waste	Precedent
17	and the whole system will work from collection till transfer of paper to large bins.	Precedent
18	The 2^{nd} phase talks about the awareness of paper waste, teaching paper waste lessons to students.	Precedent
19	The 3^{rd} phase of optimum use of paper waste generated will be executed completely.	Precedent
20	Workshops schedule was divided according to the work to be taught to students covering the whole system designed.	Precedent
21	For 3 weeks one period of 35 minutes was meant for workshop for classes 6^{th} – 9^{th} and timetable of students was changed according to it.	Precedent
22	The very 1^{st} step conducted in school was conducting a workshop with teachers of entire school.	Precedent

23	It was necessary for them to understand to motive and objectives behind the whole system, which is designed.	Precedent
24	Details were given on how paper waste issues can be incorporated within the existing curriculum of any subject with the help of object lessons.	Precedent
25	All three techniques of making paper up cycled products were shown in detail	Precedent
26	so as to make them aware about the new methods which can be taught to students for their learning.	Precedent
27	Basics of paper waste lessons were also discussed with teachers	Precedent
28	as everyone was unaware of new term called up cycling,	Referent
29	1st workshop was specially designed to teach few basics of paper waste lesson	Referent
30	Theme- Environment, landfills, garbage, lifecycle, 3Rs, up cycling	Referent
31	Main points to be covered were – What is waste? When it becomes the waste? Where does it go? Types of waste? What are landfills? Effects of landfills, How can we reduce it? 3Rs, up cycling and down cycling	Referent
32	The activity started with the story telling of that we all eat chips, we all have cold drink, so where does the wrapper go?	Precedent
33	Involving students with such questions and telling their story helped in interacting with students and this marked their complete involvement during the workshop	Precedent
34	Only one complete session was given to teach paper waste lessons and other sessions were to teach technique of making paper waste products.	Precedent
35	As students were already aware of the paper bins set up, they started bringing old notebooks and collecting in the bins.	Precedent
36	Students were given the description of how to make homemade glue in detail.	Precedent

37	Technique of making paper waste products were taught step by step and three techniques were divided among 4 classes.	Precedent
38	One technique was taught to one particular class for a week and then it was reversed.	Precedent
39	A change in behavior of the students was seen from 1st day till the last day, they became more conscious about their surroundings and their behavior.	Precedent
40	Main problem, which was faced by all classes, was making of glue as glue making was not depicted through actual making	Precedent
41	To make students understand more about making homemade glue, it was actually conducted in home science lab showing all details to make homemade glue.	Precedent
42	many observations show the changes and response of students in terms of behavioral change.	Precedent
43	Students gradually started putting their notebooks and paper in bins daily after few days.	Precedent
44	In 1st week of implementation, only 14 bins were placed.	Precedent
45	Students became very conscious about their throwing attitude and did not throw paper until the bins were installed in their classrooms.	Precedent
46	They kept on adding that paper waste in their bags but did not throw in dustbin where all wastes were thrown.	Precedent
47	While learning the technique of making paper waste products through up cycling, students started discovering new ways by themselves.	Precedent
48	It was observed that few students while make products find their way of doing more easy then what was actually taught	Precedent
49	Once large bins started filling up they were weighed every week to keep a check and account of waste collected within 3 weeks time period	Precedent
50	They stopped and noticed the placement of bins and read what the labels were all about.	Precedent

51	Overall the response was seen on a very positive side but few difficulties were faced while implementation of 3 weeks duration.	Precedent
52	it was lacking on the end of cleaning staff or teachers.	Precedent
53	Cleaning staff was seen putting other type of waste in the bins allotted for paper waste and old notebooks only.	Precedent
54	no output could be seen in terms of collection of paper waste from those classes.	
55	One workshop was conducted again with the entire classes of whole school.	
56	Another step taken to overcome the problem of cleaning staff was they were given clear instructions about segregating the paper waste and to be thrown only in paper bins.	
57	Daily all classes were visited after the school ends to keep a check on cleaning staff and see whether the problem was solved or not.	Precedent
58	Cleaning staff took the responsibility on a serious note and they also started putting if any paper waste was found on floor.	
59	When the system was designed it was a hypothetical study but when the actual implementation was supposed to be done, it demanded few changes to make it applicable for the school.	Precedent
60	For the 1st phase system was designed in a way that paper collected in small bins would be emptied by the cleaning staff every week.	
61	it was observed that appointing the students for transferring the paper waste from each class bins to large bins worked as a more effective tool	Precedent
62	2 students from each class to be appointed as green prefects and they will play the role of emptying the bins into large bins daily 5 minutes prior to their school gets over.	
63	One additional period named SUPW to be added into the timetable of students	
64	In this period students will be continuing with making of paper waste products through up cycling and take it step further with more innovative	

	ways	
65	It was noticed that there was a lack of motivation or efforts from teacher's side.	Precedent
66	To overcome this only few teachers were selected	Precedent
67	This will help in keeping teachers on track and putting their efforts towards teaching sustainability issues.	Precedent
68	An exhibition was kept to display the work of students and to motivate them to come up with new and creative paper waste up cycled products.	Precedent
69	Play was conducted by few students of class 6^{th}-8^{th} on the last day of workshop depicting the paper waste issues and problem faced by them in a school environment.	Precedent
70	The school authorities awarded best works by applauding with medals and certificates to encourage the students.	Precedent
71	It was also featured in newspaper depicting how school students has taken a new step towards environment issues and utilized the paper waste by making products for their use.	

Dissertation 3

S.No	Segment	Conjecture category
1	We can try to reduce the resource intensity of products and services by employing the following approaches and strategies:	Referent
2	Reducing the amount of materials in products and services (dematerialization)	Referent
3	Extending the product life	Referent

4	Eco-efficiency	Referent
5	Recycling and claiming the product material back	Referent
6	Reducing requirement for product	Referent
7	Increasing efficiency of the product usage phase	Referent
8	These approaches can be implemented through the services like- Product Service System, Service design, End-of-life, Design for disassemble, Emotion in design etc.,	Referent
9	which can help in increasing the products life, in making our society sustainable and reduce in using of products and provide services.	Referent
10	Formal and Informal service system both have unique approaches to make this society sustainable.	Referent
11	Formal service system based on a concept of using services instead of using only product	Referent
12	where informal service sector works independently, provides services instead of product and increase the products life.	Referent
13	Planned obsolescence in industrial design is a policy of designing a product with its limited useful life	Referent
14	Planned obsolescence	Referent
15	Case 1: Apple Products	Case
16	New Apple and other technological firms products are released regularly but with only incremental improvements.	Case/Precedent

17	On the other hand, replacing or fixing any of the parts of Apple products, such as battery, is expensive when the product is no longer in the warranty period.	Case/Precedent
18	The worst example in Apple’s portfolio of products is the iPod Shuffle, which costs about $49 to purchase but replacing the battery cost $49 as well	Case/Precedent
19	Case 2: Inkjet Cartridge	Case
20	In some cases new inkjet cartridges can cost more than the printer.	Case/Precedent
21	more than half of the expensive ink goes to waste	Case/Precedent
22	The main reason for this practice is to ensure customers repeat purchases sooner than needed	Case/Precedent
23	Canon has started many environmental initiatives to reduce the environmental burden	Case/Referent
24	After rigorous testing, used copying machines' parts are restored to the same quality level of new parts.	Case/Referent
25	92 percent of the collected machines are remanufactured or recycled	Case/Referent
26	and all of remanufactured copying machines are built using 50 percent or more recycled parts by weight	Case/Precedent
27	Since 1987, BMW has been reclaiming ceramic and valuable metals from the used catalytic converters.	Case/Precedent
28	The used components are brought to the same quality level as the new parts	Case/Precedent

29	BMW has also established the “BMW Group Recycling and Dismantling Centre," which is responsible for developing recycling-optimized product design and improving end of life vehicle recycling.	Case/Referent
30	It is well known that a major part of the workforce in India and other developing countries work in informal sector.	Case/Precedent
31	These informal sector also play an important role in terms of sustainability	Case/Referent
32	In Indian society there are various informal service sectors which helps	Case/Primary Generator
33	in increasing the life of product	Referent/Primary Generator
34	informal service sector area of Kharghar, Navi Mumbai was chosen and it was found that there are approximate 107 Informal service providers are available, in which there are 39 are Scrap dealers, 26 are Cobblers, and 17 are Electric product repair shops.	Case/Precedent
35	Rag pickers play an important, but usually unrecognized role in the waste management system of Indian cities.	Case/Precedent
36	They collect garbage in search of recyclable items that can be sold to scrap merchant (paper, plastic, tin...)	Case/Precedent
37	Rag pickers collect the scrap material from waste and sell it to the scrap dealer then scrap sell it to the dealer after segregating it.	Case/Precedent

40	From rag pickers to the recycle factory there are many dealers involves who takes their own commission.	Case/Precedent
41	Cobbler is a person who repairs the shoe, chappal, sandal, bags and umbrella (mostly in Maharashtra).	Case/Precedent
42	There are various method to repair footwear like stitching, sticking and sometimes they use leather pieces to repair these footwear,	Case/Precedent
43	which they buy from leather waste seller shop.	Case/Precedent
44	when footwear's are no longer useful and wearable then these cobbler make them wearable and increase the End of life of these footwear's	Case/Precedent
45	When our house hold product stops working then we make it repair even from company service center or local electric shops.	Case/Precedent
46	These electric shops repair all kind of electric product, form iron to fan.	Case/Precedent
47	we can't find company service center at nearby place but we can find local electric shops easily.	Case/Referent
48	These repair shops takes less time in repairing the product and sometimes use their *jugaad* technique to repair the product.	Case/Precedent
49	In an interview with these ISP's it is found that costumer don't trust on them	Case/Precedent
50	they have doubt of originality of parts.	Case/Precedent
51	They prefer local service provider for small damage only	Case/Primary

		Generator
52	Company service center is a formal service provider	Case/Primary Generator
53	Company sometimes gives its servicing work to the third party, which follow the company's rule and regulation.	Case/Precedent
54	To attract to consumers company gives warranty or guarantee to the consumer and during this warranty or guarantee company repair the product at free-of-cost.	Case/Precedent
55	Now a day many companies have started to give onsite warranty to the consumer.	Case/Precedent
56	During onsite warranty if the product stops working then technician will go to consumer place to repair the product and he wont ask for any service or conveyance charge under warranty.	Case/Precedent
57	In this onsite warranty customer no need to go to the service center to repair the product.	Case/Precedent
58	They prefer local repair shop because it is easily available and takes less time	Case/Precedent
59	Whereas companies (formal service sector) is expensive and takes more time then informal service providers,	Case/Precedent
60	They prefer local service provider for small damage only	Case/Primary Generator
61	Company service center is a formal service provider	Case/Precedent
62	how to fill this gap is new objective.	

63	To increase the products life, product should be functional as well as repairable.	Case/Referent
64	Increasing the life of product means product should with consumers for longer period and should be usable.	Case/Referent
65	product should be designed in a way so that consumer uses it for longer period.	Case/Primary Generator
66	There are many products which consumer still keep with them instead of throwing it away whether it is functional or no.	Case/Primary Generator
67	The reason behind this is "emotional attachment" of user with the product.	Case/Referent
68	User emotionally gets attached to the product because of its design or some functionality.	Case/Primary Generator
69	Design for Disassembly is becoming increasingly recognized as an effective tool by designers, manufacturers	Case/Referent
70	Dismantle offers an innovative disassembly system, based on sliding and snapping actions	Case/Primary Generator
71	Inspired by easy methods used in building toys like LEGO,	Case/Precedent
72	Dismantle can be easily opened and fully disassembled in about ninety seconds.	Case/Precedent
73	Dismantle’s basic disassembly method not only benefits recyclers dealing with disposed products, but it also encourages users to repair and upgrade their devices,	Case/Precedent
74	But when it comes to design form disassemble these irons are not good example, these are not made to be open and repair easily	Case/Primary Generator

75	Panasonic launched an Iron whose water tank can be detached and can be cleaned.	Case/Precedent
76	A survey was conducted to ask about repairing the product says that "if a product is repaired by consumer themselves then 78% get emotionally attached to the product and they will keep that product with them for longer period." which will be helpful in Increasing the life of the product.	Case/Precedent
77	Emotional design and design for disassembly these two approaches of design were studied combined, and new design was developed which says, "Repair it by yourself".	Case/Referent
78	Repair it by yourself is based on design for disassembly	Case/Referent

REFERENCES

1. Akin, O. (2002). Case-based instruction strategies in architecture. *Design Studies , 23* (4), 407-431.
2. Alexander, C. (1977). *A pattern language: towns, buildings, construction.* Oxford University Press.
3. Bamford, G. (2002). From Analysis/synthesis to Conjecture/Analysis: a review of Karl Popper's influence on design methodology in Architecture. *Design Studies, 23* (3), 245-261.
4. Betrabet Gulwadi, G. (2009). Using reflective journals in a sustainable design studio. *International Journal of Sustainability in Higher Education, 10* (1), 43-53.
5. Blessing, L. (1996). Comparison of Design models proposed in prescriptive literature. *COST 4 European Research collaboration on social shaping of technology*
6. Boling, E. (2010). The need for design cases: Disseminating design knowledge. *International journal of Designs for Learning, 1* (1).
7. Boyle, C. (2004). Considerations on educating engineers in sustainability. *International Journal of Sustainability in Higher Education*, 147-155.

8. Brandt, E. (2001). Event driven Product development Collaboration and learning. *Technical University of Denmark, Copenhagen.*
9. Brannen, J. (2005). Mixing Methods: The entry of qualitative and quantitative approaches into the research process. *International Journal of social research methodology, 8* (3), 173-184.
10. Brown, L. (1982). Building a sustainable society. *Society, 19* (2), 75-85.
11. Brundtland, G. K. (1987). *Our Common Future (Brundtland Report).* World Commission on Environment and Development.
12. Bryman, A. (2008). *Social Research Methods.* London: Oxford University Press.
13. Bucciarelli, L. L. (1994). Designing Engineers. *MIT Press*.
14. Buchanan, R. (1992). Wicked Problems in Design Thinking, http://www.jstor.org/stable/1511637. *Design Issues , 8* (2), 5-21 .
15. Buchanan, R. (1995). *Discovering design: explorations in design studies.* University of Chicago Press.
16. Capra, F. (2004). *The hidden connections. A science for sustainable living.* Anchor.
17. Chandler, D. (2002). *Semiotics: The Basics.* London: Routledge.
18. Cherkasky, T. (2004). Design Style: Changing Dominant design practice. *Design Issues , 20* (3), 25-39.
19. Clarke, H. B. (2009). *Design Studies: A Reader.* Berg Publishers.
20. Clune, S. (2009). *Developing Sustainable Literacy in Industrial Design Education.* PhD Thesis, University of Western Sydney, Industrial Design, Sydney.
21. Cobb, P. C. (2003). Design experiments in educational research. *Educational researcher, 32* (1), 9-13.
22. Cohen, L. M. (2013). *Research Methods in education.* Routledge.
23. Cross, N. (2006). *Designerly Ways of Knowing.* London: Springer-Verlag.
24. Darke, J. (1979). The primary generator and the design process. *Design Studies, 1* (1), 36-44.
25. Derntl, M. B. (2006). Essential use of cases of pedagogical patterns. *Computer Science Education* , 137-156.
26. Dewberry, E. (2011). Developing an ecology of mind in design. *18th International Conference on Engineering Design (ICED 11).* Copenhagen.
27. Dewey, J. &. (1949). *Knowing and the known. The Later Works of John Dewey.*

28. Dorst, K. &. (1995). Comparing paradigms for describing design activity. *Design Issues, 16* (2), 261-274.
29. Dorst, K. (2011). The core of 'design thinking' and its application. *Design Studies,* 36,521-533.
30. Dorst, K. (2006). The design analogy; a model for moral problem solving. *Design Studies, Elsivier.* 27,633-656.
31. Eisentraut, R., Gunther, J. (1997). Individual styles of problem solving and their relation to representations in the design process. *Design Studies, Elsivier.*
32. Eilouti, B. (2009). Design Knowledge recycling using precedent based analysis and synthesis models. *Design Studies, 30* (4), 340-368.
33. Elliot, J. (1991). *Action Research for educational change.* UK: McGraw-Hill Education.
34. Faud-Luke, A. (2013). *Design Activism: a beautiful strangeness for a sustainable world.* Routledge.
35. Fendeli, A. (2001). Rethinking Design Education for the 21st century: Theoretical, Methodological, and Ethical Discussion. *Design Issues, 17* (1), 5-17.
36. Fleck, L. (2012). *Genesis and development of a scientific fact.* University of Chicago Press.
37. Fletcher, K. &. (2002). Demi: a case study in design for sustainability. *International Journal of Sustainability in Higher Education*, 38-47.
38. Fletcher, K. D. (2001). Sustainable Consumption by Design. In M. &. Cohen, *Exploring Sustainable Consumption by Design.* Pergamon (Elsivier).
39. Friedman, K. (2003). Theory construction in design research: criteria, approaches, and methods. *Design Studies, 24* (6), 507-522.
40. Fry, T. (2009). *Design Futuring.* Oxford: Berg.
41. Goker, H M. (1997). The effects of experience during design problem solving. *Design Studies, Elsivier.*
42. Goldschmidt, G. (1997) Capturing indeterministic representation in the design problem space, *Design Studies, Elsivier*.
43. Goldschmidt, G. (2001). Linkography, Unfolding the design process. *MIT press*.
44. Habermas, J. H. (1985). *The theory of communicative action.* Beacon Press.
45. Heape, C. (2007). *The Design Space.* PhD thesis, University of Southern Denmark.

46. Heron, J. &. (2006). *The practice of co-operative enquiry: Research 'with' people rather than 'on' people. Handbook on Action Research.*
47. Hiller, B. M. (1972). Knowledge and Design. *Environmental design: research and practice*.
48. Hillier, B. &. (1991). How is design possible? *Journal of Architectural and Planning Research, 3* (1), 4-11.
49. Hinterberger, F. &. (1999). FORUM: Dematerialization, MIPS and Factor10 Physical sustainability indicators as a social device. *Ecological Economics*, 53-56.
50. Illich, I. &. (1973). *Tools of Conviviality.* Berkley: Heydey books.
51. Jackson, M. (2003). *Systems thinking: Creative holism for managers.* Chichester: Wiley.
52. Jonas, W. (2001). A Scenario for Design, URL: http://www.jstor.org/stable/1511876 . *Design Issues, 17* (2), 64-80.
53. Jones, P. S. (2010). *Sustainability education-Perspectives and Practice across Higher Education.* London: Earthscan.
54. Khorshidfard, S. (2011). A paradigm of architectural education, Kolb's model and learning styles in studio pedagogy. *Considering Research, reflecting current themes in Architectural Research.*
55. Kim, H & Lee, W. (2014). Everyday design as design process. *International Journal of Design, 8(1), 1-13.*
56. Kemmins, S. (2001). *Exploring the relevance of critical theory for action research: Emancipatory action research in the footsteps of Jurgen Habermas, Handbook of action research: Participative Inquiry and practice.*
57. Knight, A. (2009). Retrieved 2010, from Proquest Discovery guides: http://www.csa.com/discoveryguides/discoveryguides-main.php.2009
58. Kolko, J. (2010). Abductive thinking and sense making: The drivers of design synthesis. *Design Issues, 26* (1), 15-28.
59. Kolodner, J. (1993). *Case-based reasoning.* San Mateo: Morgan Kaufman.
60. Kuhn, T. (1970). *The Structure of scientific revolutions.* London: The University of Chicago Press.
61. Lawson, B. (2004). Schemata, gambits and precedent: Some factors in design expertise. *Design Studies, 25* (5), 443-457.
62. Lawson, B. (2004). *What designers know.* Oxford: Elsivier.

63. Lerner, F. (2005). Foundations for Design Education Continuing the Bauhaus Vorkus Vision. *Studies in Art Education, 46* (3), 211-226.
64. Levin, P.H. (1966). Decision making in urban design. *Building Research Station*.
65. Levin, P.H. (1966). The design process in planning. *Town Planning Review , 37* (1), 5.
66. Locke, K. & Golden-Biddle, K. (1997). Constructing Opportunities for Contribution: Structuring Intertextual Coherence and "Problematizing' in Organisational Studies. *Academy of Management Journal*.
67. Madge, P. (1997). Ecological Design, A new Critique. *Design Issues , 13* (2), 44-54.
68. Manzini, E. (2003). Scenarios of sustainable well-being. *Design Philosophy papers , 1* (1), 5-21.
69. Manzini, E. &. (2003). *Sustainable everyday, Scenarios of Urban Life.* Triannale de Milano. Milan: Edizioni Ambiente.
70. March, L.J. (1976). The Logic of Design and the Question of Value. In M. L. J, *The Architecture of Form.* Cambridge: Cambridge University Press.
71. Marchand, A. &. (2008). Product development and responsible consumption: designing alternatives for sustainable lifestyles. *Journal of cleaner production, 16* (11), 1163-1169.
72. Margolin, V. (1998). Design for a Sustainable World. *Design Issues, 14* (2), 83-92.
73. Margolin, V. (2002). *The politics of the artificial: Essays on design and design studies.* University of Chicago Press.
74. Mathews, B. (2004). *Studying Design: An interpretive and empirical investigation of design activity at different levels of granularity.* University of Queensland.
75. Maturana, H. &. (1991). *Autopoiesis and cognition: The realization of the living* (Vol. 42). Springer Science & Business media.
76. McDonnough, W. &. (2010). *Cradle to Cradle: Remaking the way we make things.* MacMilan.
77. Meadows, D. M. (1972). *The Limits to Growth.* New York: Universe Books.
78. Merseth, K. (1991). History of Case-Based Instructions: Insights for Teacher Education. *Journal of Teacher Education*.
79. Moreno, D. Y. (2015). A step beyond to overcome design fixation: a design-analogy approach. *Deign Computing and Cognition '14*.
80. Mont, O. (2004). Institutionalisation of sustainable consumption patterns based on shared use. *Ecological Economics* .

81. Nelson H.G & Stolterman, E. (2003). *The design way: Intentional change in an unpredictable world. Foundations and fundamentals of design competence.* Educational technology.
82. Newby. P. (2010). *Research methods for education.* Pearson Education.
83. Norman, D. (2013). *The Design of everyday things:* Basic books.
84. Oh, Y. G. (2013). A theoretical framework of design critiquing in architecture studies. *Design Studies, 34* (3), 302-325.
85. Oxman, R. (1994). Precedents in design: a computational model for the organisation of precedent knowledge. *Design Studies, 15* (2), 141-157.
86. Packard, V. (1963). *The waste makers.* Hardmondsworth: Penguin books.
87. Peirce, C. (1957). *The logic of abduction. Pierce's essays in the philosophy of science.*
88. Piaget, J. (1952). *The origins of intelligence in children.* (Vol. 5). New York: International Universities Press.
89. Ramirez, M. J. (2007). Sustainability integration in Industrial design education a worldwide survey. *International conference on Design Education*. Sydney: University of New South Wales, Sydney, Australia.
90. Ramirez, M. J. (2007). Promoting Sustainability through Industrial design studio projects. *International conference on Design Education*. Sydney: University of New South Wales, Sydney, Australia.
91. Rittel, H. (1973). Dilemmas in a general theory of planning. *Policy Sciences, 4* (2), 155-169.
92. Rowe, P. (1991). *Design Thinking.* MIT Press.
93. Sachs, W. (1998). *Planet Dielectics- Explorations in Environment and Development.* London: Zed Books.
94. Schank, R. (1994). Goal Based scenarios. A radical look at education. *Journal of Learning Sciences, 3* (4), 429-453.
95. Scholl, G. H. (2003). New Concepts in product use for sustainable consumption. *Journal of Cleaner Production* .
96. Scholz, R. L. (2006). Transdisciplinary case studies as a means of sustainability learning: Historical learning. *7* (3), 226-251.
97. Schön, D. A. (1983). *The reflective practitioner, How professionals think in action.* (Vol. 5126). Basic books.

98. Schön, D. A. (1987). *Educating the reflective practitioner.* Jossey-Bass.
99. Schumacher, E. (2011). *Small is Beautiful. A study of economics as if people mattered.* Random House.
100. Seager, T. S. (2012). Sustainable engineering science for resolving wicked problems. *Journal of agricultural and environmental ethics, 25* (4), 467-484.
101. Shove, E. W. (2007). *The design of everyday life.* Berg.
102. Simon, H. (1996). *The Sciences of the Artificial* (3rd edition ed.). Boston: MIT Press.
103. Sprain, L. &. (2012). Pedagogy for sustainability science: case-based approaches for interdisciplinary instruction. *Environmental Communication: A Journal of Nature and Culture, 6* (4), 532-550.
104. Stairs, D. (2005). Altruism as Design Methodology, URL: http://www.jstor.org/stable/25223989. *Design Issues, 21* (2), 3-12.
105. Stenhouse, L. (1980). *Curriculum research and development in action.* Heinemann Educational Publishers.
106. Tanner, C. (2003). Promoting Sustainable consumption, Determinants of Green Purchases by Swiss consumers. *Psychology and Marketing* .
107. Tatum, J. (2004). The challenge of responsible design. *Design Issues*, 66-80.
108. Thakara, J. (2005). *In the bubble. Designing in a Complex World.* Massachusetts Institute of Technology.
109. Thorndike, E. (1931). *Human Learning.* Cambridge: MIT Press.
110. Tischner, U. V. (2009). Worksheets. In M. C. Crul, *Design for Sustainability (D4S)- A step by step approach.* United Nations Environment Program (UNEP).
111. Tischner, U. (2009). Product Service Systems. In M. C. M.R (Ed.), *Sustainability: A Step by Step Approach.* UNEP, TUDELFT.
112. Tobin, K. T. (1994). Referents for changing a science curriculum: A case study of one teacher's change in beliefs. *Science and Education, 3* (3), 245-264.
113. Trebilock, M., & Ford, B (2006). Integration of sustainability in design process of contemporary architectural practice. *The 23rd Conference on Passive and Low Energy Architecture.* Geneva, Switzerland: PLEA2006.
114. Trebilcock, M. (2009). Integrated design process- from analysis/synthesis to conjecture/analysis. *PLEA2009-28th Conference on Passive and Low Energy Architecture.* Quebec city.

115. Tzonis, A. (2014). A Framework of Architectural education. *Frontiers of Architectural Research*.
116. Tzonis, A. (1991). Huts, ships and bottleracks; design by analogy for architects and/or machines. *Research in design thinking.* Delft University Press, 139-164
117. Unaka, N. (2014). *The Cape Verde Project: Teaching Ecologically Sensitive and socially responsive Design.* PhD Thesis, University of Wisconsin, Milwaukee.
118. Visser, W. (1995). Use of episodic knowledge and information in design problem solving. *Design Studies, 16* (2), 171-187.
119. Walker, J. &. (2008). Utilizing the design charrette for teaching sustainability. *International Journal of Sustainability in Higher Education, 9* (2), 157-169.
120. Wang, D. &. (2009). Holding creativity together, A sociological theory of Design Professions. *Design Issues, 25* (1), 5-21.
121. Weizsacker, E. L. (1997). *"Factor-Four": Doubling Wealth- Halving Resource Use.* London: Earthscan.
122. Wilson, S. (1969). Early educational reformers and contemporary architectural education. *Architectural Science Review*, *12* (4), 99-104.
123. Wood, D. B. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry , 17*, 89-100.
124. Young, W. H. (2010). Sustainable consumption, green consumer behaviour when purchasing products. *Sustainable Development Journal* , 20-31

PUBLICATIONS

1. The nature of precedents in present pedagogical practices, Designing Design Education in India, Pune, March 2013. Organised by Indian Design Council.
2. Is Sustainable consumption an oxymoron? Green Consortium, Textile committee, Mumbai, April 2013
3. Understanding attitudes and values of consumers concerning sustainability, organized by Holcim foundation, Zurich at IIT Bombay, April, 2013
4. Effectiveness of Precedent based pedagogy-a case for sustainability precedents, to be presented at International Conference for Research into Design, Jan 2015.
5. Sustainability as Well being, Embedded Values in People's relationship with Products, 2015, NIFT Technical series.
6. Presented white paper on 'Sustainability and Design education' at the plenary session at Cumulus Mumbai December 2015.

Others

1. Chair of roundtable discussions on sustainability and design education along with Prof. S Balaram (former chairman NID and current Founder Dean and Founding member DJ academy) at the Cumulus conference Mumbai, Dec 2015.
2. Chair of the conference track on 'Education and Design theory'.
3. Conducted a workshop for international students at the Cumulus '15 called 'Forming without making' along with Charles Michealson from Norway

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