ANALYSING DESIGN PROCESSES:
A STUDY ON GRADUATION PROJECTS OF
INDUSTRIAL DESIGN STUDENTS

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Approval of the Graduate School of Natural and Applied Sciences

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ABSTRACT

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This study analyses students' design processes within a graduation project that is devised as to approximate a real-life design task. It comprises a literature search on developments in design methodology, and two field studies, a participant observation study followed by long interviews with a selection of the observation sample. Through the literature search, a framework representing the nature of the design activity is brought together on the basis of three studies in descriptive design methodology. Together with the field studies equipped with this framework, this study sought to elucidate students' design processes in order to provide insights for design education. Analysing students' processes, their design problems and the academic scheme within which they operated, pertaining to their respective influences on students' projects and progresses, implications to facilitate further developments of educational curriculum and academic schemes are reached.

Keywords: Design Education, Design Methods, Design Processes.

ÖZ

TASARIM SÜREÇLERININ INCELENMESI:
ENDÜSTRI ÜRÜNLERI TASARIMI ÖGRENCILERININ
MEZUNIYET PROJELERI ÜZERINE BIR ÇALISMA

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Bu çalisma, profesyonel yasamin provasi niteligindeki bir mezuniyet projesi dersinde endüstri ürünleri tasarimi ögrencilerinin tasarim süreçlerini incelemis ve tasarim egitimine katki saglayacak bulgular çikarmayi amaçlamistir. Literatür arastirmasi ile tasarim metodolojisindeki gelismeler incelenmis ve literatürdeki üç farkli çalisma temel alinarak dogal tasarim süreçlerini örnekleyen bir çerçeve olusturulmustur. Bu çerçeveden yararlanilarak iki alan çalismasi yapilmistir. Ögrenciler önce süreçleri boyunca katilimci gözlem yöntemi ile gözlemlenmis, daha sonra ilk örneklemden seçilen ögrenciler ile görüsmeler yapilmistir. Ögrenci süreçlerinin, tasarim problemlerinin ve proje yönetiminin tasarim süreçlerine ve projelerin gelisimine olan etkilerine iliskin bulgular edinilmis, egitim programinin ve proje yönetiminin gelistirilmesine yol gösterebilecek sonuçlara varilmistir.

Anahtar kelimeler: Tasarim Egitimi, Tasarim Metodlari, Tasarim Süreçleri.

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INTRODUCTION

> The step from insights obtained in a descriptive manner to recommendations (prescriptions) is what is called in philosophy the 'is-ought' transition. Something is found to be this and that, and then it is stated that it should be this and that. In philosophy the 'is-ought' transition is a source of controversy, as in a formal logical sense something is wrong. Methodology, and in particular design methodology, however, is full of this transition. Someone observes that in several successful cases a specific similar working method has been used, and subsequently that method is recommended or prescribed with the expectation that success will also follow in other cases. The task of design methodology is to treat this kind of 'is-ought' transition with the greatest caution, because they cannot be avoided. Often things go right, but sometimes they turn out a complete failure (Roozenburg and Eekels, 1995:30).

1.1 MOTIVATION FOR THE STUDY

Learning-by-doing is a time-honoured approach in design education. It is based on the consensus view that designing is a skill, a highly complex and sophisticated one, which can be developed and practiced. Attainment of a skill, i.e. mastery with a musical instrument or having a greater understanding of the design process, is the reward of a learning process that requires guidance and practice. Competence in a skill, moreover, is almost always synonymous with the performer's proactive self-criticism, that is, synonymous with an awareness encompassing both an acknowledgement of the elements of a skill, of sub-skills that through acquisition advance one to competency; and an eagerness to reflect on one's own learning process to identify inadequacies.

The studio is the generalized setting for learning-by-doing in design education. It is organized around consecutive design projects that are more or less resemblances of the actual practice of design. Through these tasks students develop their understandings of the design process, and develop their competences in accord with their understandings. Though much of the skills that a design student has to perfect may be distributed along the curriculum and built into projects that get more complex and demanding gradually, one essential skill for designers, *a willingness and an ability to deal with uncertainty,* is an exception in the sense that it can be considered as a prerequisite to learning-by-doing. This skill, according to Lawson (2000), enables designers to continue to act in conditions where the whole does not yet make sense. These conditions which Lawson refers to are not only unavoidable realities for the practising designer, but his description also applies to learning-by-doing, which is almost by definition encompassed by vagueness. In learning-by-doing, students do not apply classroom knowledge to practical problems but are expected to perform right from the outset, before knowing what they need to do or what they need to learn (Schön, 1985). This recognized approach of design learning, in turn, renders the acquisition of other skills a covert affair: they should be somewhere around or related to the artistry of ‘thinking like a designer’, but where?

Schön (1985) states, students of design may not understand what designing means particularly in the early stages of their education. They are within a ‘double paradox’. On the one hand students cannot initially understand what they need to learn, and on the other hand they can only learn it through educating themselves by beginning to perform. Hopefully, students get the sort of experiences that will help them learn what designing means, what designing involves. According to Schön, for a time at least, students will be swimming in unknown waters, without competence, without control, and without understanding. If the students learn to think about their processes and structure and restructure their understandings of it, they will have a way

of reflecting on this new experience of the studio. Whereas if they have no concepts to describe what is happening to them, they will not.

Design students astonish their tutors from time to time with successful or lame outcomes regardless of their prior performances. The author believes that the cause of this astonishment in the form of awe or disappointment is related to varying insights the students gain from their design processes. Students' accumulations in various skills and knowledge related to design as well as their values and attitudes influence their performances substantially. Such unpredictability, however, might be stemming from students' accumulations in their understandings of the design process. As Roozenburg and Eekels point out in the epigraph to this chapter, often things may go right as students approach each new and distinct design problem with attitudes and procedures that have been, in a way, recipes from their previous assignments, but sometimes they may turn out a failure.

These recipes are in fact an indication that students do structure some understandings, but not necessarily in relation to design processes. Instead, such discoveries may be more about design education itself and performing within its recognised method. These may be shortcuts to solutions or *success*; instead of mature, fruitful design processes that they need to develop in order to tackle with the unique structures of design problems they are being assigned. This inclination partly stems from the educational setting according to Lawson (2000), for the students are not only learning through studio projects but are also performing and being assessed through them. He further points out that a process that has made a good learning experience may not necessarily generate a high mark. Thus, he maintains, students strive towards solutions, which will be assessed rather than showing a development in their methodology.

Internalisation of the famous phrase 'all is well that ends well' by the students as well as the tutors of design may pose a threat to the effectiveness of the

method learning-by-doing. A warning is already issued concerning students' processes, and especially regarding those that 'end well'. Just as a process that has made a good learning experience may not necessarily generate a high mark, a 'good' design a student comes up with at the end of a process may not necessarily mean a good learning experience; and in fact may be quite the opposite. Coupled with a high mark, it may generate a false consciousness on how to carry out the design work in the next studio project, or worse, in the real world. Thus, whilst the task of design methodology is to treat 'is-ought transition' with great caution as Roozenburg and Eekels (1995) warns, design education should be concerned with how students shape their understandings of the design activity; since it is all about what the students 'learn' by doing, and what they are, knowingly or not, 'encouraged to learn'.

Students certainly are not alone in their learning processes. Schön (1983) stresses that notions of a mature design procedure are inherent in a studio master's design reviews. Through reviewing student works and pointing out their mishandlings of particular situations, Schön implies, the notion of competent practice and the skills peculiar to this individual master would 'rub off', in terms of Lawson (2000:23). According to Lawson design teaching in its traditional form involved putting a young designer under the care of a recognized master, and the hope was that as a result of an extended period of this service the student would transfer his master's skills and style to himself. Schön argues, architecture still carries with itself an earlier view of professional competence and knowledge, of craft tradition; and this is the reason architecture education embraces such a tradition of guidance, or apprenticeship.

Schön (1983) reflects on a design review between Quist the studio master and his student Petra, and gives a somewhat heroic account of the tutor's role in design education. He stresses that the design review proceeds by means of a certain type of thinking as Quist demonstrates the competences

he would like his student to acquire. Designing, for Schön, is 'a reflective conversation with the materials of the design situation[1] (Schön, 1983)', and he calls this reciprocal process 'reflection-in-action'. In the review Quist demonstrates a designerly way to reframe Petra's problem, carries out a reflective conversation with her crisis, which 'talks back' as he makes modifications on her plans and sections. He bases his demonstrations on a set of 'design domains', not stating or listing them explicitly, and avoids making remarks that would fall out of her 'things to think with'. However, Quist's 'virtuoso performance' as observed as he 'spins out a web of moves' begs the questions whether all design tutors are or should be accomplished performers like him, what are those competences and design domains he would like Petra to acquire and what does she make out of his moves. Moreover, where do these discussions leave academic schemes, the educational programmes and guidelines in the whole picture, and what are their latent effects and uses alongside design reviews in conveying or helping students to structure an understanding of the design activity?

Relevantly, a study by Korkut and Hasdogan (1998) on the correspondence between education and practice of industrial design in Turkey reveals that managers hiring industrial designers demand less from designers than what the designers think they are capable of offering. Their study also implicitly

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[1] According to Schön (1983), when people carry out the spontaneous, intuitive performance of the actions of everyday life, they seem to be knowledgeable in a special way. This kind of knowing, Schön states, is ordinarily tacit, implicit in the patterns of action. For him, one's knowing is in one's action. But sometimes people face unanticipated events, which do not fit existing understandings, which fall outside the categories of knowing-in-action. These events, causing uncertainty, prevent one to make sense of the situation. Often these appear as unique events or value-conflicts, and together with uncertainty, they make up what Schön calls the 'indeterminate zones of practice'. They demand reflection and force the inquirer, the designer to turn to the surprising phenomena and to himself, to his knowing-in-action at the same time. Such reflection must take place in the 'action-present' according to Schön, in the period of time where the thinking can still make a difference to the outcomes of the action. While questioning and challenging the statements that will underlie the actions, it restructures strategies, understanding of the phenomena and ways of framing problems. This kind of reflection then gives rise to an action, an on-the-spot experimentation with the restructured strategies and understandings. This experimentation may provide either satisfactory results, or may bring forth further surprises, 'pleasant or unpleasant.' In these instances, it is as though the situation is 'talking back' to the inquirer, triggering a reframing of the problem, a reunderstanding of the situation. Thus, for Schön, the entire process has the quality of a 'reflective conversation with the situation.'

unveils that such preconceptions and doubts about design and designers may be shaped for the better by the designers themselves, who are ‘equipped with adequate skills and knowledge as to have an impact on the organisation of design activity and the product development process in their companies’ (Korkut and Hasdogan, 1998:131). Such prospect of reintroducing industrial design to its working environment and receiving wider recognition is, clearly, relying upon its education and its forthcoming practitioners.

1.2 AIM AND SCOPE OF THE STUDY

The aim of this study is to elucidate students’ design processes in relation to a descriptive reference of the nature of the design activity, in order to provide insights for design education and to facilitate further developments of academic schemes.

Therefore the study requires:

- An understanding of the nature of the design activity, of intuitive design, to propose a relatively common outline of the actual design practice.
- And an investigation into students’ design processes that are seemingly private and individual, yet guided as well.

To fulfil the first objective a literature survey will be carried out. The second objective calls for a field study, equipped with a natural conceptualisation of the design activity to be provided by the literature survey. Both research directions will be explored in order to bring to light, in a cause and effect manner, factors and conditions that affect students’ design processes; and in doing so, the study seeks to provide a body of information to design education through revealing cautionary or favourable conditions. The questions to be addressed in the literature survey are:

- What are the forces and mechanisms operational in design processes?

- Are there sequences of activities that naturally occur in designing?
- How do designers design? How do they carry out their design processes?
- How do designers deal with their problems? Are there strategies or cognitive styles common to their thinking?
- What factors or competences differentiate an accomplished designer and a student of design?

The questions to be addressed in the field study are:

- What are the forces and mechanisms operational in studio projects?
- How do students carry out their design processes? Do they differ in their ways of carrying out their design processes?
- What are the factors that affect students' processes, and their progresses against time?
- What are the latent effects and uses of academic schemes that are devised on a project basis? Do they conform to the nature of the design activity?
- To what extent students' design processes and academic schemes conform to each other?
- Do academic schemes convey, or help students to structure, an understanding of the nature of the design activity?

1.3 STRUCTURE OF THE THESIS

This chapter brought up and briefly discussed the essentiality of pursuing such a study. The seemingly risky nature of design education and the hardships of structuring an understanding of the design process are presented.

In chapter 2, developments in design methodology from the early 1960s to the present will be investigated. The literature search was predominantly conducted to propose, through an examination of the developments in

design methodology, a relatively common framework of actual design practice outlining a natural conceptualisation of the design activity. The findings will be discussed at the end of chapter 2, and conclusions will be made through presenting the key components of the nature of the design activity.

An observational study was carried out on students of design, equipped with the framework developed in the second chapter, in order that it may serve in elucidating their processes. The study took place at the Middle East Technical University, Department of Industrial Design in Ankara, Turkey, and covered the 2002-2003 Spring term. The academic scheme within which the students performed is discussed in terms of the framework as well. A further study, interviews with a sample of the students was found to be appropriate not only to validate the findings of the observational study, but also to supplement them. The design and conduct of both studies will be addressed in chapter 3.

Findings from the field studies will be presented in chapter 4. Considering the amount of information from both studies and their complementary nature, it is decided to keep the discussions to the interview sample. Factors in relation to commencement and development stages of students' design processes will be presented in their respective sections, and it is decided to devote a separate section to the issues pertaining to the academic scheme in keeping with the aims of the study.

Finally, the findings of the study relating to the stated objectives and their implications for further developments of educational curriculum and academic schemes will be presented in chapter 5, together with their implications for further studies.

CHAPTER 2

DEVELOPMENTS IN DESIGN METHODOLOGY

2.1 INTRODUCTION

Design methodology, as it is understood today, is the study of the principles, practices and procedures of design in a rather broad and general sense. Its central concern is with how designing both *is* and *might be* conducted. This concern therefore includes the study of how designers work and think; the establishment of appropriate structures for the design process; the development and application of new design methods, techniques and procedures; and reflection on the nature and extent of design knowledge and its application to design problems (Cross, 1984).

Throughout the rather short history of design methodology, there have been many attempts to develop models of the design process. Recently, a retrospective taxonomist approach is much favoured rather than suggesting new models. In an attempt to classify design models, Cross (1994) points out that some of these models simply *describe* the sequences of activities that typically occur in designing, where other models attempt to *prescribe* a better or more appropriate pattern of activities.

The models that describe the design process take into account the solution-focused nature of designing to build lifelike conceptualisations of design as an activity. Processes suggested by descriptive models are mainly heuristic. They regard using previous experience, general guidelines and ‘rules of thumb’ as natural and essential to the design process. Descriptive models of

the design process usually emphasize the importance of generating a solution concept early in process. This initial solution conjecture is then subjected to analysis and evaluation. The prescriptive models, on the other hand, are concerned with trying to persuade or encourage designers to adopt improved ways of working and they offer a more algorithmic, systematic procedure to follow. The prescriptive models try to make sure that the design problem is fully understood, that no important elements of it overlooked, and that the 'real' problem is identified. These models, therefore, are usually rigorously diagrammatical in form and though may be context bound; tend to suggest the basic structure of analysis – synthesis – evaluation to the design process.

Although these two main types of models identified now constitute the two bodies of design methodology with different tasks appointed to them[2] (Roozenburg and Eekels, 1995), it should be noted that the evolutionary phases of design methodology have governed prescriptive and descriptive natures respectively. Methodologists especially in the early phases, though being against individual and self-conscious ways of carrying out the design work, prescribed quite personal procedures for the design process themselves. They were influenced by the prevailing attitudes and beliefs of their times, thus together with a criticism of existing procedures in designing, they offered models that would better match their conceptions of the nature of the design activity.

It is essential to present a brief overview to the emergence of the design profession, to the issues that necessitated and initiated the design methods studies and then to subsequent developments in the field to make it clear how the prescriptive methods eventually gave way to their descriptive counterparts through a shift in focus and understanding concerning the

[2] According to Roozenburg and Eekels (1995), Descriptive design methodology tries to reveal the methods applied in design through logical structural analyses, and empirical research, as well as to identify the needs for methodical support. Prescriptive or normative design methodology forms an opinion based on descriptive analyses, and recommends for certain problems the application of certain methods, or even demands it.

design activity. At least it would aid in keeping track of the subsequent developments in design methodology if it is sustained in mind that the design methods movement has progressed through four phases: *prescription* of an ideal design process, *description* of the intrinsic nature of design problems, *observation* of the reality of design activity and *reflection* on the fundamental concepts of design (Cross, 1984).

In the period from the early to middle 1960s, there was a concern with the development of systematic procedures for the overall management of the design process, and of systematic techniques to be used within such a process. This was the period of ‘systematic design’ in which attempts were made to restructure the design process on the basis of the new methods and techniques of problem solving, management and operational research, which had been developed in World War II and in the 1950s. It soon became realized, however that design problems were not so amenable to systematisation as had been hoped and in the late 60s and early 70s, attention had turned to trying to understand the apparent complexity of these particular kinds of problems. The major issues in this phase of design methodology revolve around the ‘ill-structuredness’ of design problems. Through this acknowledgement of the complexity of design problems, researchers in the late 70s aimed to develop a greater understanding of how designers deal with such problems with their normal, conventional design procedures. Research in this phase of design methodology embodies a range of methods of enquiry, which have been used to investigate designer behaviour, from controlled laboratory experiments to open-ended interviews. Finally the last phase reflect the more fundamental and philosophical approach, which emerged in the second decade of design methodology. This more mature and reflective approach has been able to draw upon the knowledge gained and the lessons learned in the first decade (Cross, 1984). In fact many of the thinking and research done in last two phases of design methodology were interdependent. That is, many of the observations were,

in a way, the field tests of reflective thinking on the design process and also the results of observations had influenced many of the writings.

2.2 EMERGENCE OF DESIGN METHODS

The division of labour between those who design and those who make has become a keystone of our technological society (Lawson, 2000). The process of making something cannot normally start before the process of designing is complete in modern, industrial societies. This fact is unlike the vernacular process where designing is very closely associated with making (Cross, 1994). The separation between designing and making took place in the early nineteenth century with professionalisation. Initiating a new culture of designing, it forcefully distinguished itself from the anonymous vernacular practices; and later the Industrial Revolution with the technological and social changes it brought about rendered the vernacular processes incompetent. However the remaining method of design activity had also seen wanting by the design methodologists in the 1960s with the civilian consequences of the scientific and technological developments which the Second World War necessitated, such as operations research and management decision-making techniques (Cross, 2001).

Schön (1985) commenting on the dilemmas surrounding the practice and education of architecture points out that architecture had 'crystallized as a profession' before systematic approaches had emerged[3]. Lawson (2000) similarly argues that the separation of designing from making can be traced back to the nineteenth century where organizations such as the Institute of British Architects were founded 'with aspirations to rise, control and unify standards of practice'. Professionalism, he further maintains, was in reality

[3] According to Schön (1985), architecture *still* carries with itself an earlier view of professional competence and knowledge, of craft tradition; and this is the reason architecture education embraces the tradition of education for performance.

and at the outset, not concerned with design or the design process but rather with the search for status and control.

Christopher Alexander, whose work *Notes on the Synthesis of Form* (1967) now stands as a symbol for the initial phase of design methodology, based his discussion on a clear account of this shift in the designer's role and his education. According to Alexander (1967), a novice in the vernacular situation learns by 'being put right whenever he goes wrong'. The master makes no attempt to formulate conceptually just what the right way involves, thus the right way turns out to be the residue when all the wrong ways are eliminated. In the schools of design where education is influenced by professionalisation and its concern for status, on the other hand, success and failure is defined and students are told to perform according to the principles generated from such definitions. Personal style is dominant, and individuality is encouraged. Alexander calls a culture *unselfconscious* if its form-making is learned informally, through imitation and correction; and he calls a culture *selfconscious* if its form-making is taught academically, according to explicit rules, a culture in which a profession called 'architecture' exists (Alexander, 1967).

The *unselfconsciousness* of the vernacular process means design decisions are made according to necessities in a collective way rather than any individual's new ideas. Changes are based on incremental evolution, and after many generations of evolution, the end product becomes a totally integrated response to the problem[4]. The unselfconscious processes do not move from one change to the next in discreet steps, rather the movement, the changes are continuous and smooth over a long period of time. The process is self-adjusting, homeostatic in Alexander's terms, consistently producing relevant forms that are adequate until the next necessity for change appears. In such cultures, Alexander points out, 'there is no special

[4] Design solutions offering an integrated response to the problem, where it is not quite identifiable which part of the solution handles which part of the problem are usually accepted as good designs by many, including Lawson (2000).

market for individual inventiveness'; and as Lawson (2000) states, the Eskimos do not require an architect to design the igloo in which they live. Thus the form maker is an agent simply, no creative strength is required of him; he does not need to be able to improve the form, only attempting some sort of change when he notices a failure, his sole existence in the process is thus adequate.

The *selfconsciousness* of the professionalised process, on the other hand, comes from architectural individualism according to Alexander: "The artist's self conscious recognition of his individuality has a deep effect on the process of form-making. Each form is now seen as the work of a single man, and its success is his achievement only" (Alexander, 1967:59). With the cultures in which a profession called architecture exists, where the individual and the unique is praised, the changes born out of necessity and a detection of failure in the vernacular tradition weakens and 'change for its own sake' becomes acceptable. Failures are 'detected' in the vernacular process and adjustments are made within its self-adjusting evolutionary process, whereas in the professional process, failures have to be 'reported' several times before the necessary improvements could take place only in the next design (Alexander 1967). In Frank Lloyd Wright's experience, 'The physician can bury his mistakes, but the architect can only advise his client to plant vines (Lawson, 2000).'

The discovery of architecture, coupled later with the irreversible changes that the Industrial Revolution brought about, cost the form-making process many fundamental changes. As Dormer (1990) states, the essence of craftwork is working a particular material. However with the Industrial Revolution, changes in both the materials and technologies available became too rapid for the craftsman's evolutionary progression to manage. The professional specialised designer producing drawings from which others build has in fact come to be such a stable and familiar image, according to Lawson (2000), that this process is regarded as the traditional form of design. However, for

Alexander, what this traditional form, this selfconscious process tries to do is ‘to achieve in a few hours at the drawing board what once took centuries of adaptation and development, to invent a form suddenly which clearly fits its context’ (Alexander, 1967:59). The selfconscious process, relying on style and professional tradition, and a selfconscious designer’s view of himself as an ‘artist’ or his depending on ‘catchwords’ or intuition is severely criticised by Alexander. For him, ‘in an era that badly needs designers with a synthetic grasp of the organization of the physical world, the real work has to be done by less gifted engineers, because the designers hide their gift in irresponsible pretension to genius’ (Alexander, 1967:11).

Christopher Jones, one of the pioneers of the early design methods similarly refers to the separation of designing from making (Jones, 1970). Compelled by how the craftsman’s know-how and ignorance could yield such fascinating results with a high level of formal organization, he outlines some characteristics of the craft process. One important characteristic of the craft tradition as identified by Jones is that, the craftsmen do not and often cannot draw, and give adequate reasons for their decisions. Secondly, he too mentions the evolutionary process of craft tradition. Through countless failures and successes in a process of trial and error over many centuries, it produces astonishingly well-balanced results fitting the needs of the users. Forms do not change except to correct errors or to meet new demands, and changes occur only one thing at a time, relying on precedents. This is the weakness and inadequacy of the vernacular process for Jones (1970) in a modern and industrial world, which is calling for a complete reorganization of the form as a whole. He refers both to the vernacular and the professional processes as ‘traditional methods’, and for him in the former the designer is the ‘maker-of-things’, and in the latter he is the ‘maker-of-drawings’. Jones calls the latter tradition design-by-drawing and sees it as an accelerated version of the craft evolution. The change from craftsmanship to draughtsmanship gave the designer a much greater ‘perceptual span’, Jones states; and separating thinking from making, it allowed designers to change

and arrange several components of a single design by means of drawings. But the ‘critical early stages’ of a design process in design-by-drawing were carried out in a single mind, that of an illustrious ‘chief designer’ where inputs from many minds, from many specialists from diverse fields of research were required according to Jones (1970). Thus just as drawings served as a new way of modelling the final product, newer models were required in order to keep up with the rapid rate of change and innovation.

2.3 DEVELOPMENTS IN DESIGN METHODOLOGY

2.3.1 Prescription of an Ideal Design Process

Dissatisfied with the traditional procedures of carrying out the design process, and finding them improper for their times, design methodologists from various areas of design proposed new, systematic design procedures. There were considerable commonalities in the reasons given for the emergence and the necessity of these systematic approaches.

Firstly, along with the discussions on vernacular evolution of products and the traditional procedure of design-by-drawing mentioned before, methodologists were also motivated by the increasing technological changes occurring in the late 1950s and the early 1960s, which inevitably caused increasing complexity in the designer’s task; while introducing new bodies of interdisciplinary knowledge into the design field.

Jones (1963) mentioned a trend throughout the 1950s towards more logical and systematic methods of design as a result of the new technological developments such as computers, automatic controls and systems. He also referred to the attempts during the same period to give more scope for imagination and creative thought by means of recent techniques such as ‘brainstorming’ or ‘synectics’. He attempted to integrate all such developments he had noticed into a unified system of design. Fascinated by

the solutions of craft tradition, as already seen, Jones aimed his *A Method of Systematic Design* particularly at the area that lies between traditional methods, based on intuition and experience, on the one hand, and a rigorous mathematical or logical treatment, on the other (Jones, 1963). Alexander similarly based his discussion on the same concern, stating: 'Today more and more design problems are reaching insoluble levels of complexity' (Alexander, 1967:3). To match the growing complexity of problems, he suggested taking advantage of the growing body of information and specialist experience. He too stressed the introduction of mathematics and logic into design. Mathematics should be used as a tool to 'explore the conceptual order and pattern which a problem presents to its designer' and through logic, designers could 'invent purely artificial structures of elements and relations' according to Alexander. The method he described was based on non-numerical mathematics arising from the use of sets and graphs to represent systems of interacting functions, and he used a computer to carry out the method since the application of his method demanded a great amount of computation (Alexander, 1963). Archer (1965) recalled the times when the user needs were simpler, materials few, and manufacturing methods relatively basic. At such times the industrial designer was able to adopt rules of thumb to meet these domains and functions and his job was rather sculptural according to Archer. Paradoxically the relaxation of the limitations of materials and manufacturing processes has made the job of the designer more difficult, Archer points out, 'since he must now choose and decide in many cases where the decision was previously made for him (Archer, 1965:57)'. This situation, for Archer, demanded a shift in emphasis from the sculptural to the technological, incorporating knowledge of ergonomics, cybernetics, marketing, and management science into design thinking. Archer, like Jones, mentioned the prevalent trend of their time towards the adoption of a systems approach rather than an artefact approach. He based his work on systematic methods of problem solving that were borrowed from computer techniques and management theory for the assessment of design problems and the development of design solutions.

Thus it can be said that, the prevailing tendency in design methodology at the outset, was to consider the whole system of which the product is a part, instead of considering the product as an isolated object.

Secondly, the aims of these systematic procedures were quite similar as well. Jones' method for example, integrating creative thought and systematic means is set to have two effects: to reduce the amount of design error, re-design and delay; and to make possible more imaginative and advanced designs (Jones, 1963). Archer similarly pointed at three conditions, which, under one or more of them systematic methods should be considered: '…when the consequences of being wrong are grave; when the probability of being wrong is high (e.g. due to lack of prior experience); and/or when the number of interacting variables is so great that the break-even point of man-hour cost versus machine-hour cost is passed (Archer, 1965:63).'

These common concerns resulted in a considerable commonality of approach. There was an emphasis on extensive problem exploration and analysis to identify all the factors that have to be taken into account, and they also adopted the common approach of breaking down the overall problem into its sub-problems and then attempting to synthesize a complete solution by combining partial solutions. Cross (1994), however, points out that these apparently sensible, rational procedures are not always followed in conventional design practice.

Jones' method, *A Method of Systematic Design* (1963), was one of the first attempts to provide a completely new way of proceeding with engineering design. As mentioned before it did not attempt to replace every aspect of conventional design; it was based on the recognition that intuitive and irrational aspects of thought have just as important roles to play in designing. Jones' method was a way of organizing the design process so that his two essentials to the design process, logical analysis and creative thought would proceed in their own different ways. For Jones, logical analysis called for a

step-by-step sequence which could break down with the least departure from the chain of progress, whereas creative thought required alternation between all aspects of the problem, in any order, and at any time. Thus, his systematic design method attempted to recognize and to separate the two ways of thinking by the use of clear, externalised procedures, rather than leaving them as internal mental struggles for the designer. It suggested leaving the designer's mind as free as possible for random, creative ideas or insights by providing systematic methods for keeping data, information, and requirements out of the memory. In his own words Jones' method is:

> 1. To leave the mind free to produce ideas, solutions, hunches, guesswork, at anytime without being inhibited by practical limitations and without confusing the process of analysis.
>
> 2. To provide a system of notation which records *every* item of design information outside the memory, keeps design requirements and solutions completely separate from each other, and provides a systematic means of relating solutions to requirements with the least possible compromise (Jones, 1963:10-11).

Jones' method suggested a rational framework within which the irrational has its own time and space. The framework consisted essentially of a procedure of three distinct stages:

> 1. *Analysis*: Listing of all design requirements and the reduction of these to a complete set of logically related performance specifications.
>
> 2. *Synthesis*: Finding possible solutions for each individual performance specification and building up complete designs from these with least possible compromise
>
> 3. *Evaluation*: Evaluating the accuracy with which alternative designs fulfil performance requirements for operation, manufacture and sales *before* the final design is selected (Jones, 1963:11).

Though at first sight this basic model of *analysis – synthesis – evaluation* seems quite *descriptive* for the conventional design process and reasonable to follow, what makes this sequence a *prescription* is its implementation.

Jones offered a variety of techniques within each stage, appropriate to the main task. In the *analysis* stage the participants list all the thoughts that

occur to them to form a *random list of factors*. The objective is to obtain a large amount of information in a short time. Once the initial reactions and feelings about the problem are stated, Jones suggests extending the random list to cover every single factor, which could be thought to influence the design. Then these factors are organized using *classification charts;* and through this activity more factors may reveal themselves to be added to the list. *Sources of information* relevant to the factors listed are examined and verified through literature, observations and experiments and then *interactions between factors* are drawn. The systematic approach uses charts to ensure that all possible interactions are discovered, and diagrams to make clear patterns of relationships. For Jones, a complete separation of problem from solution can only be achieved if the requirements are expressed purely in terms of performance and with no reference to shape. To do this each requirement is rewritten as a *performance specification*, or a P-SPEC, in Jones' terms. The complete list of P-SPECS is then circulated to all persons whose agreement to the final design will be required at a later stage.

In the *synthesis* stage, the initial move is given to *creative thinking.* According to Jones, the power of imagination which can be applied to solving of a design problem involves first a clear statement of the problem, which also justifies the previous stage of analysis, and a free atmosphere in which any idea can be expressed without regard to its practicability. He suggests the use of techniques such as brainstorming to unleash creative ideas. Brainstorming sessions are recorded for thorough evaluation later. After the *creative thinking* step, Jones strongly proposes to generate *partial solutions,* which are developed and handled completely independent of any other. Traditional methods, according to Jones, develop a single solution proposal which is conceived as a whole with details being considered gradually. Systematic design on the other hand, reversing this procedure, generates partial solutions, one or more for each P-SPEC, and then combines them by permutation 'to give several alternative whole solutions.' Then the *limits*

under which each of the partial solutions will perform satisfactorily are determined. The next step involves *combining partial solutions* with the least departure from P-SPECS. An interaction matrix is suggested in this step to determine compatible and incompatible partial solutions, through which logical sequences, hierarchies in which partial solutions should be combined are made visible. *Solution plotting* concludes the synthesis stage, which is a means of making clear the relationships between solutions; not only between the proposed alternative combinations, but also the previous designs on the market are considered and substantial departures from existing designs are sought.

The purpose of the *evaluation* stage is to detect errors within the process when they can be most cheaply corrected, that is, when the increasingly expensive processes of drawing, manufacture, selling, installation, and use do not have to be repeated in order to make the correction. According to Jones, evaluation phase should incorporate more logical, more exhaustive and more expensive methods of evaluation than the traditional ways of judgement, which are based on the experience of designers and done over design drawings. For him, the evaluation stage should take advantage of the recent methods such as field trials, market surveys, models, simulations, computers, operational research, pre-production and pre-engineering studies and product planning. Jones relates these new methods to the techniques described in the stages analysis and synthesis to evaluate designs for operation, manufacture and sales.

As can be observed in Jones' various steps for each of the stages of his model, the emphasis here is on performance specifications logically derived from the design problem, generating several alternative design concepts by building up the best sub-solutions and making a rational choice of the best of the alternative designs.

Alexander's method conceived for urban design presented in his work *The Determination of Components for an Indian Village* (1963), and discussed thoroughly in his influential book *Notes on the Synthesis of Form* (1967), was essentially based on a successive hierarchical division and partition of the problem context, and then a successive hierarchical composition and fusion of sub-solutions leading to the physical object. The first part of the method is truly *analytical*, and the second part of it is *synthetic* in nature. Alexander, praised the good designs that the unselfconscious, evolutionary craft process had developed, but also pointed out that it no longer may do so under the quick shifts in contextual requirements. Together with his mistrust for the professional procedures that rely on pre-conceived concepts and categories, Alexander offered to start from scratch. For him, the unselfconscious process could be expressed as follows (Figure 2.1):

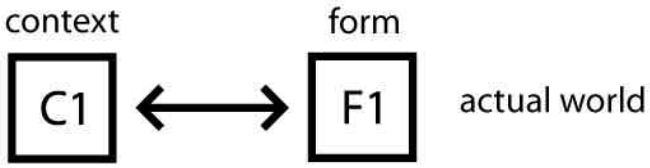

Figure 2.1 The unselfconscious situation (Figure adapted from Alexander, 1967: 76).

Here the process that shapes the form is a complex two-directional interaction between the context C1 and the form F1, taking place in the actual world. The craftsman is only present as an agent in this process. He reacts to inadequacies by changing them; but does not impose any designed conception on the form. In the selfconscious situation on the other hand, the design process is remote from this direct interaction between the context's demands and the inadequacies of the form. Form is shaped by a conceptual interaction between the conceptual picture of the context which the designer has learned and invented on the one hand, and ideas and drawings which stand for forms on the other (Figure 2.2).

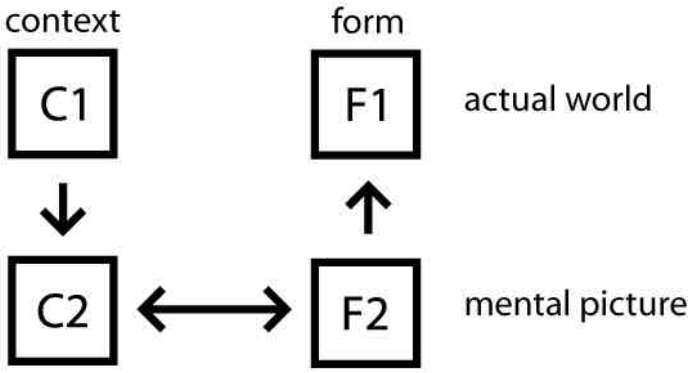

Figure 2.2 The selfconscious situation (Figure adapted from Alexander, 1964: 76).

In the traditional design practice, Alexander argued, this critical step during which the problem is prepared and translated into design always depends on some kind of intuition. Such an imaginative and intuitive process offered little confidence to Alexander. For him, nobody makes a picture of the context in the unselfconscious process, so there cannot be a wrong picture. Conversely the selfconscious designer worked entirely from the picture in his mind, and this picture, for Alexander, was almost always wrong (Alexander, 1967).

Drawing upon biological and chemical analogies, he was motivated by how deeply the nature of an object is determined by the nature of its components. However, much of the forms, according to Alexander, were ensnared by the persistence of known components that direct the designers' conceptions of the problem:

> Once you decide that a car is to be made of four wheels, engine, chassis and superstructure, there are really very few essential changes you can make. You can alter the shape of the components, and the way they are put together; but what you have remains a car, as we have known it for fifty years, even though it may be this year's model rather than the last year's. (Alexander, 1963:34)

Alexander was concerned with the problem of finding the right physical components of a physical structure, in a way that each component can be altered independently to suit future changes in the environment. To

accomplish this he proposed a method of structuring design problems that would allow designers to see a graphical representation of the structure of non-visual problems, adding another step to the process. His purpose was to give a further abstract picture of the first picture of the problem (Figure 2.3).

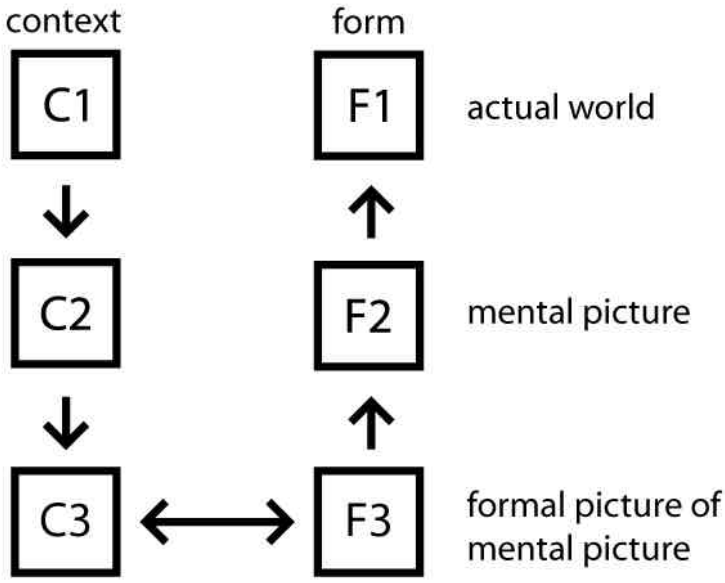

Figure 2.3 Third step to retain conceptual structural features (Figure adapted from Alexander, 1967: 76).

This further step, Alexander argued, got rid of the bias of the selfconscious process and retains only its conceptual structural features. Therefore, this second picture may then be examined according to precisely defined operations apart from the bias of form language and experience. The individualistic and arguable picture of the context's demands, C2, which develops in the designer's mind, is followed by a mathematical picture, C3, which is composed of sets. Similarly the design F2 is preceded in Alexander's method by an orderly complex of diagrams F3. He admits that the derivation of these diagrams from the mathematical picture, F3 from C3 is still intuitive. However, Alexander was comfortable with intuition as long as it took place remote from C2 or F2, remote from the designer and his pre-

conceptions. Forms were then shaped by a process at the third level, which was ‘out in the open, and therefore under control.’

This brief outline to Alexander’s method illustrates how it seems reasonable and quite interesting at first sight, like Jones’ model, but is not only exceedingly complex to carry out, but also paradoxically rather vague and individualistic in transforming the decomposed problem into form. In Alexander’s words, his process proceeds as follows:

> The starting point of analysis is the requirement. The end product of analysis is a program, which is a tree of sets of requirements. The starting point of synthesis is the diagram. The end product of synthesis is the realization of the problem, which is a tree of diagrams. The program is made by decomposing a set of requirements into successively smaller subsets. The realization is made by making small diagrams and putting them together as the program directs, to get more and more complex diagrams. To achieve this we must learn to match each set of requirements in the program with a corresponding diagram.(Alexander, 1967:84)

Alexander’s components for the Indian village started with an observation of the problem context and an exhaustive listing of its requirements. Then he decided for each pair of requirements whether or not they interact, or are dependent. Partitioning the linked requirements into independent subsystems then derived the subsystems of the problem context. Since this was a large and complex task Alexander derived a computer method for doing this, based on graph theory and the remaining task was to design components to match the subsystems. In the Indian village, Alexander identified a total of 141 basic requirements, which are then grouped into twelve independent minor subsystems, which could be combined into four major subsystems. For each subsystem he provided a diagrammatic concept for a matching component. Thus his ‘entire village’ took form (Figure 2.4).

The weak point in Alexander’s method was that while searching for objectivity in shaping forms, he contended that the diagrams could both describe the context and bring implications for form. Since, he argued, the set of variables constituting *the program* came from its physical structure (the

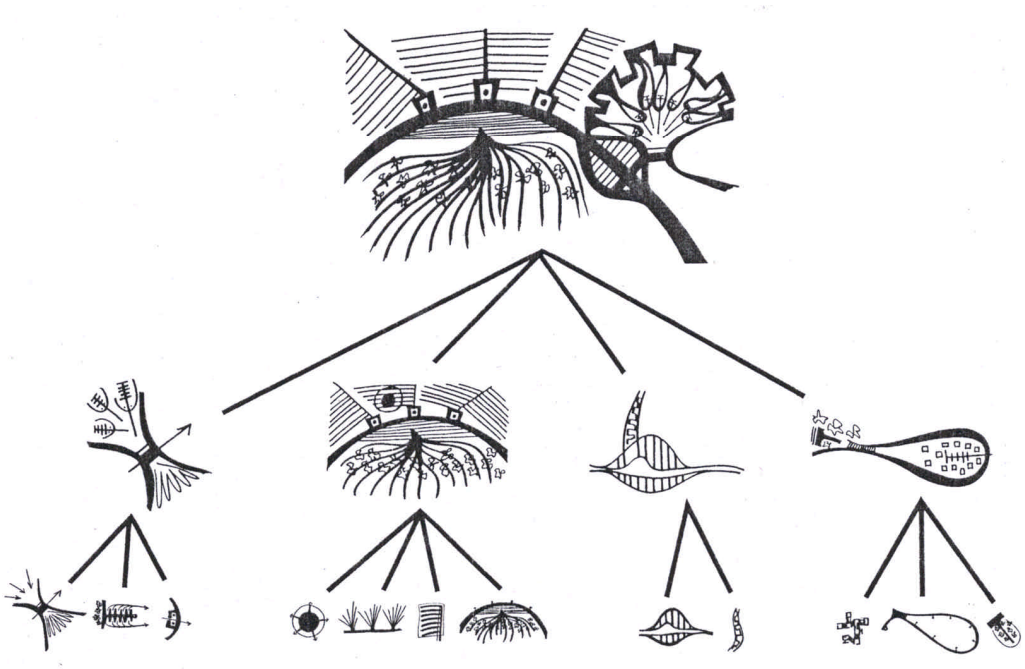

Figure 2.4 The entire Indian village (Alexander, 1967:153).

components), they could only be grasped graphically, by means of diagrams. However the generation of diagrams were still dependent upon designers' representational abilities which are rather personal. These "logical or magical" compositions towards the synthesis stage (Hillier, Musgrove and O'Sullivan, 1972:258), how the requirements take the form they are given and combined to form wholes, not only in Alexander's method but in the systematic procedures in general, remained a question.

The common aims underlying these initial methods and the models they propose are beginning to take shape. These methods as Jones pointed out were "attempts to make public the hitherto private thinking of designers; to *externalise* the design process" (Jones, 1970:45). In some cases he maintained, this was done in words, sometimes in mathematical symbols and nearly always with a diagram representing parts of the design problem and the relations between them. Many proponents of this initial phase of design methodology also agreed that designing includes three essential stages of analysis, synthesis and evaluation. Focusing on the problem, they broke it into pieces, put the pieces together in a new way and tested to discover the

consequences of putting the new arrangement into practice. Many elaborations of this three-stage process have been made, including renaming of the stages to address more to the new problems of systems design[5], or proposing much more complex models which often tended to obscure this general structure by 'swamping it in fine detail of the numerous tasks and activities' (Cross, 1994:26).

According to Lawson (2000), much isolated thinking and little or no observation involved in the derivation of the earlier design models. These logical and systematic 'maps of the design process' maintains Lawson, tended to be both theoretical and prescriptive, and resulted in no apparent achievement. With first hand evidence from design protocols, he expresses his discomfort with the idea of representing the design process as a sequence of activities and even conceiving these activities as separate undertakings. Broadbent commenting retrospectively on this early phase of design methodology, similarly points out: "…asked to catalogue its achievements, in terms of buildings built, cities designed, and so on, most of its advocates find themselves in difficulties" (Broadbent, 1979:337).

Although there are many variations of these linear models, the rationale behind them, according to Buchanan (1992), was that their proponents assumed that the design process was divided into two separate phases: *problem definition* and *problem solution.* All the elements of the problem were determined and all the requirements to a successful design were specified in the *problem definition* phase. In the latter phase, these various requirements were combined and balanced against each other, thus proposing a model through a *logical* process for production. These models, according to Buchanan, suggested a methodological precision to the extent that the process is carried out independent from the perspective of the individual designer. There were two obvious points of weakness with such models, according to Buchanan: 'one, the actual sequence of design thinking

[5] Jones (1970) later renamed the stages as divergence, transformation and convergence.

and decision making is not a simple linear process; and two, the problems addressed by designers do not, in actual practice, yield to any linear analysis and synthesis yet proposed' (Buchanan, 1992:14).

Roozenburg and Eekels (1995) are cautious to denigrate prescriptive design models altogether, and even though it has seldom been established that design methods work, they think it sensible to make use of them especially when a firm's own experience falls short, and when a design process seems to lack progress. For them, methods may not guarantee a result, but may increase the chance of achieving a result, depending on the manner in which they are used. Thus, for Roozenburg and Eekels, design methods should be applied sensibly and knowledgeably. Sensibly since the application of a certain method depends largely on the user's interpretation of its rules, and knowledgeably since a practical knowledge of the problem area involved is normally required.

However it is worth noting that most of the scholars and researchers of this early phase of design methodology, whose intensive efforts to provide a collective control over designers' activities have often been regarded as *the design methods movement*, also commented critically on the movement and its motives afterwards. Alexander, for example, became disillusioned with design methods and especially design methodology because he felt later in the early 1970s that the development and study of design methods has failed to contribute to better design (Alexander, 1971). Similarly, Jones directed his efforts to chance and random processes to pursue his ongoing concern to resolve the conflicts between rationality and intuition, logic and imagination (Jones, 1977). Finally, for Archer, what was wrong with the mathematical and logical design methods was that they were 'the product of an alien mode of reasoning (Archer, 1979:348).'

2.3.2 Description of the Nature of Design Problems

Attempts to describe the kinds of problems that designers deal with can be characterized as a clash of views between those who want to develop an objective scientific approach and those who want to reconstitute the design process in recognition of the vague nature of design problems. Earlier views were centred on observing people's, users' behaviour and an objectivity in the formulation of design problems. Alexander and Poyner (1966) believed that rightness or wrongness of any building was a question of fact, not a question of value. Their concern, naturally in league with Alexander's motives described previously, was to limit the designer's role as to be an agent again in the design process. Instead of taking the needs as a starting point to design, Alexander and Poyner introduced the concept of *tendencies, i.e.* what people do when they are given the opportunity in an environment. A tendency, they argue, is an operational version of a need and it can be tested and stated objectively by observing people's behaviour. A tendency, like a scientific conjecture, is open to refutation. It can be tested, refined, and made more accurate or shown to be wrong. According to this view there is no design problem until tendencies come into conflict; and the problem consists of a set of conflicts between tendencies which might possibly occur in the environment under consideration. The designer's role here is to identify these conflicts and then to point out known or to invent a new set of relations, which are the geometrical arrangements of the environment which prevent these conflicts.

What Alexander and Poyner were trying to do was to establish an externalised objective body of design knowledge, similar to the body of scientific knowledge. By following their procedure, they suggest, design could become 'a cumulative scientific effort', on the basis of defining and improving the body of known design relations. Thus designing would be objective, not intuitive, and if a relation is relevant to the environment a

designer is working on, he would not have the right to reject it on the basis of his subjective preferences.

As research and thinking on design methods proceeded there was more recognition of the complexities of both the design problems and the design process. Addressing the question of why so many attempts at large-scale planning fail and result in criticism of planners from the public, Rittel and Webber (1973) stated that the kinds of problems that planners deal with were inherently different from the problems that scientists and perhaps some engineers deal with. For them, any search for scientific bases for solving problems of social policy is bound to fail, because of the very nature of these problems, which are according to Rittel and Webber, 'inherently wicked.' They illustrate their point with a comparison: The problems that scientists and engineers focus on are mostly 'tame' ones which can be likened to a problem of mathematics or that of the chess player, where both the problem and whether or not the problems have been solved are quite clear. Wicked problems, on the other hand, have neither of these clarifying qualities. However it should be noted that, for some, the analysis – synthesis model and its elaborations could still provide a somewhat satisfactory framework into which the new thinking could fit. Simon (1973) for example, argued that there is no clear boundary between 'well-structured' problems and 'ill-structured' problems, which in Rittel and Webber's terms, means the absence of a real distinction between 'tame' and 'wicked' problems. Simon believed that all wicked problems may be tamed, structured through decomposition before analysis begins. Thus, Simon's aim was to suggest that the logical procedures, towards which a suspicion had started to grow, could successfully handle ill-structured problems.

Rittel and Webber outlined ten properties of wicked problems. For example their first property is the absence of a definitive formulation of a wicked problem. Here they argued that identification of relevant information to a wicked problem depends on the kind of solution proposed or considered:

‘One cannot understand the problem without knowing about its context; one cannot meaningfully search for information without the orientation of a solution concept; one cannot first understand, then solve’ (Rittel and Webber, 1973:138). This apparently was a point to ponder on for the early systems approach methods of design, which relied on exhaustive information collection followed by data analysis and then solution synthesis or a ‘creative leap’[6].

2.3.3 Reflection on the Fundamental Concepts of Design

Most of the attempts made during the 1960s were to develop and to promote an explicitly organized, rational, and wholly systematic approach to design. Despite the statements of design methodologists of this phase about the distinctions between science and design, their efforts contained a scientific basis, or a scientific bias as indicated by Cross (2001). According to Alexander, for example, “scientists try to identify the components of existing structures where designers try to shape the components of new structures” (Alexander, 1967:130). Simon commented on this distinction similarly, stating that “the natural sciences are concerned with how things are, design on the other hand is concerned with how things ought to be” (Simon, 1969:58). Also for Gregory, “the scientific method is a pattern of problem-solving behaviour employed in finding out the nature of what exists, whereas the design method is a pattern of behaviour employed in inventing things of value which do not yet exist” (Gregory, 1966:6).

Cross (2001) criticized this ‘pattern of behaviour’, and discusses whether it should exist. Method must be vital to the practice of science, according to him, where it validates the results, but not to the practice of design where results do not have to be repeatable, and, in most cases, must not be repeated, or copied. According to him the works of early design

[6] From Archer’s *Systematic Method for Designers* (1965), not discussed in this study.

methodologists can be summarized as an effort to develop a ‘design science’, whereas starting from the 1970s, the efforts were aimed at developing a ‘science of design’, that is, a research and reflection on the nature and extent of design knowledge and its application to design problems. Similarly Darke points out that one of the shortcomings of the early phase of design methodology was that it concentrated on ‘a sequence of boxes bearing particular labels, rather than the way particular designers filled the boxes with concepts, and the sources of the designers’ concepts (Darke, 1979:187).’ The rejection of the value of the subjective and the hope that the building would ‘design itself’, according to Darke, seemed to be products of a ‘scientistic’ rather than a scientific way of thinking.

Hillier, Musgrove and O’Sullivan’s (1972) research following the scientistic era was concerned both with a philosophy of design method and with the related issue of the role of design research. They argued that systematic design method was initially conceived as a potential academic core for the discipline of architecture, with other research-oriented disciplines providing information to be used in a systematic design process. However they pointed out that these aims were fruitless, and that an ‘applicability gap’ has opened between research and design. In order to restate the role of research in design, Hillier, Musgrove and O’Sullivan referred to the developments in the philosophy of science. Influenced by Popper, Kuhn and Lakatos’ achievements in the philosophy of science, they stressed that science operates from prestructured viewpoints and pursues investigations of the world from these viewpoints. They advised that this new recognition in science was important for design as well, that designers must prestructure, and in fact *have been* prestructuring their problems in order to solve them. As science relies on conjectures according to Popper, design relies on conjectures as well, they suggested.

Thinking of the design process as involving first the generation of alternatives and then testing of these alternatives against a whole array of requirements

and constraints within feedback loops was not a new idea in design methodology. Simon (1969) for example, called this procedure 'the generator – test cycle'. However Simon's methods were still analytic and in Simon's generator – test cycle, the alternatives were produced on the previously decomposed elements of the problem. Hillier, Musgrove and O'Sullivan's idea of generating solutions very early in the process *to structure an understanding of the problem*, on the other hand, has been a paradigm shift in design thinking according to Darke (1979). Design, for them, was a matter of prestructuring the problems based on some constraints internal and external to the designer. It is necessary to give a more detailed account of this new understanding to point out how Hillier, Musgrove and O'Sullivan's views advance considerably on systematic design methods.

2.3.3.1 A Descriptive Design Model Based on Conjectures

Hillier, Musgrove and O'Sullivan's study (1972) aimed to accentuate the achievements in the philosophy of science while embracing the intuitive, imitative and quasi-scientific procedures which characterize design activity as it is carried out. They criticised the rationalism of early design methods, which proposed to start from scratch just as the rationalist line of thought in philosophy sought to eliminate or reduce to a minimum the preconceptions to get at truth. They also maintained that the rational approach had gained recognition because it embodied a liberal-rational sentiment that designs should be derived from an analysis of user requirements rather than designers' preconceptions. Hillier, Musgrove and O'Sullivan's model of design is based substantially on Popper's 'conjectures and refutations' model of science. They stress that like scientific problems, design problems can only be handled by prestructuring them, proposing approximations of solutions based on the prestructured problem and then subjecting them to analysis or investigation.

Design as a cognitive problem-solving activity is '*essentially* a matter of prestructuring problems' based on variety reduction and conjectures for Hillier, Musgrove and O'Sullivan (1972:253). Variety reduction is achieved by some constraints internal and external to the designer. External constraints involve clients, norms of appearance, availability of technological means, costs and standards, etc. whose effectiveness as variety reducers become clearer as being specified within the process. The internal constraints are the designers' cognitive capabilities in relation to the certain type of problem at hand. Such cognitive capability, according to Hillier, Musgrove and O'Sullivan, is made up of his *knowledge of solution types* in relation to the particular problem or the field; his *knowledge of the latencies of the instrumental set,* that is, his knowledge of the potentials of the available technological means; and knowledge of some informal codes which relate users' needs to solution types and instrumental sets. Hillier, Musgrove and O'Sullivan argue that before the problem is specified by the gathering of data about the problem, it is already shaped by these external and internal constraints. Thus the designer does not collect data at random, but selectively in relation to the prestructured problem, implicitly or explicitly.

The designer then conjectures possible solutions or approximations of solutions in order to structure his understanding of the problem. Since a vast variety of design decisions cannot be taken before the solution in principle is known, which is a characteristic of design problems stated before (Rittel and Webber, 1973) conjectures of approximate solutions should come very early according to Hillier, Musgrove and O'Sullivan (1972). With new data relevant to the prestructured problem, conjectures acquire sharper definition. It can be observed that, in this approach, problem specification and problem solution proceed side-by-side rather than in sequence. What is more, conjectures do not *synthesize* from data analysis, but from the designer's pre-existing cognitive capability stimulated by the particular problem at hand. That is, from his knowledge of the instrumental sets, solution types, and informal codes, and occasionally, for Hillier, Musgrove and O'Sullivan, from an

analogy, or a metaphor, or simply, from inspiration. For them designers using these last three sources extend their conjectural field considerably.

The model of a rational design process developed by Hillier, Musgrove and O'Sullivan, therefore has a *prestructures – conjecture – analysis*, rather than the conventional *analysis – synthesis – evaluation* sequence. There are several differences of this basic descriptive model from its earlier prescriptive counterpart according to its creators. Firstly the purpose of analysis is primarily to test conjectures rather than to optimise by 'logical or magical procedures.' Earlier models relied on designers' 'creative leaps' (Archer, 1965), recent problem solving techniques of their times such as 'brainstorming' (Jones, 1963) or on mathematical functions and computer programs (Alexander, 1963) to derive conclusions from largely independent subsets of the problem from the analysis stage. Secondly the solution, in principle, comes much more earlier in this model. Thirdly, the model suggests convergence on a unique solution during the process rather than notions like optimisation of information which, according to Hillier, Musgrove and O'Sullivan, 'while attractive theoretically, are largely unlifelike and unworkable.' Fourth, it recognizes implicitly that both information and conjectured solutions are inherently incomplete, but a stop has to be called somewhere. Fifth, the model emphasizes the importance of the designer's prestructuring of the problem. It recognizes that designers approach, and should approach design holistically and not piecemeal.

This descriptive model of the design process proposed by Hillier, Musgrove and O'Sullivan has effected much of the works succeeded them, and their suggestion that designers must and in fact *do* design this way has seeded the next phase of design methodology. Their approach has been a springboard for a number of observations and design protocols through this revaluation of the individual contribution to design processes, and other studies provide evidence for their conjectural method.

2.3.4 Observation of the Design Activity

It is seen that to deal with the complexity of design problems, there had been attempts to observe users' behaviour, but with a demand of objectivity in the formulation of design problems in the early phases of design methodology (Alexander and Poyner, 1966). This main area of design methodology, on the other hand, has been the investigation of 'what it is that designers actually do when they are designing' (Cross, 1984:167). This line of research treats design activity as a natural phenomenon of human behaviour, and relies on methods of enquiry drawn from social research; particularly on design protocols, which are the attempts to reveal the strictly internal maps of designers' activities by means of experiments and observations conducted usually under controlled conditions. Insights gained from protocol studies that has been conducted with a focus on certain phases of a process or design activity have revealed some of the most important pivoting points on which the design methods studies turned. Also design protocols have helped to bring down the earlier conceptions of the design process, or rather the prescriptions, through their evidence, where there has not been a case observed with a clear and distinct analysis-synthesis sequence when designers are permitted to design as they actually design. It is also seen through these studies that designers adopt a solution-focused strategy, and get to know their problems via solution proposals, through conjectures as Hillier, Musgrove and O'Sullivan suggested.

2.3.4.1 Design Thinking

Lawson (1979), with an interest in the general question of cognitive style in the design process and how it was acquired, devised a set of experimental situations in which the subjects would solve design-like problems under laboratory conditions. For his experiment he required a controllable, model design activity, and so he devised a task which required subjects to produce a spatial configuration of elements to try to achieve some given goal and to

satisfy some initially unknown rule. In one experiment the subjects had to complete a design using a number of modular coloured wooden blocks. They were given more blocks than they would actually needed, and the design problem required a single storey arrangement. The vertical faces of the blocks were coloured red and blue, and on each occasion the subject was required to make the perimeter wall of the final arrangement either as red or as blue as possible. The task was made more complex by the introduction of some ‘hidden’ rules governing allowed relationships between some of the blocks. This meant that some combinations of the blocks would be allowed while others would not. These rules were changed for each problem, and the subjects knew that some rules were in operation but were not told what they were. Thus Lawson’s abstract problem was a very simplified design situation where a physical three-dimensional solution had to achieve certain stated performance objectives while obeying a relational structure which is not entirely explicit at the outset (Figure 2.5).

Lawson compared the performances of final year students of architecture and post-graduate science students; and although both groups performed the task equally well, he found out that the two groups displayed quite consistent and different strategies. The scientists adopted a technique of trying out a series of designs which used as many blocks and combinations of them as possible. They tried to maximise the information available to them about the allowed combinations, tried to discover the governing rules that would allow them to produce correctly coloured arrangements. The architects, on the other hand, proposed combinations with appropriately coloured perimeters. If this proved not to be an acceptable combination, then they proposed the next most favourably coloured block combination until an acceptable solution was discovered.

The essential difference between these two strategies is that, while scientists focused their attention to understanding the underlying rules, the architects were obsessed with achieving the desired result. Thus Lawson described the

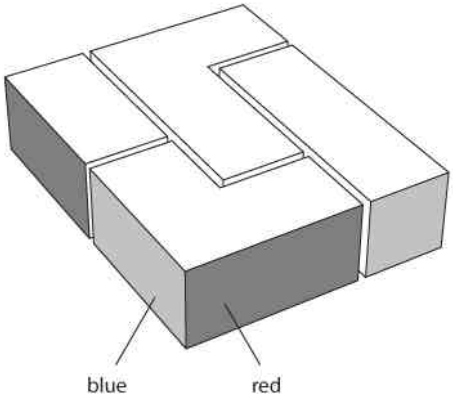

Figure 2.5 An arrangement of blocks in Lawson's experimental task (Figure adapted from Lawson, 2000).

scientists as having a problem-focused strategy, and the architects as having a solution-focused strategy. Lawson running a second experiment comparing high school graduates and junior architecture students concluded that the consistently different cognitive styles of science and architecture students is a result of their educational experiences, since in the second experiment neither of the groups showed a common strategy. The result of Lawson's experiments also further questions the division between analysis and synthesis seen in the systematic design models, since he observed that the senior architecture students consistently used a strategy of analysis through synthesis. They learned about the problem through attempts to create solutions and seeing where it went wrong, rather than a deliberate and separate analysis of the problem itself.

2.3.4.2 Goals

Cognitive psychologists Thomas and Carroll (1979) studied designer behaviour with both experimental and observational methods. Their studies ranged from recording real design dialogues between clients and designers to setting structured design problems to groups of selected subjects. Their definition of design covers a vast variety of activities, ranging from designing

computer software to letter writing, and even to coining names to events and situations that lack established names.

Through their studies, they concluded that a crucial aspect of design is the specification and handling of goals. From their observations of design dialogues, Thomas and Carroll found that clients typically have both knowledge of their goals, and 'a concrete knowledge of details of the particular situational context for the design as implemented (1979:225).' In the letter writing case, the designing seemed to be going on during the actual writing process. A person, they argue, seems to spend little time thinking about goals and planning out the approach before beginning to write. New goals seem to emerge as the writer ponders on why certain words or phrases are not quite right. In contrast while designing a restaurant, Thomas and Carroll's subjects seemed to have a fairly clear idea of what they were trying to accomplish before even beginning to draw a floor plan. In the naming case, Thomas and Carroll varied the goals of the name creation task. In one study, ten subjects named a series of symbols according to the instruction that names *distinguish* between referents while another ten named the symbols under the instruction that names are *labels*. Names *designed* in the two conditions differed greatly. In the case where subjects were asked to distinguish through naming, they came up with names like 'left one' for the leftmost of three identical symbols. However in the case where the subjects were asked to label, the name generated was 'boxed vee'. This work implies, for Thomas and Carroll that the particular goal structure brought to the design problem would provide a remarkable influence on its solution.

Initial design definition of Thomas and Carroll was 'a particular class of problem-solving in which the goal, the initial conditions, and the allowable transformations are all ill-defined.' Through their experiments and observations, their notion of design changed from that of a type of problem to a way of looking at a problem. Thomas and Carroll argue that any problem

can be looked at as a design problem through a creative redefinition of goals; and conversely, some problems that may seem to be a typical design problem, such as designing a house, might be viewed otherwise. A process in which the designer is merely an instrument that collects information and acts according to an established routine, they imply, is not designing. They view the efforts to render ill-structured design problems into well-structured procedures as trying to accomplish the same ends, without requiring design. Thomas and Carroll, therefore, arrived at 'a highly problem-solver oriented problem-solving definition of design'. For them design is 'a type of problem-solving in which the *problem-solver* views his/her problem or acts as though there is some ill-definedness in the goals, initial conditions, or allowable transformations.'

2.3.4.3 Constraints and Criteria

Akin in a more realistic experiment, asked experienced architects to design a single person dwelling. The architects were asked to report their thoughts aloud when asked during the course of the project, which took place within controlled conditions. The purpose of Akin's study was to explore intuitive design, the design process 'as manifested in the behaviours of human designers' (Akin, 1979:189). He distinguishes intuitive design from the more systematic procedures of 'design-methods' and the computer-aided techniques of 'machine-design'. He argues that these non-intuitive design tools failed because of their incompatibility with the intuitive nature of design. He suggests that a better understanding of intuitive design will not only enable appropriate design methods and computer aids to be formulated, but also would inform design practice and education.

Upon completion of his study incorporating a real designer and a moderately sized real design problem, Akin concluded that some long held views of the design process did not reflect normal design behaviour:

> Not only is the compartmentalization of the design process into three rigid phases (i.e. analysis – synthesis – evaluation) untrue, but the tactics implied for each of these compartments are also unrealistic. All solutions do not arise from an analysis of all relevant aspects of the problem. Often a few cues in the environment are sufficient to evoke a pre-compiled solution in the mind of the designer. Actually, this is more the norm than a rational process of assembly of parts, as suggested by the term 'synthesis' (Akin, 1979:205).

Akin observed that one of the unique aspects of design behaviour is the constant generation of new goals and redefinition of constraints. Thus, for Akin, analysis is a part of all phases of design and synthesis begins very early in the process. Other than his conclusions on the nature of design processes, Akin's protocol analysis revealed some further characteristics of the intuitive design activity concerning the nature of design solutions and design problems. Many rational methods of design, he argues, defy a natural design norm widely adopted by human designers, which is the opting for satisfying solutions. It has been seen that in attempting to make the process of design more scientific, the early methodologists assumed that the best solution would be the one that optimises all factors that contribute to a design circumstance. Such an approach, according to Akin is destined to satisfy a minimum value for each factor that has been taken into account in the process of optimization. Such outcomes are inevitable due to the complexity created by the method itself, through the determination to address each and every factor that build up the design problem. Akin observed conversely that the human designers create solutions that satisfy an acceptable number of design criteria, which are handled to perform much better than a minimum value for each of them.

It is important to note here that Lawson (2000) makes a distinction between constraints and criteria. Criteria for Lawson, implies clearly stated goals in advance of attempts to produce solutions. Similar to Thomas and Carroll's goals of the client, they are sets of relative and disparate expectations, which are held often implicitly by clients, users and legislators as well as members of the design team. A designer must surely work to negotiate a solution which meets these varying criteria to some extent, however these criteria and the sources of them form only a single dimension of design problems

according to Lawson. He stresses that design problems can best be structured by a set of constraints which must be taken into account when forming the solution. They form the design problem, and may only become apparent through attempts to create a solution. He bases his analysis of the structure of design problems on an investigation of the generators of design problems, their domains of concern and their functions; and identifies the constraints involved in a design situation as imposed by these generators, domains and functions. Through this analysis, Lawson assembles a model through which, he hopes, designers would come to terms with the natures of their design problems in all their variations.

Lawson identifies the generators of design problems as *designers*, *clients*, *users*, and *legislators*. This order of presentation also implies a level of flexibility inherent in the constraints, i.e. designer imposed constraints being the most flexible or optional, and that of the legislators being the most rigid or mandatory.

Lawson's domain related constraints are categorized according to their domain of influence. Some constraints establish relationships between elements of the object being designed, where others relate the designed object to its context. The former constraints according to Lawson are *internal constraints*, where the latter determine the *external constraints* of a design situation. Here, the internal constraints are the more flexible of the two. It is important to note that both internal and external constraints may be generated by designers, clients, users and legislators. This effect can be made clearer through witnessing some of the constraints involved in a hypothetical design situation.

In designing a yacht, *legislators* may render some arrangements between certain elements of the design impossible. The field of vision of the captain, the slant of the windscreen to prevent glare or some arrangements that must be avoided for fire prevention, for example, are clearly stated in the rules of

the MCA Code of Conduct for the yachts to be built in the UK. The *builder* on the other hand, might express a wish for avoiding certain surface details to ease moulding operations, the *owner* may demand a direct access hatch from his suite to the foredeck, and the *designer* may find it sensible to try to organise all the spaces around a central concern for privacy or some other theme. These concerns illustrate some of the *internal constraints* for a yacht design problem, brought about separately by all four of the generators of design problems. On the other hand, the design *regulations* for a yacht may demand a certain measure of seaworthiness for various cruising conditions, may ask for sound naval architecture which in turn would effect weight distribution, the placement of structural partitions and the character of the hull. The *builder* may have to limit the overall length of the yacht in order to be able to construct it within their facilities, the *owner* may be delighted to see the horizon from his suite, and the *designer* may strive to come up with a gang-plank system that would accommodate access to the yacht in various marinas and harbours around the world. Here the sea, the horizon, the builder's facilities and the various docking conditions are all *external constraints* to the problem, they are more rigid to negotiation, and again imposed by the same generators of design problems.

The difference between domains of design constraints lie essentially in the freedom they offer to the designer. Though each design problem comes with its own peculiar structure, according to which the balance between internal and external constraints may vary, internal constraints generally allow a greater degree of freedom and choice since they govern factors that are mainly under designer's control. In the yacht design example stated above, what makes the internal relationships difficult to integrate and to coordinate is the need to carry out such an arrangement within the governing hydrostatic and structural rules, and inside a certain hangar.

Whereas many design studios have a definite trademark characterized by a certain form or style, Winch's studio, it is claimed, is characterised by their

concise interpretation and realisation of the *dreams* of each new prospective owner, within and at times extending the chosen builder's capabilities. It has been seen that it is the interplay and interdependence of constraints what builds up the unique structure of each new design problem, and according to Lawson, recognising the nature of the problem and responding with an appropriate design process is one of the most important skills in designing. It should be noted also that in contrary to what these examples from the marine industry might seem to imply, a great amount of design is commissioned by clients who are not the users themselves. For Lawson, the traditional image of designer establishing a personal relationship with the client-user is misleading especially in public architecture and industrial design. In the examples from yacht design field, thus, the builder should be taken as the client, while the owner is contributing to the constraints associated with the user.

Andrew Winch, one of the most distinguished designers in the yacht design scene today, illustrates the interplay of such constraints, and the role of the designer amidst them:

> No owner likes his yacht to sail slowly yet, as a general rule, the faster the hull shape the smaller the interior. Lighter weight means lower freeboard which means lower deckheads which, in turn, have tended to produce more claustrophobic atmospheres. Space in any configuration emits an atmosphere – it can be intrusive or generous, dangerous or safe, uninviting or welcoming, hot or cold. Whichever ambiance the designer achieves represents the failure or success of his art. (Winch, 2000:75-6)

Thus two dimensions of Lawson's model of design problems, relating generators of design problems to the domains they influence take shape (Figure 2.6). It is seen that the *external variety reducers* as named by Hillier, Musgrove and O'Sullivan (1972) are related to the particular problem structure at hand, and some of them have already found their places in the incomplete model of design problems, such as clients and standards. The third dimension of the model, the functions of design constraints, reveal and match another set of *external variety reducers* in Hillier, Musgrove and O'Sullivan's terms. Before introducing this third dimension, it is found

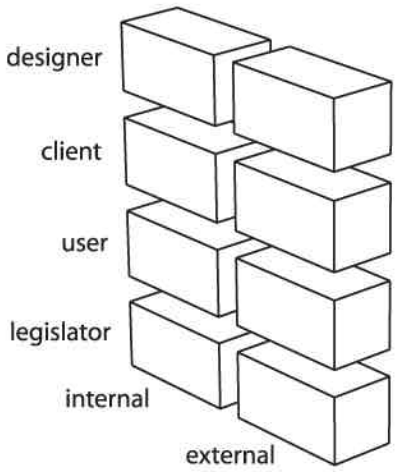

Figure 2.6 Two of the three dimensions of Lawson's model of design problems.
(Figure adapted from Lawson, 2000:98)

appropriate to return to the developments in design methodology to witness a different approach taken by Darke (1979) in gaining insights from designers' various strategies to handle design situations. Darke's study further displays these constraints in operation, but more importantly, discovers a new concept utilised in design activity by practising designers, which is the *primary generator*.

2.3.4.4 The Primary Generator

With a distrust for the design protocols, experiments and observations taking place in controlled settings that are devised to develop an understanding of how designers actually design, Darke (1979) based her research on the nature of design activity on interviews with well-known British architects. Darke also acknowledges the problems of her own observation method, for example her respondents might have faulty memories, or they might post-rationalize their procedures. While her method lacks the controlled experimental precision of laboratory observations, it granted an insight which contains some intrinsic reflections on real-world designing. The evidence from her interviews not only supports the validity of Hillier, Musgrove and

O'Sullivan's (1972) *conjecture – analysis* model, but also reveals the presence of some organising principles; some relatively simple ideas that the architects tend to adhere to very early in the process. These ideas, *primary generators* as Darke calls them, often to express some qualities of the site, concerns to provide for a particular relationship between dwellings and surroundings, to maintain social patterns, etc, have allowed her architects to narrow down the range of possible solutions in quite complex design problems, usually involving economic and legislative controls, subtle social requirements and varying demands of diverse building sites (See Figure 2.6).

A primary generator may be 'to create a mews-like street' or 'to leave as much open space as possible', or as in the design of Michael Neyland, 'to get the building to respond and breathe with its surroundings'. The site was 'one of the generating things' for Neyland, without Darke's prompting or previous use of this term. It should be stressed at this point that these primary generators are not statements written out in advance; rather they appear to be quite personal views initiated by the problem. The experiences of the architects, where they were born, where they grew up, what they have registered in their memories are also sources of their primary generators in addition to other problem specific constraints. Another of her subjects, Kate Macintosh for example, grew up in Scotland and worked in Scandinavia where flats both are common. Mackintosh's opting for two tall blocks in her design, according to Darke may be considered as 'a *negative* generating factor[7]: the *lack* of a presumption *against* flats.'

A primary generator serves as 'a *way-in* to the problem'. It is a rather subjective starting point for the designer, in contrast to the early models that

[7] Lawson (2000) prefers to address such factors as *guiding principles* that designers carry with them throughout their working lives. He refers to these as an 'intellectual baggage' brought by designers into each new project (Lawson, 2000:162). They may be some conscious design philosophies, may be some inclinations towards some movements in design, some certain attitudes towards the users or clients, or some moral issues.

prescribe listing all the factors of a design problem beforehand. When a primary generator enters the design process, Darke maintains, 'it is usually more of an act of faith on the part of the architect, a designer imposed constraint, not necessarily explicit' (Darke, 1979:181). Referring to its relationship with the first conceptualised image, the *conjecture* in the terms of Hillier, Musgrove and O'Sullivan, Darke makes a distinction. According to her, the term *primary generator* does not refer to that image but to the ideas that generated it. Thus as an elaboration of their model, Darke proposes: *generator – conjecture – analysis*.

To sum up, Darke's study further reveals that designers do not start with a full and explicit list of factors to be considered, with performance limits predetermined where possible. Rather it is seen that they have to find a way of reducing the variety of potential solutions to the hitherto imperfectly understood problem, to a small number of solutions that is cognitively manageable. To realize this, it is revealed that designers fix on a particular objective or a small group of them, usually strongly valued and self-imposed. These major aims, the primary generators, then give rise to a proposed solution or conjecture, which makes it possible to clarify the detailed requirements of the particular design situation as the conjecture is tested to see to what extent they can be met, managed or coordinated.

Darke commenting on her evidence asserts that this is actually the way that many architects design. It was clear in Darke's interviews that in most cases the design concept was arrived at before the requirements had been worked out in detail. This is necessarily so, according to Darke, since these requirements could only become operational in the context of a particular solution. In Darke's sample, broad requirements coming from varying generators of design problems in either of the domains in Lawson's terms, are used along with the designer-imposed primary generators in arriving at an initial conjecture or concept. The designers had been aware all along that there were several detailed requirements to be met by the design (criteria),

but performances on these parameters were not specified in advance, or they were rather arguable. Once the initial concept had been generated, it was tested against various constraints and modified if necessary. The performance levels with respect to particular constraints were decided interactively, as in Thomas and Carroll's design dialogues, in the light of their effects on the emerging concepts. This process is not linear, rather often in spiral form or iterative in character according to Darke. In her respondents' processes in housing design, Darke observed a frequent switching between considerations of dwelling type plans (internal constraints) and considerations of site layout (external constraints), as each of these has implications for the other. The conjecture, Darke points out, is not rejected unless there is an obvious mismatch between it and the requirements gradually getting more detailed. Additionally, if these generating ideas are taken as goals for the designer's part, motives and directions to proceed with the project, as a particular approach, then their effects on the whole process, for good or ill, were effectively illustrated by Thomas and Carroll's experiments.

Darke's study can in fact be seen as a field test that validates the model proposed by Hillier, Musgrove and O'Sullivan, who argued previously that designers should and essentially do prestructure their problems. It is important to note that the steps Hillier, Musgrove and O'Sullivan and Darke established for the design process are not attempts to compartmentalise it into distinct phases. Rather, they are attempts to clarify how designers actually design, how they set out with a design project and proceed iteratively through conjecturing design solutions and analysing them to see to what extent they address to the problem's structure.

The author believes that similar, though maybe quite personal observations must have seeded or at least substantiated the development of Hillier, Musgrove and O'Sullivan's more philosophical approach. They start their argument with a discussion of scientific points of view and derive from there

the prestructures and the conjectural approach and relate these to the design situation. Through evidence from the studies of Lawson, Akin, Thomas and Carroll, and finally Darke, it can be inferred that Hillier, Musgrove and O'Sullivan's *is-ought transition*[8] had been a well-founded one.

Darke's study not only helps substantially to uncover how practising designers actually design, but she also comments on the processes of students of design as well. Her following statement points out that the *is-ought* transition mentioned by Roozenburg and Eekels shows itself in the inferences and deductions from individual intuitive processes of design students:

> Probably the main difference between the practising architect and the student is that the former has the experience of solution types required for a realistic conjecture. A frequent problem in a school of architecture is that the student who has a limited stock of generating ideas which he attempts to apply to every problem without considering whether they are appropriate (Darke, 1979:181).

2.3.4.5 The Model of Design Problems

Sources of design constraints, and the domains influenced by them have already been related in a two dimensional model. The purpose, the function of these constraints, the third dimension of Lawson's model, is to ensure that the designed object performs the functions demanded of it as adequately as possible. There are many models of the functions of design constraints or classifications of them, like some of Schön's design domains; and again some other external variety reducers of Hiller Musgrove and O'Sullivan will find their places in the model of design problems as it is being completed. Lawson (2000) adopts four functional constraints which are, *radical*, *practical*, *formal* and *symbolic* constraints.

[8] As defined in the epigraph to the first chapter, by Roozenburg and Eekels (1995).

Radical constraints according to Lawson are those which deal with the primary purpose of the object being designed. Thus, in the design of a school for instance, the radical constraints would include the need to accommodate the activities and people involved in schooling. A radical constraint in a yacht design project may accompany the settling on a particular type of yacht, and usually comes with the 'dreams' of the owner. They can be likened to a combination of Schön's (1983) design domains of 'program/use' and 'building character', and the activities, idiosyncrasies of functions or qualities inherent in them. Schön defines the former domain as functions of buildings or building components, uses of buildings, and specification for use. He gives 'gym', 'auditorium', and 'classroom' as examples. The latter, he defines as the kind of building, a sign of style, or the mode of building; and gives the examples, 'warehouse', 'hangar', beach cottage', etc.

Practical constraints are those aspects of the design situation which deal with the reality of producing, making or building the design. For the industrial designer, for example, they would include not only the materials used, but also the manufacturing processes. Practical constraints are not solely concerned with realisation of the design; they also cover the performance of the object during its lifespan.

Formal constraints are those to do with the visual organisation of the object. And 'the trick of good design' according to Lawson 'is to get an appropriate amount of order to meet the needs of the context.' Looks, styles and trends, formal characteristics associated with design movements like simplicity, or just preferences like a sleek appearance or a flush deck of a yacht are all formal constraints within which the designers sometimes seek to, or have to organise other design constraints.

Symbolic constraints usually rise from a search for meaning on which to base the rest of the process. Metaphors and analogies have been mentioned in Hillier, Musgrove and O'Sullivan's (1972) approach as alternative sources

of conjectures, and a designer who uses these sources, it was stated, acts in a clearly different way from one with more modest ambitions. But Lawson issues a warning here that much of symbolism may in fact be built into or around products after the design is complete, either by critics or the designers themselves.

The complete three-dimensional model of design constraints can now be constructed (Figure 2.7). The model, in theory, implies that each of the generators may contribute to each type of constraints. In practice, however, according to Lawson, each of the generators tends to generate more of one type than another. The client and/or the user are responsible for the majority of the radical constraints and are likely to contribute to some symbolic ones, while the designer is the main generator of the formal and the practical and also contributes symbolic constraints. More importantly, Lawson emphasizes that 'it is the designer's task to integrate and coordinate all these constraints by whatever device (Lawson, 2000:106).'

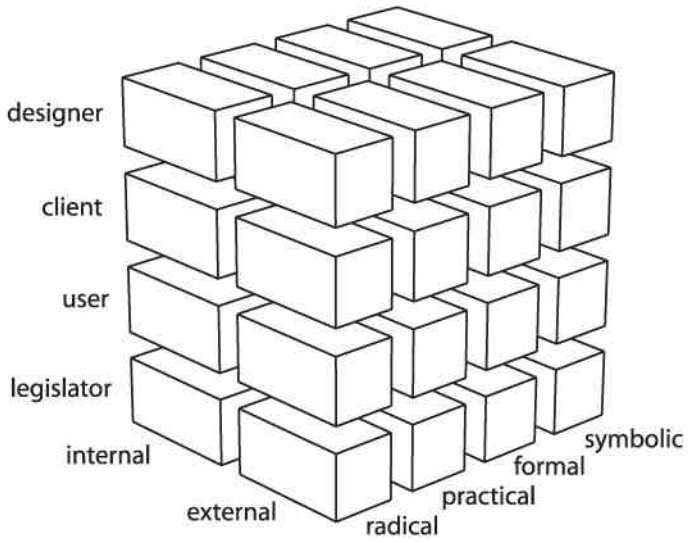

Figure 2.7 The completed model of design problems. (Figure adapted from Lawson, 2000:107)

For Lawson, good designs usually incorporate successful design solutions or design elements, which serve as integrating devices to solve, to handle various design problems associated with various design constraints simultaneously. The quality of such designs is inherent in these design elements, which may be accentuated and allowed to dominate the visual aspects of a design as well. Usually this emphasis is done in a way that which constraints are satisfied[9] by these elements remain quite implicit, and these dominant design elements, now forming the prevailing visual aspects of the design usually evoke surprise, amazement and wonder in the onlooker, or give a sense of good formal organisation. In the course of interaction with the designed object, by means of experience and reflection on the other hand, these feelings turn to an understanding of the design and result in appreciation and/or admiration, through an ascending comprehension of the design element and which constraints it successfully handles and accomplishes to satisfy. The reverse is equally acceptable and implicit in the quote from Andrew Winch referred to before, where he stated that the result, the ambiance the designer achieves in a yacht represents the failure or success of his art.

There is another interesting point to note according to Lawson's empirical research and anecdotal evidence gathered from practising designers, which again illustrate designers' subjective contribution to a design project. He witnessed that in the early phases of design the problem is not studied in minute detail but in a fairly rough way, 'as the designer tries to identify not the most important (to the client) issues, but the most crucial in determining form (Lawson, 2000:212)'.

These discussions reveal where do good or lame designs come from, implying that the structure of the design problem in the form of constraints, the designer's position and approach in handling these constraints, and the process through which these are wrought together have their respective

[9] See Akin's satisfying solutions.

parts to play in their making. However, design situations may vary in terms of the overall degree of freedom and control available to the designer. Lawson talks of ‘open-ended design’ (2000:109) where most of the constraints are internal and designer generated. Where by contrast, clients or legislators bring in heavy demands or there are many external factors to consider, he talks of ‘tightly constrained design’. Some designers seem to prefer the open-ended situation, while others are more comfortable with highly restricted problems. This distinction causes much of the success or disappointment in student works and it will be discussed and made clearer in the following chapters. Moreover regardless of a design situation’s being open-ended or constrained, it is still very easy to neglect a set of constraints according to Lawson. He stresses that ‘students of design often devote too much of their time to unimportant parts of a problem. He notes the ease with which the inexperienced generate almost impossible practical problems by following ill-conceived formal ideas, which remain unquestioned but could quite easily be modified. Thus one of the major roles of design tutors, for Lawson, is to ‘move their students from one part of the problem to another and the job of the students is to learn to do it for themselves (Lawson, 2000:109).’

Quite similarly in Schön’s design review mentioned in the first chapter, Quist, aiding Petra to move on from the dead end that she had led herself to, displays a set of strategies in action and demonstrates how an ‘accomplished architect’ does and therefore she should perform. Reflecting critically on the situation before him and drawing on ‘a repertoire of design domains (Schön, 1983:97)’, he conducts an on-the-spot experiment with Petra’s framing of the problem, and reframes it. He sees the new situation in terms of his experience in design problems, his inventory of particular situations, exemplars and images, and constructs variations on themes with which he is familiar. Thus he implicitly guides Petra from one dimension of her problem to another, as Lawson suggests.

It can be observed, apart from the equivalence of Lawson's constraints and Schön's design domains that Hillier, Musgrove and O'Sullivan's procedure and the one demonstrated by Quist are just about identical, with their internal variety reducers (the experience available to and contained in Quist), and their external variety reducers (the design domains of Schön, the design constraints of Lawson) by which a designer prestructures a design problem to make a conjecture.

2.4 FINDINGS AND CONCLUSIONS FROM RELATED LITERATURE

This chapter briefly investigated the developments in design methodology and focused especially on the works that now constitute the descriptive body of design methodology. This concentration on descriptive design methodology ensued upon realising along the study that there were designers designing while the early design methodologists found their efforts irresponsible and soon-to-be incompetent. They handled and coped with their problems adequately regardless of their being coined ill-defined or wicked; and they were still designing as ineffectiveness of relying solely on systematic methods had become apparent and under criticism in terms of outcome. It can be said that an important return of the early studies in design methodology had been a revaluation of and a focus on *the subjective* in design.

It is stated in the first chapter that an understanding of the developments in design methodology would provide a foundation for a study on design processes of industrial design students. If a relatively common outline of design process as exhibited in the procedures of practising designers can be brought together, it would serve in understanding and elucidating students' design processes. Framing a conception of the nature of the design activity, it would aid in analysing their efforts in keeping with the aims and concerns stated in the first chapter.

It is found out through the literature search that the most conspicuous feature of natural design processes is that designers adopt a solution focused strategy. They learn about their problems through solution attempts and seeing where it went wrong, rather than a deliberate and separate analysis of the problem itself (Lawson, 1979). Proceeding with the design, Akin (1979) observed, analysis is a part of all phases of design and synthesis begins very early in the process. Darke's (1979) interviews further illustrate that designers approach their problems with quite personal views. These subjective starting points may be motivated by the design problem, but as it is seen, 'intellectual baggages' that designers bring into each new project can be effective in their making (Lawson, 2000). It is also seen that in proposing their initial solution attempts, designers favour to identify those points that would aid them in form generation. Not to compartmentalise the design process, it can be said that the findings from the literature search converge on and present two key stages of design processes together with the respective roles of the designer and the design problem in them: the commencement of the design process, and its development (Figure 2.8).

Figure 2.8 The two key stages of design processes focused in empirical studies.

Hillier, Musgrove and O'Sullivan's (1972) conjectural design model preceded the empirical studies that later validated it with evidence. Moreover, it addressed and related the two stages. It is seen that design, according to Hillier, Musgrove and O'Sullivan, is essentially a process of progressive reduction of variety starting with the prestructuring of the problem. It is followed by conjectures of approximate solutions to structure an understanding of the problem and progressively testing, analysing these

conjectures to refine the solution as the time allocated for the process permits. Thus figure 2.9 can be elaborated as follows (Figure 2.9):

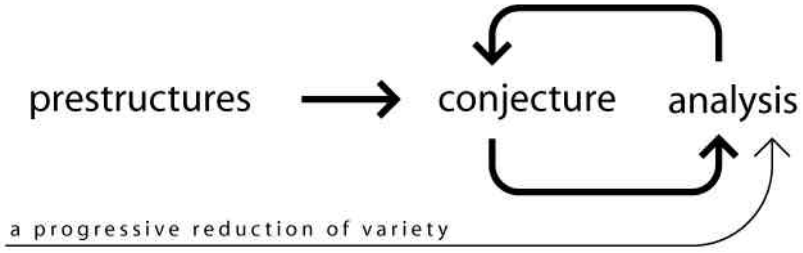

Figure 2.9 The two key stages in relation to Hillier, Musgrove and O'Sullivan's model.

In the pursuit of bringing together a relatively common outline of the design process, Hillier, Musgrove and O'Sullivan's (1972) conjectural design model will form the basis of the assembly. Lawson's model of design problems will be utilised to clarify the issues related to design problems in both commencement and development stages; and while Darke's primary generator concept will be incorporated into the commencement stage by its definition, its roles in the development stage will be made clear as well.

2.4.1 Commencement of Design Processes

According to Hillier, Musgrove and O'Sullivan (1972), when a design problem is stated there are theoretically an infinite number of possible solutions and variety, yet only one of these will be the final one that is going to be built. It is seen that through conjecturing approximations of solutions and testing them against the increasing understanding of the problem, the designer reduces the variety of possible solutions to one unique solution. However, beginning with a theoretically open problem, with an unlimited number of solutions, Hillier, Musgrove and O'Sullivan stress that the variety of possible solutions is already reduced before any conscious act of designing begins by two sets of limiting factors, one set internal to the designer, and one set external.

External variety reducers are stated as some evident or discernible constraints in the problem at hand, whereas internal variety reducers being the designer's cognitive capability in relation to the problem. These together constitute or reveal the latencies and preconstraints that the designer will proceed with the design problem, effectively determining the course of the design process (Figure 2.10). It is worth reiterating Thomas and Carroll's (1979) empirical studies and noting that the particular goal structure brought to the design task, the designer's prestructuring of the problem, provides a remarkable influence on its solution, for good or ill.

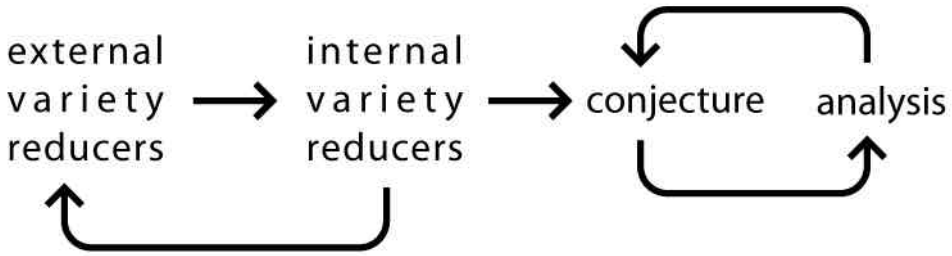

Figure 2.10 External and internal variety reducers in the prestructuring phase.

2.4.1.1 External Variety Reducers

External variety reducers present an initial conception of the design problem. They usually come with the design brief and generally attend to a number of constraints, framing possibly the intentions of the client, the production means, materials, norms of appearance maybe, or some wishes or goals, which effectively reduce the number of possible directions. Hillier, Musgrove and O'Sullivan (1972) stated that some of these possibly will not be fully understood by the designer at the outset, but as he specifies them, their roles as variety reducers would become clearer.

It is stated before that Lawson's model of design problems will be utilised to clarify the issues related to design problems throught the design process.

Hence the external variety reducers will be dealt with in terms of the generators of these variety reducers, their domains of influence, and their functions as variety reducers in analysing students' design processes (Figure 2.11). Doing so would not only help to organise these variety reducers, these constraints in a more structured and consistent way, but would also aid in distinguishing between whether a problem is initially an open-ended one or one that is tightly constrained by the design brief. It is also important to note here that, according to Lawson (2000), just as the problem and the solution proceed side by side in design processes, ideally, designing and the design brief should develop interactively as well; the design brief being restated to match the new and ascending understanding of the problem.

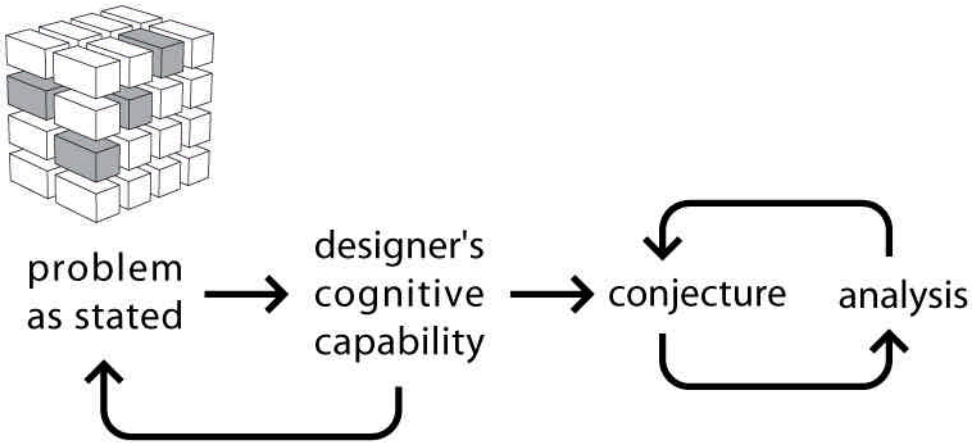

Figure 2.11 External and internal variety reducers in the prestructuring phase.

2.4.1.2 Internal Variety Reducers

It is seen that conjectures do not *synthesize* from data analysis, but from the designer's pre-existing cognitive capability stimulated by the particular problem structure at hand. Internal variety reducers are an expression of the designer's cognitive map related to the problem, and in particular his knowledge of instrumental sets (technological means), solution types (precedents or exemplars), and additionally what Hillier, Musgrove and

O'Sullivan (1972) refer to as informal codes. Informal codes are knowledge of user or usage requirements that a designer operates to link his knowledge of instrumental sets and solution types to built outcomes. They can be likened to an understanding of the radical constraints of a particular design problem.

Hillier, Musgrove and O'Sullivan suggest that these internal variety reducers 'are, and must be, used by the problem-solver in order to structure the problem in terms in which he can solve it' (1972:257). This pre-existing cognitive map, according to Hillier, Musgrove and O'Sullivan, acts as a plan for finding a route through the problem material 'that would otherwise appear undifferentiated and amorphous' (1972:257). As a consequence, data about the problem are not collected at random, and what is to be called data is already determined by the problem material and the designer's route through it. In other words, even before the problem is further specified by the gathering of data about the problem, it is already powerfully constructed by the two sets of limiting factors: the problem as presented, and the designer's cognitive capability in relation to that type of problem. It is worth reminding Thomas and Carroll's (1979) empirical studies again, and noting that this route through the problem material would provide a remarkable influence on its solution, and again, for good or ill.

It is quite likely that, the designer's pre-existing cognitive capability and the one as required by the problem situation may vary. For example, the client might opt for a particular material, or may either have or lack certain manufacturing means or technologies that would challenge the designer's knowledge of instrumental sets. The designer might be uninitiated to the sector he will design for, or might not be up-to-date with advances in the sector, thus his knowledge of solution types might be limited. Research should predominantly influence the designer's cognitive capability, according to Hillier, Musgrove and O'Sullivan, at the stage of prestructuring the problem in order for him to understand it.

Additionally, Hillier, Musgrove and O'Sullivan state that when the manufacturing methods were relatively unsophisticated, materials and precedents were few, and their evolution was relatively noticeable, notions about users' needs were coded and contained in instrumental sets and solution types. But together with a proliferation of instrumental sets and solution types, they maintain, users' needs in terms of activities, physiological requirements, and cultural expectations are no longer contained solely in instrumental sets and solution types, and a body of information expressed in terms of the users emerged. This presents a proliferation of information as well, often generated by research-oriented disciplines, and often in the form of legislative constraints, which, in a sense, formalise users' needs. Since conjectures do not synthesize from data analysis, Hillier, Musgrove and O'Sullivan stress that 'results' of research in the form of packaged information does not lead easily to better solutions. They stress that the designer will, and should, use this information heuristically by using it in relation to his informal codes, or otherwise its influence on design and the designer's conjecturing ability will remain limited (Figure 2.12).

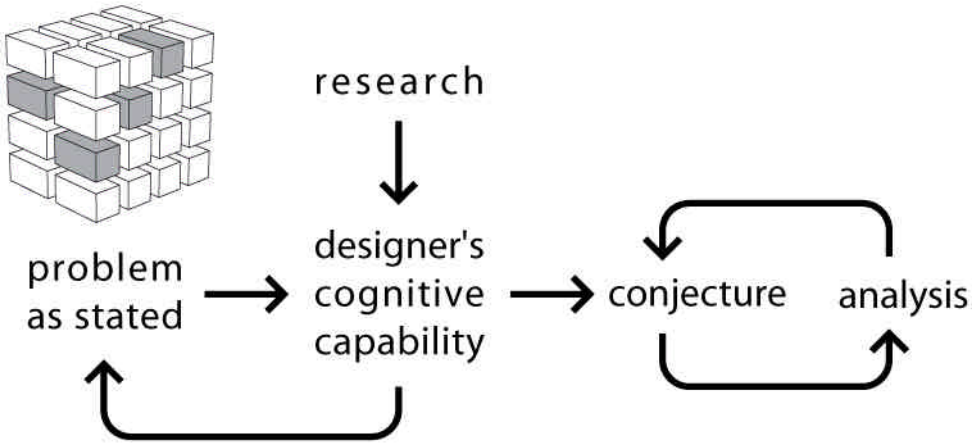

Figure 2.12 The major role of research in the design process.

Hillier, Musgrove and O'Sullivan's conceptualisation of the design process was validated by Darke's (1979) field studies as discussed before. Their model suggests in principle the possible origins of design solutions, but Darke's interviews with practising architects further revealed the presence of some organising principles, some relatively simple ideas that they adhere to very early in the process. These ideas, primary generators as Darke calls them, are stated as some quite personal views initiated by the problem, allowing designers to narrow down the range of possible solutions in quite complex design problems.

Although Hillier, Musgrove and O'Sullivan gave an elaborate account of the prestructuring phase and also mentioned analogies, metaphors, or inspiration as alternative sources of conjectures that extend the designer's conjectural field, it was Darke who witnessed and brought into discussion the ideas that generate a conjecture. Although definitions of both the prestructuring phase in Hillier, Musgrove and O'Sullivan's model and the primary generator are quite alike, in Darke's approach, the designer proceeds to the next stage with an idea, an organising principle, a 'concept'. Thus a primary generator appears to be a settlement, a decision to handle the design problem in a particular way, and a rather subjective starting point for the designer.

Lawson (2000), through Darke's findings as well as his own empirical studies and interviews with practising designers, identifies three general sources of primary generators, of central design ideas. Considerations on the primary purpose of the object being designed, the radical constraints of a design problem are the first general source of primary generators. Secondly, he states, it is likely that any particularly important external constraint would influence the designer's thoughts significantly. Finally, according to Lawson, it is likely that designers' guiding principles, their 'intellectual baggage' might be effective in their emergence. Such an identification of the possible sources of primary generators would aid in analysing students' design

processes, by making clear where to look for in search of the sources of their central design ideas.

The concept of primary generator is also consistent with the notion of ‘good design’ as Lawson mentions. A primary generator gives way to the development stage, and helps in organising and neatening the whole design. Moreover, this generative idea may become quite important to the designer and the design process as well. According to an architect Lawson (2000) interviewed, unless there is enough power and energy in this ‘generative concept’ as he defines it, the result would not be remarkable. The quality of this idea is the ‘food’ for the design process for him, and it can rejuvenate a sinking enthusiasm in the design team during the design process (Lawson, 2000:196).

According to Darke (1979), a primary generator may arrive very early in some processes; however in other cases a certain amount of preliminary work may take place before a concept arises. Therefore conjectures of approximate solutions may start to come before a primary generator does. This central idea may emerge later on the process, a principle may start to display itself as the designer structures a better understanding of his problem. From that point on, the development of the design may be reorganised around this primary generator, and the ongoing efforts may be integrated through it.

A primary generator may affect most of the decisions, qualities as well as formal features of a built outcome, although it will be seen in the next section that a primary generator or a certain line of progress may have to be cast aside during the process. It is seen that Hillier, Musgrove and O’Sullivan’s model illustrates a ‘path of convergence on a unique solution’ along the design process (1972:258). Therefore, if a certain organising principle is evident in the built outcome, it should be possible to track the emergence of

this principle going back in the evolutionary timeline of the design, and spot where a primary generator entered the process.

2.4.2 Development of Designs

An ‘on the spot experimentation’ in a design review between Quist and Petra was mentioned in the first chapter. Although the time allocated for the development of a design may differ from one project to another, and in some cases may be spread over years, this phase of the design process, it can be said, proceeds through what Schön (1983) identified as a ‘reflective conversation with the materials of the design situation’. In this phase, the process advances iteratively through conjecturing design solutions or approximations of solutions and analysing them to see to what extent they address to the problem’s structure. If the ‘pre-existing cognitive map’ of the designer is taken as Schön’s tacit ‘knowing-in-action’, conjectures help reveal ‘value conflicts’ between the designer’s pre-existing (and ever-developing) cognitive map and the design situation.

It is seen that conjectures should come early in the process, before much of the constraints and requirements have been worked out in detail, since these constraints and requirements can only become operational in the context of a particular solution (Darke, 1979). Value conflicts revealed through conjectures demand reflection and force the designer to turn to his cognitive map and the design situation at the same time, using Schön’s conceptualisation; and through analysis, strategies and the understanding of the problem are restructured for the next conjecture. Further conjectures provide either satisfactory results or present further value conflicts; and thus in its analysis, it is as though the situation is ‘talking back’ to the designer (Schön, 1983).

As the designer collects and organises the problem data, and data about constraints, his conjectures acquire sharper definition. The designer has an increasing fund of information against which to test his conjectures, which is truly in relation to his particular approach, his unique solution path. It is seen that the designer will use this information heuristically by using it in relation to his informal codes, by which abstract requirements are linked intuitively to built outcomes; and according to Hillier, Musgrove and O'Sullivan, this increasing fund of information can also be used to test the new conjectures. Thus conjecture and problem specification proceed side by side, as mentioned before, rather than in sequence (Figure 2.13).

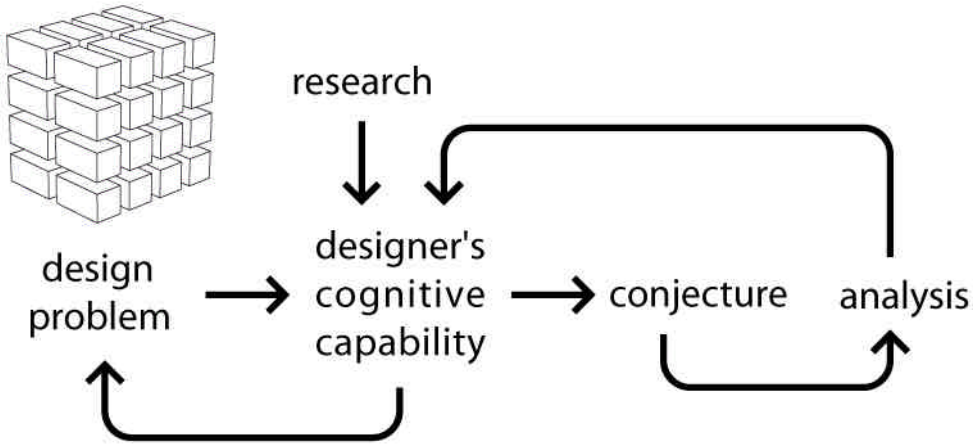

Figure 2.13 Development of the design.

In analysing students' design processes, it is stated, Lawson's model of design problems will be utilised to track their progresses in their design development stages as well. It is seen through Akin's (1979) empirical studies that designers satisfy an acceptable number of constraints, those addressed initially by the designer's prestructuring of the problem and those that present themselves as crucial ones later in the process. The model of design problems, it is hoped, would make it possible to track students' progresses in a consistent manner, as well as their problems'. Through analysing students' conjectures and subsequent conjectures, it should not

only be possible to witness how they integrate and coordinate these constraints, but also to assess the effectiveness of their analyses, i.e. whether they listen as the problem situation ‘talks back’.

As it is seen previously, Hillier, Musgrove and O’Sullivan’s model recognizes implicitly that both information and conjectured solutions are inherently incomplete as the design process ends. It is always possible to collect more data and to produce more conjectures. According to Hillier, Musgrove and O’Sullivan, when a conjectural approximation of a solution stands up to the test of increasingly specific problem data, a solution in principle is reached. Further variety reduction takes place in detailing this solution as the time allocated for the process permits, and further refinements are made as production drawings are developed. It is sensible to infer that, the maturity of the final design in this process should be in relation to the stage of the process where the ‘path of convergence on a unique solution’ is entered. It is reasonable to assert that an early convergence should leave to the process as well as the designer more time to refine and detail the design, and vice versa. This reasoning can be tested by going back in the evolutionary timeline of the design as well, in order to recognise a point of convergence and to assess the effects of its timing on the final outcome.

It is seen how the range of possibilities can be restricted by initially focusing on a limited selection of constraints and moving quickly towards some ideas about the solution, towards some primary generators. It is also seen that in the early phases of design, the problem is not studied in minute detail but in a fairly rough way as the designer tries to get hold of the issues that would aid him in determining form. Once a solution idea is formulated, and conjectures put forward tangibly, it can be tested against the ascending understanding of problems in the design situation. However, as mentioned before, unless the design proves to be totally successful as the designer gradually modifies the ‘embryonic design’ (Lawson, 2000:203), this certain line of development, this evolutionary progress may have to be cast aside

during the process. According to Lawson (2000), either the general form of the solution appears to be incapable of solving enough problems, or so many modifications may have to be made that the idea behind the solution is lost or diminished. In either case the designer is likely to take a revolutionary step and to commence a completely new train of thought.

However, Lawson maintains, ‘ the design process can only begin once, and lessons learned, attitudes developed and understandings acquired cannot be denied’ (Lawson. 2000:204). In other terms, the designer’s cognitive capability in relation to the design situation is now in a considerably higher state. Together with an increased understanding of the interplay of design constraints, and seeing where the previous efforts went wrong and why, the designer either may commence a new line of progress with his primary generator, or he may find and adhere to new central design ideas, organising principles. Therefore although his remaining time might be limited for the refinement of his design, his new cognitive capability should allow him to sidestep much of the early efforts with a design problem spent in order to understand it. He can now put forward his conjectures with a sharper definition. Therefore an early convergence might not automatically mean a better progress or an increased maturity to be displayed in the final outcome.

2.4.3 Key Components

It is believed that a relatively common outline of the design process is brought together through these discussions. The literature search presented a number of interlocking and overlapping key components of design processes, and it was found appropriate to present these key components in relation to their effects on the commencement of a design process and its development.

Key components in a design process can be identified as:

- The design process as a progressive reduction of variety, and the variety reducers,
- The design problem in the form of constraints,
- The designer's cognitive capability consisting of instrumental sets, solution types and informal codes,
- The importance of the designer's prestructuring of the problem in terms in which he can solve it,
- The concept of primary generator as a central design idea, as well as an organising principle for the whole process, and its likely sources,
- Design development in the form of a reflective conversation with the materials of a design situation; with conjecturing possible solutions, analysing them and reassessing both external and internal variety reducers, the design problem and the cognitive capability in relation to it,
- Therefore the understanding that designing and problem specification proceed side by side,
- The role of research in a design process that has to be conducted in relation to the design situation and particularly in order to nurture the designer's cognitive capability, i.e. relevant research,
- And the design development as a path of converging on and refining a unique solution as the time allocated for the process permits.

CHAPTER 3

FIELD STUDIES

This chapter addresses two field studies conducted in order to gain insights from design processes of industrial design students. Firstly, an observational study conducted on senior industrial design students will be introduced. The setting, the particular studio project observed and the elements that added up to its academic scheme as determined by the studio tutors will be discussed. Then, in relation to a brief literature review on social research techniques, a participant observation study carried out by the author on industrial design students at their final semester will be brought in. Then a secondary field study, long interviews conducted with a number of the initial sample will be conveyed. This second field study was conducted not only to validate the first study, but also to supplement it. The findings from the field studies will be discussed in the next chapter.

3.1 STRATEGY FOR RESEARCH

It is witnessed that the ways designers get to understand their design situation in an intuitive design process and a student's grasp of those underlying connections in learning-by-doing are quite similar. It is seen that students have to perform right from the outset, they have to educate themselves by beginning to perform, they need to structure and restructure their understandings of both designing as well as learning in learning-by-doing. They need to refine these understandings as much as possible within

the time allocated for the learning process permits. These understandings would naturally be partial or immature as the learning process ends, and at certain stages of their education, they should be handling their projects with their existing cognitive capabilities related to (learning) the design activity. Moreover, to continue with the analogy, their particular attitudes towards this learning problem, i.e. shortcuts to success or vice versa, should provide a remarkable influence on its solution, i.e. the attainment of individual design processes. Therefore, even though Lawson's (1979) own research sample, the senior architecture students, displayed a consistent strategy in his experimental design task, students' accumulations in their understandings of the design process and consequently their individual approaches to design problems may vary.

Nevertheless, Lawson (1979) concluding his experiment stated that the consistently different cognitive styles of science and architecture students is a result of their educational experiences, and it is seen in the first chapter that students are not on their own through these educational experiences. However, an issue was also raised in relation to latent effects and uses of academic schemes in conveying or helping students to structure an understanding of the design activity on a project basis alongside design reviews: how institutional are students' processes as much as they are personal?

According to Akin, "any method of design, whether it is a small aid to be plugged into the overall intuitive design process or it is a complete design process itself, has to conform to the human parameters, if interface is anticipated at some level" (1979:206). If the framework the second chapter provided gives a judicious account of the design activity as it is carried out in the real world, then it can be utilised for two major purposes. Firstly, outlining a natural design process, it can be utilised to assess existing design aids and processes in terms of their correspondences with it, or to develop new ones correspondingly. The latter purpose was Akin's main anticipation from his

own studies on the nature of design activity, devised ‘to understand intuitive-design’ (1979:189); and he also commented critically on existing design models through his findings. Secondly, the framework can serve in observing, understanding and elucidating design processes. It is seen in the first chapter, for example, how Quist analyses the design situation before him intuitively, starts a dialogue with his student’s problem and reframes it through his understanding of the design activity (Schön, 1983). Thus the framework the second chapter synthesized may replicate Quist’s implicit and intuitive accumulation from design practice.

In this study, the framework will be utilised for both purposes. It will be used to elucidate design processes of industrial design students, and it will be used to assess the academic scheme within which they performed. In elucidating students’ design processes an observational study is found to be appropriate, which was subsequently supplemented by long interviews conducted with a number of the initial sample. The setting, the particular studio project observed, and the elements that added up to its academic scheme as determined by the studio tutors will be communicated briefly. The academic scheme will be analysed in terms of the framework to assess its conformity with the human parameters in design, as well as its latent effects on students’ processes.

3.1.1 The Research Method

It was decided to carry out an observational study on industrial design students at their final semester working on their graduation projects. The study covered the Spring 2003 term and took place at the Middle East Technical University, Department of Industrial Design, Ankara, Turkey. The main reason for the selection of this sample, together with a practical

concern[10], was the expectation, quite naturally, that the students should be at their ripest at this final stage of their undergraduate education as far as learning-by-doing is concerned.

The graduation projects at the METU Department of Industrial Design differ from regular studio projects in a number of ways. They are devised and carried out in a way that they function as rehearsals for actual professional practice. Firstly, the department essentially carries out the graduation projects in association with industrial support to equip the students with an increased awareness and concern for the industry. Secondly, graduation projects cover a whole term where the students work independently on individual projects. They are expected to incorporate the variety of skills they have accumulated throughout their past three and a half years to their efforts, and it is an opportunity to demonstrate the current states of their cognitive capabilities related to the design activity. Although the degree of involvement and participation from the industry partners may vary, this situation where each senior student works with an industry partner renders this process relatively analogous to a real-life situation, where a designer works with or for a client.

In order to gain some form of empirical, observational evidence that would aid in elucidating design processes of industrial design students, a method has to be adopted. In the second chapter it is seen that the study and analysis of design activity is a growing research field, and a variety of empirical research methods have been employed to reveal the highly implicit cognitive abilities of designers. Monette, Sullivan and DeJong (1998) point out that observational studies differ from one another along three dimensions. One dimension has to do with whether the data collected through the observations are quantitative or qualitative in nature. A second dimension deals with whether the observations are done in a naturalistic

[10] The author, being a teaching assistant, involved in the graduation project, and also participated in the design studios of the same students the previous term.

setting or a contrived setting. The design protocols planned to gain insights into the design activity are mainly observations within contrived settings, which are observational settings created by the researcher. A naturalistic setting is a real-life situation in which people behave as they routinely would if they were not the subjects of an observation, and in some cases they may not know that they are being observed. The third dimension involves the extent to which the investigator participates in the activities of the people being observed. The two general possibilities, according to Monette, Sullivan and DeJong (1998), are assuming the role of a participant observer or a nonparticipant observer. They maintain that there are various types of observational methods that combine these dimensions in different ways, and the decision to proceed with one is usually determined both by the nature of the research problem and by practical considerations.

The value of observing senior students, particularly within a graduation project that is devised as to approximate a real-life design task have been discussed. Since this study aims to convey students' subjective, personal experiences, the observation calls for the gathering of qualitative data. It is also evident that the observations had to be done in a naturalistic setting, in the design studio where the design work is carried out. The author participated in the graduation project, being a teaching assistant, and since he participated in the design projects of the same students the previous term as well, his presence was taken for granted. These dimensions, the nature and aims of this research problem prestructured the observational study, thus reduced the variety of the number of observational methods that could be employed to observe students' design processes to one, to participant observation.

3.1.1.1 Participant Observation

Participant observation is a method in which the researcher is a part of, and participates in, the activities of the people, group or situation that is being

studied (Monette, Sullivan and DeJong, 1998). Participant observation research is naturalistic where the degree of participation by the investigator may vary. It is suggested that investigators should seek opportunities to conduct this kind of research to develop a better understanding of particular groups or subcultures. Monette, Sullivan and DeJong mention that in some cases, the investigator may have belonged to the group prior to the start of the research and can use this position as a group member to collect data.

Although some quantitative data may be collected during participant observation, it is typically a highly qualitative form of research, which offers access to a very valuable type of data, the subjective experiences of those under study. Its association with these subjective experiences leaves participant observation in the middle of a fundamental controversy in the social sciences according to Monette, Sullivan and DeJong, between the positivist and subjectivist positions of social science. Despite its focus on subjective experiences, participant observation is still considered empirical in the sense that it is grounded in observation, as long as the researchers are concerned about issues of reliability and validity. Monette, Sullivan and DeJong point out that this observational technique is often selected when the research question is exploratory in nature. Through observation, the researcher can begin to formulate concepts, variables, and hypotheses that seem relevant to the topic and grounded in the actual behaviour of people (Monette, Sullivan and DeJong, 1998). There are several key elements that determine the structure of a participant observation study, such as observer roles, steps in carrying out participant observation, recording observations, assessing validity and reliability of a participant observation.

Observer Roles

In many types of research, the relationship between the researcher and those participating in the research is quite clear. In surveys, for example, participants and researchers openly know the roles of each other in the

study. In observational research, and particularly with participant observation, the researcher–participant relationship may become challenging since it can take number of different forms. Monette, Sullivan and DeJong (1998) point out two major issues: the extent to which the observer will change the setting that is being observed and the extent to which people should be informed that they are being used for research purposes. The way in which a researcher resolves these issues determines the nature of the observer – participant relationship for a given research project.

The first issue is often referred to as a question of whether the researcher is primarily a *participant* or an *observer*, according to Monette, Sullivan and DeJong (1998). Those who emphasize the importance of the participation of the observer argue that, in order to comprehend fully the activities of the group and the dynamics of the situation, the researcher must become fully involved with the group. Otherwise group members may not confide in the observer, or the observer may not become aware of the ongoing activities of the group. On the other hand, those who would emphasize observation over participation argue that the more one becomes a member of the group, the less objective one becomes. If researchers become so immersed in the group, they may take on the perspective of the group and can no longer view the situation from scientific perspective.

The second issue in the researcher–participant relationship is both practical and ethical according to Monette, Sullivan and DeJong (1998). Whether the scientific gain justifies the deception of human beings is a matter that the researcher must judge in order to conduct the study. This is an important issue in participant observation because in some cases informing people would undermine the researcher's ability to gather accurate data.

Steps in Participant Observation

In order to conduct any participant observation, the researcher must organise the research and make considerable amount of effort in a number of steps to initiate the study (Monette, Sullivan and DeJong, 1998). The first step is to specify the goals of the research and to decide that participant observation is the most appropriate research method. The second step is to decide which specific group to study. One way this issue is commonly resolved is simply by the accessibility of the group, but representativeness may also be considered. The third step is gaining entry into the group to be studied. For certain subcultures or ethnic groups this step may be extremely difficult. The fourth step in participant observation is to develop trust with the people being studied so that they will serve as useful and accurate sources of information. If the researcher joins the group in some of their routine activities, such as drinking or playing cards together, Monette, Sullivan and DeJong point out, they are likely to view the researcher as one who accepts them, and thus accept the researcher. The fifth step in participant observation is to observe and record. Recording field notes is particularly problematic for participant observers whose status as observer is disguised. Moreover, this step can healthily begin only after the other steps are taken satisfactorily.

Recording Observations

The manner in which observations are recorded depends largely on whether observations are primarily quantitative or qualitative. Quantitative observation calls for more structured recording of data on *coding sheets*, whereas qualitative observation may use less-structured *field notes* (Monette, Sullivan and DeJong, 1998).

Detailed, descriptive accounts of the observations made during a given period are called *field notes*. Precise nature of field notes may vary according to the research problem, however all field notes should include five elements (Monette, Sullivan and DeJong, 1998): A *running description* makes up the most of field notes. Being simply a record of the observations of a session,

recording running descriptions should not interfere with the observation. Field notes also include accounts of previous episodes that were forgotten or went unnoticed but remembered while the investigator is still in the field. A researcher should include analytical ideas and inferences to his or her records. Reviewing these ideas after the completion of observations can be of great benefit to the final data analysis and writing of the report. According to Monette, Sullivan and DeJong (1998), personal impressions and feelings should also be recorded. Doing so helps to minimize bias by giving a sense of the perspective from which the observer is viewing various persons, places, events. And finally by incorporating notes for further information, the observers plan for future observations, specific things or persons to look for, and the like.

According to Marshall and Rossman (1999), in the early stages of qualitative inquiry, the researcher typically enters the setting with broad areas of interest but without predetermined categories or strict observational checklists. The value in doing so is that, the researcher is able to discover the recurring patterns of behaviour and relationships. After such patterns are identified and described through early analysis of field notes, more contextual field notes or checklists, they maintain, become more appropriate.

Time Sampling

Refining a research problem also requires a decision about the time dimension. Participant observation involves gathering data over an extended period, which might span months. This form of research is called *longitudinal research*, as opposed to *cross-sectional research* where a single snapshot of some phenomenon is observed (Monette, Sullivan and DeJong, 1998). Participant observers record things as they are present or happen, and more systematic observers mark coding sheets, for as long as an interchange or social setting persists. However, in some situations continuous data collection is costly and unnecessary. Time sampling, or making observations

during certain selected time periods can provide adequately valid data (Monette, Sullivan and DeJong, 1998).

Validity and Reliability

Observational techniques, like other forms of data collection, need to be assessed in terms of how valid and reliable they are. Observation rests on human sense organs and human perceptions, which can be quite fallible. Especially with observational methods, people are inclined to determinedly state, “I was there. I saw it. I comprehend what was going on” (Monette, Sullivan and DeJong, 1998:240). Observational techniques are considered to have a greater validity than many techniques that rely on second hand accounts like surveys or questionnaires, which fall back on someone else’s perception and recollection. Nevertheless misperception can still occur in observational techniques, and the validity of a study may have to be measured by correlating the results achieved by the observation to some other results achieved by other studies. When such direct measures of validity are not present in observational research, Monette, Sullivan and DeJong (1998) suggest evaluating the observational efforts in terms of factors that might work to reduce validity.

Advantages and Disadvantages

Observational research can focus on both verbal and non-verbal behaviour. This is an advantage because actual behaviour is being studied in addition to people’s statements about how they behave. Secondly, being mainly longitudinal in nature, observational research enables researchers to make statements concerning changes that occur over the time. Observers would have greater insight to establish correct causal sequences than would be the case with surveys. Observational research is capable of studying groups and behaviour that would be closed to other forms of research, especially if the role of the researcher is concealed. Another quite significant advantage of

observational research is that, it is usually the case that the research is conducted by the most qualified person on the research problem, as opposed to surveys, for example, where interviewing may be carried out by hired interviewers.

Most of the disadvantages of observational research relate to the more qualitative, naturalistic and unstructured types. With less structure, the quality of the results of an observational study depends heavily on the individual skills of the researcher, and this leads to several criticisms. Lacking structured tools of other methods to ensure objectivity, the mostly expressed concern with participant observation research is observer bias on the results. Over identifying with those observed is another issue. This carries the risk to deteriorate the research into propaganda piece for the group studied and is labelled ‘going native’ in social research, since this effect is first noted in anthropology. The lack of structure also makes exact replication of an observational research often impossible. There is little chance that a replication attempt would select precisely the same aspects of a given setting to be recorded. The nature of the data collected in some observational research makes them very difficult to quantify, code or categorize. Participant observation also affords the researcher little control over the variables in the setting. Finally observations are commonly limited to a small group, such as a family or a gang, or one setting.

3.2 BACKGROUND TO THE OBSERVATIONAL STUDY

3.2.1 Overview to the Academic Scheme

The Graduation Project of 2003 lasted 17 weeks. There were 38 students in the studio, guided by a staff of four, and occasionally a fifth part-time tutor. The students worked on individual projects for some 23 clients. Monday, Wednesday and Friday afternoons were reserved for studio sessions, adding up to a weekly total of twelve hours of studio work. A timetable handled out

at the beginning of the term outlined the process, specifying several presentations and assignments distributed along the 17 weeks (Appendix A.1). Marked in black in this timetable are the checkpoints where students presented various states of their projects. At the end of the 3rd week the students presented their initial ideas. There were two interim juries at the 6th and then the 11th weeks of the project. The graduation jury took place at the 17th week, which ran along with the graduation projects exhibition. It should be noted that none of the 38 students failed in the graduation project, and that the grade range was quite narrow.

Design reviews and discussions filled the space between these presentations. The design reviews were carried out according to an appointment schedule, which made sure that each of the four tutors see each of the 38 students at least once a week, and vice versa. The students demanded this procedure at the beginning of the term with a primary concern for levelling review times. Additionally the students were requested to organise their ideas and sketches in bound sketchbooks instead of separate sheets, so that when reviewed, these sketchbooks would depict their progresses in a structured way.

Upon examination of the time plan, it will be seen that there was also a peculiar submission sideline to the whole process; an auxiliary activity of researching and reporting pursued parallel to design activity. The students were accustomed to doing supplementary research and presenting their findings in the early phases of projects, but this research sideline of the graduation project differed from their previous practices and routines in a number of ways. Firstly research was a part of the whole process. The findings were not presented, but submitted in report form in three parts with a premeditated content. First part of the reports explored the problem area and its submission was scheduled for the 5th week, a week before the first interim jury. The second part explored the solution area and the reports were collected at the 9th week, again a week before the second interim jury. The

final part of the reports requested the students to describe and justify the design solutions, and was collected until the 14th week of the term.

Although the graduation jury marked the end of the process, the time allocated for designing ended by the 13th week. From that point on the students were expected to start working on their presentations and models, which were expected to be of the highest quality.

3.2.2 Projects and Clients

Determining projects to work on and relating these projects with firms to work with was an important stage of the graduation project. The very first day of the term was particularly reserved for taking in the design projects that the students would like to pursue as their graduation projects and assigning them appropriate partners, clients from the industry. Here, they were asked to submit an initial project statement defining the projects that they would like to work on, and also asked to describe the reasons that motivated them towards going for that particular project including their personal experiences, backgrounds and interests (Appendix A.2). They were asked to identify a number of firms that would potentially support the projects they described, and a list of available partners from various sectors of the industry were present during this study. This list was not restrictive though, and the students could propose design projects other than those associated with the fields of the industry partners available. They could offer potential clients as long as a prospect of a healthy collaboration with these clients existed and verified. The students further specified three alternative projects and clients as well to alleviate this placement procedure.

At the end of the first week, a document outlining the department's expectations both from the graduation project and the collaboration was forwarded to the students and to the clients whose participation in the graduation project were confirmed (Appendix A.3). In this document it was

stated that the principal expectation from this collaboration was a support of expertise. Firms were requested to guide and inform their students especially on the design, production and marketing related issues of their respective sectors, and though originally students were expected to come up with project proposals, it was stated, the firms might suggest particular projects as well. It was also noted that the collaboration should ideally involve some six to twelve meetings throughout the term.

It is mentioned before that the initial project statements voiced the projects and the clients that the students wished, preferred to proceed with; and needless to say, some of them had to go with their second or third choices. Nevertheless, project statements marked the beginning of the design processes. Having had their clients fixed and their initial project statements as well as their early ideas discussed with the tutors (and with the clients, for some), the students resubmitted their project statements in the middle of the third week, prior to the presentation of their initial ideas. It was also recommended that the students reassess their project statements occasionally, thus each research report submission contained the project statement, went over and revised if necessary.

3.2.3 Research Reports

According to Fatma Korkut, one of the tutors who participated in the preparation of research reports, such a difference and change in role of research at the graduation project had two major reasons. Firstly it was intended to be a guide for such a serious and lifelike undertaking. Research was conceived by the tutors as a process where the students acquired and internalised information related to their domains, like the state of the art in their domains, exemplars and precedents, standards, etc. Its distribution throughout the whole term contrasted other studio projects and their ‘research phases’. Instead of a research phase that is carried out in the early

stages of a project and then discontinued or maybe cast aside, it was devised, according to Korkut, as to aid in time planning throughout the term as well, made up of several phases itself. Secondly, she maintained, a focus group study conducted with practising graduates of the department in December 2002 concluded that graduates of the department were being found deficient in report writing, reporting, keeping track of or documenting their procedures, actions, processes or results. The research reports also targeted this deficiency and were devised in order to play, more or less, the role of a graduation thesis.

Research reports, submitted in conjunction with certain presentations in the process with premeditated contents, expressed an expectation of distinct, if broad, steps of progress. Moreover, students were not only to document their research findings through the reports, they were also to explicate their present states, their design decisions, their goals, the results etc. A research report outline was handled out in the middle of the third week (Appendix A.4), as the students resubmitted their project statements. This outline explained the scope and content of each submission, and thus spelled out quite early in the process, what the students were to accomplish at various stages of the graduation project.

Research Report Part One focused on the problem area. It started with the project statement and asked the students to explore the problem area defined by this project statement in three main directions. Students investigated related products, concepts, and design trends in the market; they reviewed related technologies, materials, and production techniques related to their fields as well as their particular projects; and they explored the characteristics and expectations of potential users of the products they were designing. The students were asked to draw some conclusions that might help them in formulating some critical issues to address, potential solution areas and further research topics; and submitted their reports a week before the first interim jury. Exploring these research directions and

interrelating the findings, one of the three students working for a dishwasher manufacturer concluded this phase as follows:

> According to the research I've done, I see that customer's requirements from the dishwasher are towards the ease of usage. The life style especially determines the demands. Some of them want it to clean fewer dishes as well; some of them want it to clean more dishes. For some of them it doesn't matter if there is any dishwasher at home or not, for some of them it is an object that 'can't be done without'. But as far as I noticed they want to do washing easily and quickly**.** As part of a dynamic environment, dishwashers should also be dynamic. It should be done suitable for the traffic of the kitchen. The user should easily access to the baskets and load the things easily to their right places in an order. It should be easily adjusted to the different kinds of dishes and pots.
>
> In my project I especially want to deal with the ergonomic and functional problems of the dishwasher in the traffic of the kitchen. After observing the user-product relation to analyse the posture of the human body while using the dishwasher, some critical points for the statement can be derived. According to this analysis usage of the dishwasher should be made suitable for the regular movements and postures of the users in that kitchen.

Research Report Part Two focused on the solution area and requested again a week before the second interim jury. This part started with the project statement as well, revised or reformulated if necessary. Here, the students were firstly asked to develop some project 'constraints, objectives, and directives' based on the insight and information gained during the first part of the research and their ongoing design activity. Through these constraints, objectives and directives, the students communicated the decisions or criteria that they had been working with and those that they wanted to be evident in their finalised products. Constraints, according to the outline the students were given, state what must or must not be done in a clear way. Objectives are statements less forceful that constraints, outlining some goals or criteria that the designer tries to achieve as much as possible. Directives are stated as the goals that are desirable, but not necessarily urgently important like some preferences of style, or personal biases that the designer brings to the project. Next, the students were asked to make further research into specific issues that revealed themselves as the projects developed, according to the defined goals. Analyses of potential design solutions

concluded this part of the research reports. Here the students were asked to incorporate some exploratory sketches and solution proposals that would satisfy the defined constraints, objectives and directives; they were asked to assign priorities to these goals and to justify these priorities with research.

Together with a revised project statement, R*esearch Report Part Three* included a brief description of the design solution and justification of the design decisions that shaped it. Students were also asked to discuss their design solutions in terms of client response, market potential, material selection, production techniques, cost and price, user response, design features and style, usage scenarios, etc. This final part of the research reports was accepted in the 14th week, a week after the time allocated for designing ended (Appendix A.1).

3.3 DISCUSSIONS ON THE ACADEMIC SCHEME

Akin's (1979) concern was mentioned before, that any method of design has to be compatible with human parameters, to intuitive design, if interface is anticipated at some level. It is also seen that other than students' accumulations from their past studio projects, that is, what they have learned by doing, they carried out a design work within an academic scheme that identified certain levels of progress. It was comprised of various presentations and submissions distributed to the process as determined by the timeline. Although this scheme neither was, nor intended to constitute some definitive design method, it still implied a process. The research reports with their varying contents were also devised in order that it might to aid the students in handling the graduation project in its wider scope. In this part of the study, some key elements of the academic scheme of the graduation project and the design aid for the term will be studied in terms of the framework brought together in the second chapter, to assess to what extent they conform to the human parameters identified by it. It is important

to note here that the students were graded for most of these steps that will be investigated.

3.3.1.1 Projects and Clients

Descriptive design methodology brought about a revaluation of the subjective, of designers' experiences and their intuition. According to Lawson (2000), designers do not approach each design problem afresh, with a blank mind. Rather designers have their own motivations, reasons for wanting to design, sets of beliefs, values and attitudes. It is seen that designers may carry their guiding principles into each project, and may differ in the kinds of constraints they keep in focus. According to Lawson, moreover, some designers may become known for specialising in certain kinds of problems and, thus, sets of radical constraints. A better command of radical constraints for a given field should also mean well-developed informal codes. By giving the students the opportunity to select the projects that they wish to undertake and the clients they would like to work with, it can be said that the department aids the students to specialise in and start contacts for those fields that they would like to work in following their graduation. This also helps the students in enriching their portfolios related to those fields.

It is seen that conjectures come from designers' cognitive capabilities in relation to the particular problem at hand. Therefore, letting students select their projects themselves would also let them select those projects which may be in relation to their pre-existing cognitive capabilities, which, though may be questionable in educational terms, should certainly aid them with their conjectures. Although the sources of design briefs may vary and the problems may differ in structure than as initially conceived or anticipated by the student, still if a student had served an internship in a related field, if s/he has some experience or familiarity in the usage of the particular product to be designed or in the activities that are related to it, it should still aid the student dearly with his or her prestructuring.

3.3.1.2 Project Statements and their Resubmission

Students' first assignment, the submission of project statements requested them to define their projects as follows (Appendix A.2):

> Write a short statement describing the design project that you wish to pursue as your graduation project. A project statement is essentially a goal statement or problem definition; it defines the problem space in general terms and avoids preconceived solutions.
>
> This statement may be revised several times during the development of the project.
>
> Examples:
>
> Design an outdoor play environment which accommodates the physical exercising needs of visually impaired children between the ages 7-14.

Project statements of the academic scheme were adapted from Owen's *Structured Planning* model (1987). According to Owen, although it is not possible to define a project absolutely, it is still important to take a position about how to proceed with it in the early stages of its specification. These positions, Owen maintains, help in clarifying points of interest as well as possible limitations concerning the project. When stated well, he claims, project statements communicate what must be done without attaching some preconceived ideas or existing conceptual frameworks to the project. This should mean, according to the key components of the framework, that the statement should help the designer in variety reduction, but should not reduce variety excessively at the outset, especially the designer's pre-existing cognitive capability. Nevertheless, for Owen, it should take into account, and maybe reveal, the designer's standpoint relative to the problem, and address some constraints identifiable in the problem as much as its limited understanding affords.

Though project statements start the process, they do not necessarily specify 'a way-in to the problem', an idea, a primary generator. To remind the central design idea of one of the architects Darke (1979) interviewed, it is not likely that he had started with a project statement like, "design a mews-like street

that…". Project statements are to define the problem area, according to Owen (1987), and especially with function-oriented terminology.

Points to refrain from in a project statement and their effects may be made clearer through an experiment carried out by Thomas and Carroll (1979), where design students were asked to solve a series of problems. In the experiment half of the students were provided with a design aid, which required subjects to specify the goal of a problem, the objects, the transformations and some of the relevant attributes. To their surprise, the performance in the no-aid group was superior to performance in the aided group. Thomas and Carroll based the aid on the notion that people often fail to solve problems because they do not formulate the problems well. The results still supported their notion upon the analysis of the answers given to the questions about the goals, objects and attributes. They found out that many people slightly but vitally misunderstood the problems.

The result of Thomas and Carroll's experiment does not tell whether such an aid helps designers with their prestructuring or really hinder their performances; but together with their other empirical studies, voices once more that the particular goal structure brought to the design problem provides a significant influence on its solution. Therefore it can be inferred that the project statements of the academic scheme, other than their probable benefits in the commencement of design processes, may aid the tutors in assessing the positions the students' take, and the latent effects of these initial positions, assumptions and understandings.

Additionally, if writing out project statements is important to take a position about how to proceed with the project in its early stages, reassessing and rewriting them as encouraged by the academic scheme is equally or maybe more important according to the framework. Although the framework does not specifically include or suggest a project statement, it does suggest that problem definition and problem solution, designing and briefing should

proceed side by side, by reformulating the problem in relation to the ascending understanding of the problem. Therefore it can be inferred that asking students to resubmit their project statements in the middle of the 3rd week conforms to the nature of the design activity. Although this particular resubmission served another purpose as well, fixing for good the students, the projects and the clients, it was suggested that the students refine them with each research report submission along the process. This again conforms to the framework properly, however the extent of this refinement and its limits were not constrained or stated.

3.3.1.3 Initial Ideas

Discussions on project statements and initial ideas had started by the 2nd week, at the studio, in design reviews. Students were also encouraged to seek advice from their clients in reformulating their project statements or on their embryonic design ideas if there were any. After the students expressed their positions with regard to their projects more knowledgeably and reasonably through their reassessed project statements, they presented their initial ideas at the end of the 3rd week. This presentation urged the students to represent their abstract positions with approximations of solutions and possible directions.

The framework suggests that conjectures of approximate solutions should come early in the process, since not only a vast variety of design decisions cannot be taken before the solution in principle is known, but also the problem would not reveal itself sufficiently unless it is explored via solution attempts. It is seen that conjectures do not synthesize out of a thorough analysis of the problem. Thus, by asking students to embody their abstract positions with relatively tangible approximations of solutions, and doing that quite early in the process, it can be said that the presentation of initial ideas is not only in harmony with the framework, but is also an invaluable

component of the academic scheme with its potential to influence students' understandings of the design activity for the better.

Conjectures at this stage were of those that are put forward to structure an understanding of the problem rather than those to refine a unique solution. Thus, primary generators, central design ideas may or may not be evident at this stage; or there may be several of them, the potentials of each of which pursued to some extent by means of reflective conversations. The time plan for the graduation project reveals that the students were asked to build and bring mock-ups in design reviews during the following week. Thus, without delay, the students were also driven to advance, to test and analyse their routes through the problem material.

During the fourth week, the students were also conducting research to those areas as identified by the first part of the research report outline, which was handled out only a couple of days ago. Therefore if some students started to converge on design solutions following the presentation of initial ideas, it can be said that their pre-existing cognitive capabilities as well as the design problem as initially stated sufficed to reduce variety considerably, and to initiate the development stage. Additionally, the design reviews preceding the presentation of initial ideas as well as clients' counsels and contributions should have played their respective roles in the prestructuring of problems, and thus in such early convergences. Since the students' cognitive capabilities were nurtured 'institutionally' starting from the middle of the third week, an early convergence may also imply that they already have their own ways to nurture their cognitive capabilities. But it should be remembered that a conjecture may be found to be answering less problems than it creates, or an idea may prove to be lacking adequate quality to nourish the whole design process, and revolutions may be required especially in early stages.

3.3.1.4 Research Reports

The framework addressed the role of research in a design process. It is stated that unless research can influence designers at the stage of prestructuring the problem in order to understand it, then its influence on design will remain limited. Moreover, further research during the development stage of a design process, it is maintained, should be relevant to the ongoing progress of the design process. Thus, it is necessary to assess the latent effects of research on various stages of students' design processes in relation to its progression in three stages.

Research Report Part One, it can be said, illustrates a total match with the framework. It was aimed specifically to nurture each one of the constituents of a designer's cognitive capability. It is seen that the students were to investigate related products, concepts, and design trends in the market (solution types); they were to review related technologies, materials, and production techniques related to their fields (instrumental sets); and they were to explore the characteristics and expectations of potential users of the products they were designing (informal codes). It also governed the project statement to be revised if necessary, and previously in the analysis of the academic scheme, this was found in compliance with the framework as well. The timing of this part of the research reports were quite accurate, that is, these research directions were to be explored in the commencement stage of processes, as the students were structuring their understandings of their design problems. However, it can be observed that the time allowed for completing this part of research reports was relatively short (Appendix A.1). A reason for this limited time may possibly be the client and project assignment process. It is mentioned before that this assignment process lasted for more than two weeks, and concluded for good by the resubmission of project statements in the middle of the third week.

Research Report Part Two, as stated previously, firstly asked the students to develop some project constraints, objectives, and directives (CODs) based

on the insights and information gained during the first part of their research as well as their ongoing design activity. Through these CODs, the students communicated some design factors that they identified or had been working with, to form bases for their design decisions that they wanted to be evident in their finalised products. Like the project statements, these CODs were also elements of Owen's *Structured Planning* model (1987). The research report outline defined these CODs as Owen defined them and pertaining to their definitions, their role was similar to Owen's model. However, in Owen's model CODs belong to the problem space and are used for finding and structuring information; whereas in the academic scheme they were put to use in exploring the solution space. In Structured Planning, CODs are defining statements with varying degrees of strength, which serve to focus the project within the general instructions of the project statement. They are stated before any conscious design activity begins. These defining statements, CODs are written out to a certain format, and for Owen, they are to isolate issues that are important and suggest *the* direction that the project *should* follow with regard to them.

Structured Planning was especially aimed to deal with complex design situations, such as designing a space station for the NASA, which require a great amount of team effort across many disciplines. Yet, in terms of rather individual intuitive design practices, in comparison to the framework brought together in the second chapter, it is evident that such a method of commencing a design process presents some mismatches. As they are specified in Structured Planning, the CODs come closer to what Lawson (2000) prefers to address as criteria rather than constraints. To remind once more, criteria, for Lawson, implies clearly stated goals in advance of attempts to produce solutions. It is seen that not only conjectures do not synthesize out of information, but also it is hard to estimate or suggest a particular direction that the project *should* follow without an understanding of possible solutions in principle. To quote Rittel and Webber again, 'one cannot understand the problem without knowing about its context; one cannot

meaningfully search for information without the orientation of a solution concept; one cannot first understand, then solve' (1973:138). Therefore it can be stated that, in choosing *not to* incorporate these CODs into the process as Owen specified them, the academic scheme conforms to the human parameters as represented by the framework.

The academic scheme still made use of these CODs however, and they were introduced into projects about the half way into the time allocated for designing. This should be a stage of the process where the students' and their clients' positions were more or less determined, where the students had improved their cognitive capabilities and elevated their understandings about their problems as well as their resistances. Consequently, it is quite likely that some criteria and crucial design considerations as well as some central design ideas might already be in operation, and it can be expected that the students might already be converging on unique design solutions. Therefore in relating these CODs to a later stage and asking the students to explicate their goals after they are some way into the development phase, the academic scheme again conforms to the framework. However, if such an analysis is sensible, then CODs were mainly put to use in making the solution space explicit, rather than exploring it.

Research in the development stage, as it is seen, should be in relation to the ongoing efforts. In asking students to carry out further research particularly in relation to the stated CODs, into specific issues that reveal themselves as projects developed, and especially through the existing design solutions, the academic scheme is found to be in conformity with the nature of the design activity. Analyses of potential design solutions concluded this part of the research reports. Here, the students were firstly asked to 'make further analytical sketches that support the CODs (Appendix A.4)'. This statement should mean a request to reassess their existing design solutions through the point of view of these explicated CODs, especially since it is stated that these criteria are likely to have evolved and developed as the projects and

the problems have. CODs would not be some newly discovered or separate criteria, and the students should already have their priorities assigned to their goals. A second request was that, the students were to identify some 'basic strategies to follow', and to determine 'which CODs are more critical than the others'. Here again it can be expected that the students would put their existing strategies on paper, since some strategies should already have underlined their actions. In identifying which CODs are more critical than others, this statement should mean a documentation of those constraints and criteria that the students found crucial and shaped their routes through the problem material accordingly. This final part of this phase of research reports, it can be assumed, was aimed for documentation and revelation. Additionally undergoing such a documentation exercise in this phase should prepare the students for the next part of the research reports.

Together with a revised project statement, R*esearch Report Part Three,* included a brief description of the design solution and justification of the design decisions that shaped it. This final part of the research reports was accepted in the 14th week, a week after the time allocated for designing ended. Here the students were asked to discuss their design solutions in terms of client response, market potential, material selection, production techniques, cost and price, user response, design features and style, usage scenarios, etc. Though this part of research reports was seemingly concerned with an involved documentation of students' own undertakings in relation to certain headings, its more profound effect to the whole process should be the explication of some key design considerations in the form of these headings that should be thought out in shaping their designs. Through CODs, the students had already explicated those crucial design considerations that surfaced in relation to their individual approaches and their design problems. Here, these headings were some additional considerations in relation to the nature and significance of a life-like graduation project, and were imposed by the tutors. Therefore, just as it is a tutor's role to guide the students and channel their efforts from one part of

their problems to another, these considerations, stated quite early in the process, can be taken as a way to achieve the same ends in an implicit and passive manner.

3.3.1.5 Juries and Anticipated Levels of Progress

It is seen that the presentations and submissions in the graduation project followed an alternating sequence. Through such an outline, it can be said that, as the initial ideas were most likely to arise out of students' pre-existing cognitive capabilities, students' conjectures in the *first interim jury* should have been the results of their improved cognitive capabilities and their elevated understandings about their problems. Thus students were to explore their problem areas adequately by the first interim jury. It is seen how the range of possibilities in a design situation can be restricted by initially focusing on a limited selection of constraints and moving quickly towards some ideas about the solution, towards primary generators. Favourably, the students had advanced to their design development stages, and had adhered to some organising principles. However some of them could still be prestructuring their problems through partial developments, through different lines of attack in relation to various primary generators, and might be 'starting over' upon realising that their conjectures were answering less problems than they create.

In between the first and the second interim juries students might be converging on unique design solutions and refining their conjectures. They should be making further research to alleviate this refinement process, and they should have determined some crucial design considerations that allowed them to explicate their CODs. By the *second interim jury*, the students were to have quite tangible design solutions, since sources of these design solutions were to be analysed, discussed, and supported with further research in the second research report. They were to put forward more

rigorous efforts in refining their design solutions, with goals and aims determined, and some additional design criteria beginning to be settled.

Although *the graduation jury* marked the end of the process, the time allocated for designing ended by the 13th week. From that point on the students were expected to start working on their presentations and models, therefore they were expected to be of the highest quality. Since the time plan was handled out at the beginning of the term, and since the research report outline was handled out at the third week, the students knew quite early in the process what they were expected to fulfil at certain stages of the project. Additionally, a desired level of completeness and its constituents as well as some qualities in relation to the final product were also made explicit. Therefore together with high quality presentations and models, it was also expected that the students explored these considerations, and fulfilled them through their designs.

3.3.1.6 Conclusions

Through these discussions, it can be concluded that the academic scheme determined for the graduation project significantly matched a natural design process as represented by the framework. While the juries in the process and especially the presentation of initial ideas urged the students to proceed with conjectures, the research reports are found to be capable of nurturing students' design processes effectively and in the right time. They also helped the students in their analysis of their design solutions.

Additionally, just as latent effects of students' initial positions could be assessed by means of their project statements, the research reports also provided a common ground in tracking students' research directions and how they incorporated research into their processes. Therefore submissions of the academic scheme were not only latently effective as aids for the

students, but for the tutors as well, supplementing insight gained into students' processes through design reviews and presentations.

3.4 CONDUCT OF THE OBSERVATION

The setting, the particular studio project observed, and the elements that added up to its academic scheme as determined by the studio tutors are communicated briefly, and the academic scheme within which the students worked is analysed in terms of the framework and found to be in conformity with those human parameters in design as outlined by the framework.

3.4.1 Structure of the Research

It is seen that qualitative observational research is characteristically relatively unstructured, since what is to be observed is largely dependent on what patterns emerge as the study proceeds, on what is revealed by the subjects and their activities. It is stated that there are several key elements that determine the structure of a participant observation study, such as observer roles, steps in carrying out participant observation, recording observations and assessing validity and reliability of a participant observation. It is appropriate to give an account of the conduct of this particular observational study in line with these elements.

3.4.1.1 The Research Problem

This participant observation study was predominantly conducted in order to elucidate the design processes of the students observed. Upon disclosure of these individual yet guided design processes carried out throughout the graduation project, it is hoped that some insights into various phases of the students' design processes, their design skills and some personal

procedures and approaches would be revealed on an individual basis together with the actual effects of the academic scheme on their processes.

3.4.1.2 Observer's Role

Different from some cases where participant observation is chosen as a research method to study a particular social group, a subculture, for example that may be quite closed to outsiders, members of a design studio, the 'social group' for this observational study includes both the students and the tutors with predetermined and accepted roles. Thus the author was primarily *a participant* in the setting, but one with an accepted role as an educator who should deliberately affect the activities in the setting for the better. This accepted position as a participant brought with it an objectivity that reduced the risk of 'going native', or over-identifying with the group that is being studied. It should be a truism to say that all design tutors with a wholehearted interest to develop an understanding of their students' processes are, in a way, participant observers. In addition to the author's role as a participant in the setting, which comes naturally with his being a research assistant with the group, he also participated in various activities of the students transcending a regular tutor-student relationship, thus the author had been able to get to know the students intimately, which certainly aided the observational study.

The second issue in the researcher–participant relationship, the extent to which the students should be informed that they are being used for research purposes was resolved again by the assumed roles in the studio setting. A student acknowledges that s/he is under some sort of surveillance for educational and evaluative purposes; hence a 'closer inspection' should not cause much ethical issue. Moreover had the students been informed that their processes are being studied, this would have degraded the position of the author as a tutor in the first place, leaving aside its latent effects on a healthy data collection process.

3.4.1.3 Steps in the Observational Study

The first step to this observational study, the goals, and the reasons necessitating to go for participant observation are stated previously together with the second step, which is to decide on the specific group to study. The decision to observe senior students, particularly on their graduation projects are resolved both by the accessibility of the group, together with their representativeness in terms of learning-by-doing. It should be noted that inexperience of novice students would probably condone their procedures had such a study been carried out on their processes. The third and fourth steps in participant observation, gaining entry to the group and developing trust with the subjects had started the term before. The author had been able to develop rapport with the students that not only exceeded regular studio hours, but at times a regular student-tutor relationship as mentioned before. Most of the students inhabited the studio after studio hours and occasionally made the studio their homes. The author had spent long hours in the studio as well, helping the students with their projects as well as participating in their activities. Sharing similar interests and involving in their activities such as watching animated cartoons or playing games on the studio's computer network with them, or carrying this activity into the physical world by participating in paintball combats with the students, the author was accepted as a member of the group and got to know the subjects better, while balancing his role as a tutor. The acquaintance with the students from the previous term also provided an insight into students' guiding principles, their motivations, capabilities and their skills as well as some rough ideas on how they carry out design work. The fifth step in participant observation, which includes observing and recording started after these steps had been taken.

3.4.1.4 Data Collection

Observation

The research was initiated with the intention of observing as much students as possible with broad areas of interest during the whole term. The whole 38 students working for 23 different clients were observed for a while, and along the observation the number of the subjects were reduced to 30 collaborating with 19 clients. These 8 students were dropped from the sample for various reasons that complicated the collection of data and its continuation, such as irregular attendance to studio sessions, inadequate rapport achieved with them or insufficient information about their clients. Also some students prefer to collaborate more with some tutors over others and establish a 'critique-bond' with them. This effect also played a role in the reduction of the sample since it rendered tracking progresses of these students problematic.

Observations took place during the critique sessions, the design reviews that ran according to the appointment schedule. The time plan of the graduation project (Appendix A.1) reserved 18 studio days entirely for design reviews, where other days were spared for various presentations and studio discussions. According to the appointment schedule the author was to meet some 13 students in each studio session for 15 minutes, though at times both the number of students and the time allowed for each one of the students varied. In theory, this schedule made sure that each tutor saw each of the students at least once a week, though availability of students usually dictated these sessions, at times overriding the appointment schedule especially nearing the end of the term. Also the appointment schedule brought with it a drawback, that is, had the students miss an appointment with a tutor, they either waited for the next week's meeting, or if they had to to see that particular tutor, they had to seek for breaks, in-between times and available openings from absent students in the appointment schedule.

The key components of the framework were utilised selectively and in a general sense in this participant observation, keeping in mind the complexity

had it been utilised in its entirety coupled with the quite large sample and the time frame. Since one purpose was to spot differences in students' design procedures and the reasons of them, the decision to observe a large number of students and to understand their procedures won over a narrower sample examined in detail or in a constricted time frame. Consequently, the students were observed according to some implications that the three main constituents of the framework, the conjectural model, the model of design problems, and the primary generator brought. In the early stages of the study the observational efforts were kept to recording students' initial assumptions, statements and positions as well as their clients' roles and expectations for future reference. As project constraints and individual approaches began to emerge, the observations started to adhere to the simplified framework more closely.

The implications that the *conjectural model* brought to the observational study were from the core stratagem of the model, the conjecture – analysis cycle. The first aspect sought for was the notion that problem definition and problem solution should ideally proceed side by side. This brought with it a focus on the ways the students develop their understandings of their problems. Ideally, these understandings should have been developed via approximations of possible solutions, as opposed to extensive analyses of problems without putting forward tangible and communicable solution proposals. This was one of the main points sought for in the observation. The conjectural development also brought the sources of design briefs into question, and the effects of the design briefs and whether the students rehandled or challenged them along the process was looked for as well. Additionally, factors that keep students from making sound analyses were investigated. Critical and central design decisions that troubled their progresses; sources of these decisions and their effects were observed and noted as the projects evolved. Essentially, the analysis of students' analyses was done according to the model of design problems.

The model of design problems made it possible to observe the projects in terms of the constraints involved in a design project, constraints employed and constraints missed. The author analysed students' projects in terms of the generators of design problems, their domains of influence and the functions of design constraints. The constraints the students took into account or missed were made clear through examining their design solutions and their consequent solutions. Thus, what else they ought to consider and the present or possible effects of their focuses were noted. Doing so also aided the author substantially in commenting on students' projects in design reviews and elucidating and at times predicting for them the effects of their design decisions on a wider scope. Additional implications that the model of design problems supplied to the observation were a notion of good design and a balanced design process as identified in the second chapter, the opportunity to identify whether a design problem was or beginning to be open-ended or tightly constrained, and the constraints to seek out the sources of students' primary generators, if any.

The concept of *primary generator* was not solely taken as 'a way-in' to the problem. It was taken as a central design idea for the particular problem at hand as identified in the second chapter, around which all other design decisions were made. Employing the concept of primary generator with such an understanding was also consistent with to the notion of good design as Lawson (2000) identified it. It was expected that a primary generator should be one that has the quality to nourish and enrich, yet help in organising and neatening the whole design process, while helping in generating and justifying design solutions and forms. Therefore, projects without a primary generator existed for the observational study, and each 'way-in' to the problem did not automatically mean a primary generator.

Recording

Since the research problem called for the gathering of qualitative data, of accounts of students' subjective experiences, field notes were found to be appropriate for recording observations instead of coding sheets. The study was not devised to document the presence or absence of some elements of the framework in a checklist-like approach, just as it was not compiled with an intention to criticise the students' efforts as true or false, right or wrong according to their level of compliance with it. It is apparent that even distinctly categorising the key components of the framework brought to this study without referring to others was not possible since they were the elements of a highly interrelated whole. Therefore the study was aimed to observe what was present, what was revealed by the students, their design processes and their projects. The framework was seen as an aid to making sense of their processes and documenting the observations with a shared language.

It is seen that recording field notes is considered to be particularly problematic for participant observers whose status as observer is disguised. This complication was also resolved by the accepted role of the author in the setting and alleviated further by a routine activity common to all tutors in the studio, which is to take brief notes on students' progresses during design reviews. The author witnessed and adopted this custom early in the previous term, therefore taking concise notes during design reviews did not pose a threat to observational secrecy. However, it was important to ensure that taking notes during design reviews did not pose a threat to educational aims as well, especially since design reviews are considerably more interactive happenings compared to design presentations or juries. They are marked by demonstrations for and dialogues with students, and are opportunities for the supervision of students and their projects with the chief purpose of the betterment of both. Therefore it was important to prevent note taking to interfere with the aims of design reviews.

Of the 18 studio sessions reserved entirely for design reviews, the author recorded in 14 of them. These mainly covered the section of the graduation

project between the presentations of initial ideas at the end of the 3rd week and the second interim jury at the 11th week. These studio days are marked in Appendix A.1 in grey. The author sought to record field notes at the beginning, during the course of and after design reviews, however the content and amount of the notes taken in those three occasions varied from each other and from design review to design review.

The notes taken at the beginning of design reviews were mainly on the present states of students' projects and their current positions as well as their clients'. When notes were taken during design reviews, the author made use of their conversational nature. Thanks to the rapport achieved with the students and the casualness attained through it, as soon as a relevant and valuable point is reached during a conversation, the author had been able to suspend the design review temporarily and record running descriptions by saying "Look I'm writing this down" or "Here, I'm noting this". This explicit note taking during the observations focused students' problems, possible ways to overcome these problems and potential directions that emerged during the conversation. Students' sketchbooks, which can be browsed back and forth helped to bring their former decisions into discussion and to reorganise data, collected in previous episodes. Additionally, students' critical statements that reveal their understandings and assumptions regarding their projects were noted, which also contained clues on their understandings of the design process. At this stage the author shared these notes with the students as long as they wanted to know what is put on paper, to make them sure that they were not being observed. Provided that they were not aware of the study, putting things on paper exceeding the routine could have been associated with evaluations, an aspect of their education about which they are highly sensitive and at times sceptical. Thus, not sharing the notes could have demotivated them by giving way to an impression of some hidden criteria. Therefore these running descriptions mainly avoided terms from the framework, and seemingly were those points that this particular tutor had found critical. The notes in relation to the

framework were taken after a design review ended, just before the next scheduled review. These incorporated the author's analytical ideas on students' design decisions and his comments on their projects, his expectations, predictions as well as some subjective impressions often expressed as questions, hopefully to be answered through students' efforts later.

Both the amount of data recorded during design reviews and their dependence on the framework enhanced in time, as the projects evolved. As stated previously, in the early stages of the study the observational efforts were kept to recording students' initial assumptions, statements and positions as well as their clients' roles and expectations mainly for future reference. And as project constraints and individual approaches began to emerge, the observations and field notes started to adhere to the implications of the key components of the framework more closely.

3.4.2 Analyses of the findings

It is stated that the nature of the data collected in qualitative observational studies makes them very difficult to quantify, code or categorise. As the framework aided the author with the observations and recording of the field notes, it aided in the final analyses of data as well. It provided a common ground, a common language for this stage. To facilitate the analysis of the data, the author compiled separate sheets for each one of the students upon completion of the term. The author principally went over the field notes in compilation of these sheets, and occasionally consulted his memory. Conspicuous and striking aspects of students' efforts and some conditions that marked or affected their processes were identified by means of a thorough analysis of the field notes, and these were correlated to each other with analytical ideas referring to the framework. Thus these sheets turned out to be short, condensed articles, summarising students' design processes

under three main headings, the three main constituents of the framework (Appendix B.1). Overlaps between these components were inevitable in making interpretational statements, thus a strictly distinct categorisation or coding of the findings in relation to the headings was neither hoped for nor intended. Students' project statements as they were resubmitted in the middle of the 3rd week were incorporated as well to check deviations from them. These analysis sheets formed the foundation of the final analyses of data from the observational study.

3.4.3 Validity and Reliability of the Observation

It is seen that observational techniques are considered to have greater validity than many techniques that rely on second hand accounts like surveys or questionnaires, which fall back on someone else's perception and recollection. However, they also need to be assessed in terms of how valid and reliable they are. It is stated that most of the drawbacks of observational research relate to the more qualitative, naturalistic and unstructured types. As being a participant observation, this study was highly qualitative and was naturalistic. The framework according to which this study was conducted aided considerably in collection of the data; as well as providing a measure of objectivity and structure in observations. The main intention was to provide a body of information to design education by trying to draw meaningful conclusions from students' observed processes. The appointment schedule also structured the collection of data, allowing the author to observe as much students as possible in a systematic way, on equal terms.

To ensure objectivity, the author collected and reviewed various documents produced along the term. These aided in validating the findings of the observational study as well, and also provided additional tools for analyses of the data. Cross-examining the observation findings with students' research reports, where they had documented their own undertakings in detail, aided

in measuring the objectivity, validity and reliability of the observations. However not to be biased by students' justifications or rationalisations of their own undertakings, usually the earlier and relatively more objective phases of the reports such as the project statements, their research areas, their constraints, objectives and directives and their further research areas were consulted. Additionally, examining students' research reports together with the analysis sheets provided an opportunity to review students' understandings of and compliances with the academic scheme. The CODs the students stated and their research areas were examined in terms of relevancy. Students' grades for all of the presentations and submissions were available as well, which aided in drawing further conclusions from the study.

3.4.4 Limitations of the Study

Compared to a relatively distant observation or one where the researcher is not naturally a part of the setting being observed, this study where the author had a privilege in observing the participants on a regular basis with an accepted role (as well as a responsibility) might justify to some extent his saying, "I was there. I saw it. I comprehend what was going on", in Monette, Sullivan and DeJong's terms (1998:240). If this was not the case, ideally it could be said that the author should not have the right to evaluate the students, their processes and the outcomes in the first place. However misperceptions could still occur stemming from the conduct of the observation as well as the highly intrinsic nature of the design processes.

It is stated that recording of observations started after the students presented their initial ideas. Also, during the phases where the students should have been prestructuring their problems, field notes were mainly records of their intangible dealings or initial decisions for future reference. Although the results of students' pre-existing cognitive capabilities and their initial priorities

were tangibly evident at the presentation of initial ideas, their sources and their making could have been missed. There was a large number of clients with varying levels of collaboration and interest in the graduation project, thus a knowledge of their effects in students' decisions was limited, especially pertaining to these early stages. Moreover, since the observation was a longitudinal one in terms of the time dimension, it was not easy to bring up matters that happened and finished in early phases, although design reviews, students' sketchbooks and research reports aided with this problem to some degree. The observation sessions were quite structured owing to the appointment schedule and the framework structured the collection and analysis of the data. However, assuming the role of a participant over an observer, coupled with the quite large research sample inevitably yielded field notes with a variety in structure.

3.5 FURTHER RESEARCH

It was initially intended that the observation would conclude this study, however upon its completion, through its acknowledged limitations as well as upon reviewing the data gathered, a second study is found to be necessary. The observational research was a linear process in time as was the graduation project, and it was found out that most of the conditions that marked students undertakings emanated from the earlier phases. Therefore it was decided to conduct interviews with a number of the students observed.

This supplementary study was designed to complement those points where the author needed to consult his memory in the compilation of analysis sheets. The points that called for additional data were mainly from the prestructuring phases of students' design processes. It was stated that the framework was utilised selectively and in a general sense in the participant observation, and in the earlier phases of students' design processes their initial assumptions, statements and positions as well as their clients' roles

and expectations were observed and recorded, but not specifically in terms of the framework. To complement data collected in this phase, it was decided to have students' own views of their strong points and weaknesses and their guiding principles as to be able to elaborate more deeply on their pre-existing cognitive capabilities and the particular approaches these capabilities led them to. Their familiarities with the product types to be designed or the fields they had worked for were also needed in order to have another handle on their prestructuring abilities. To get to know the external variety reducers in more detail, their problems as stated, it was found necessary to have further information about the students' collaborations with their clients and their clients' roles in the design process as well as the sources of design briefs.

Additionally, thus far the study had addressed the two processes belonging to the educational setting, students' design processes and the academic scheme, and held them separately against the framework. This further research was thought of as an opportunity to put students' design processes and the academic scheme within which they performed side by side, and to have students' opinions and comments on the academic scheme in terms of whether it conformed to their preferred or established procedures, to what extent they conformed to it, or whether the design aid for the term succeeded to aid.

3.5.1 The Research Method

The interviews were conducted four and a half months after the graduation project ended. It is stated before that interviewing designers, in this case the students of design after the design work is finished would carry with it the risk of post-rationalisation. This would be more effective had it been taken as the sole method of data collection. This was one of the main concerns that had effected the decision to go for the participant observation study. Since this supplementary study was conducted following an observational one, which

served as a pilot study, the author already had a handle on the design processes of the students to be interviewed. Therefore, conducting long interviews with the students was selected as the research method, not only to obtain further qualitative data, but also to be able to balance the effects of post-rationalisation or faulty memories especially after such duration.

3.5.1.1 Sample Selection

The author initially decided to conduct interviews with 10 students, and identified some 16 students interviewing with whom would provide relatively more valuable insights. These students had presented some of the most conspicuous and captivating issues in their processes, such as exploring the problem area in depth through design alternatives, employing a number of primary generators for different levels and aspects of a project, transgression of one's conceived limits and accustomed approaches, extraordinarily late coming of convergence on a unique solution or vice versa, excessive analysis prior to approximations of solutions, excessively tightly constrained or open-ended design situations, exemplary or inadequate relationships with their clients, etc.

Selection of the 10 of them was mainly determined by practical considerations, their availability. A substantial amount of students were from other towns where they turned back to following their graduation, and a number of them left Ankara to pursue professional or academic careers in other cities. Even so, the author had been able to arrange meetings with 8 of those from the initial 16. Appointments with these 10 students were fixed for the same weekend at the author's house, and the students were distributed to the weekend days evenly. However one of the students asked to be excused from the study at the last possible minute, thus the number of the sample reduced to 9.

The author had reviewed the compiled analysis sheets and field notes of the sample and their research reports prior to interviewing. Additionally he went through a digital compilation of the final presentations of all of the students, which aided in reminding what to track retrospectively regarding their convergences on those unique solutions.

3.5.1.2 Interview Questions

The research questions were devised to supplement the observational study, and the questions were divided into six categories accordingly:

- The first category focused on the notion of convergence on a unique solution (Appendix C.1). Here the students were asked to indicate the stage of the project where their convergence had started and through further variety reduction had resulted in the final design. They were also asked to elaborate on the causes of the timing of their convergences.
- The second category focused on the initial stages of their projects and enquired into their familiarities with the product types and fields they worked on (Appendix C.2). Their goals at the start of the project as well as those points that they thought to be of primary importance at this stage were also inquired. Questions in this category aimed to reveal their prestructuring tools, both their knowledge of the solution types and instrumental sets in relation to the problem as well as their particular approaches or their primary generators and the sources of them.
- The third category focused on the strong and weak points of the students and their guiding principles, again related to the prestructuring phase, and the extent to which they affected their processes (Appendix C.3).
- The fourth category focused on the clients and their influences on the design process (Appendix C.4). The quality of the collaborations and the effects of clients as external variety reducers were sought for.
- The fifth category focused on the design briefs and the sources of them (Appendix C.5). Their initial constrictions and whether they were open to debate were inquired.

- And finally the sixth category focused on the academic scheme (Appendix C.6). The effects of the academic scheme on students' processes, and any mismatches between the levels of progress implied by the academic scheme and their progresses were investigated.

To explore each of these categories with considerable detail, the research questions were designed to be open-ended. Main questions were to introduce the concern of each category, and probe questions were determined in advance of the study together with their relations with the framework. Each of the students were asked the same questions, however examples or explanations in relation to their particular cases, it is thought, would be given if needed. The research questions were designed to avoid any terms or phrases that could be unfamiliar to the students, and in some probe questions classroom jargon was employed to facilitate the discussions on common terms.

3.5.2 Conduct of the Interviews

In arranging the appointments, the author made a brief introduction to the study, revealing that their processes had been studied throughout the term and some further clarifications on their design processes were needed. None of the students were annoyed by this confession. Separate meetings were arranged with the students with intervals of at least an hour and a half. An hour was thought adequate for interviewing and the additional 30 minutes were spared for reviewing the answers given, reviewing the interview questions and preparing for the next student, as well as to balance for probable timing related mishaps.

The interviews were done in a relaxed and intimate atmosphere. The time plan for the term was available during the interviews to help the students recollect their memories and to alleviate discussions related to various

stages of the process. The author briefly introduced the purpose of the interview, and keeping especially those students pursuing their graduate studies at the same department in mind, made sure that their identities would strictly be confidential, and that the study is on a process that is over and done with, and therefore could not affect their current positions in any means.

The interviews were conducted in Turkish. The author read the main interview questions to the students, and through probe questions directed the course of the dialogues. However, since the questions were mainly open ended, at times the students got ahead of the argument and brought up concerns of other categories. This was again due to the interrelatedness of various phases of the design activity. Such chains of argument were not interrupted or stopped, but noted for future reference and further elaborations were made on those points as their relevant categories were arrived at. Interviews lasted 45 to 60 minutes, each of them were tape-recorded and their verbatim transcriptions were made.

Since the students were graduates, it was observed that they were quite relaxed and free to comment frankly and critically on their own processes, and also on the management of the graduation project. Upon reviewing the transcriptions, it is seen that relevant data related to the known limitations of the observational study were obtained, and those points that could not have been investigated due to the limitations of the observation were made clearer. Each of the categories built upon the data obtained from the observations considerably; and insights were gained on students' views of the management of the graduation project, as well as the design aid for the term. Interviews also revealed some interesting clues about students' adopted design procedures and occasionally their friends'. These further insights validated the worth of these interviews.

3.6 DECISIONS FOR FINAL DATA ANALYSIS

It is seen that a significant advantage of observational research is that the person carrying out the study is usually a qualified person on the research problem. This was just the case with the interviews as well, although not the custom, where the author was equipped with insights on each one of the interviewees' design processes. It is realised that solely relying on interviewing would not have been adequate without the observational study. However, just as the author was able to direct the course of the dialogues effectively and often to students' surprise; the students also provided invaluable insights as well. Some of these insights were totally new, and others revealed that the author had failed to notice or misinterpreted some aspects of students' processes during the observations. Therefore it was also evident that relying solely on the observation findings, and especially those related to the prestructuring phases of students' processes or limitations of the first study would be insufficient.

Considering the amount of information from both of the studies and their complementary nature, it is decided to keep the discussions on the findings to those students who were interviewed; at the cost of excluding some other conditions that had presented by those students who were not interviewed.

CHAPTER 4

DISCUSSIONS ON THE FINDINGS FROM FIELD STUDIES

4.1 INTRODUCTION

In the following sections, the findings from the field studies will be presented in keeping with the interests stated in the first chapter. Conditions observed pertaining to commencement and development stages of students' design processes will be presented in their respective sections, and it is decided to devote a separate section to the academic scheme in keeping with the issues raised in the first chapter. The interviews were conducted in Turkish; therefore quotes from the transcriptions that will be referred to below are translated to English by the author. Students' names are kept confidential, and the students from the interview sample are denoted by letters from A to I. It is also needed to include 3 students from the observation sample, and they are denoted by the letters X, Y and Z.

4.2 COMMENCEMENT OF DESIGN PROCESSES

It is seen that conjectures arise from designers' cognitive capabilities stimulated by their problems. In relation to a research question stated in the first chapter, it is seen through the studies that much of the differences between an accomplished designer and a student of design should culminate from their pre-existing cognitive capabilities.

Practising designers usually specialise in certain fields and consequently work within similar sets of radical constraints related to their fields for extended periods of time. It is more than likely that this experience forms a pre-existing cognitive capability, comprised of a notion of ‘what is possible’ in the field with well-internalised solution types, production means and informal codes. Similarly this extended labour in the field should render each new design problem, in a way, analogous to each other or at least relatively manageable. Students’ pre-existing cognitive capabilities and prestructuring tools, on the other hand, may not aid them with their conjectures in such a direct way. The graduation project where each student worked on a separate and life-like task revealed the effects of students’ pre-existing cognitive capabilities in relation to their diverse design problems.

The discussions on prestructuring phases of students’ processes, on how do they commence their design projects and structure understandings of their design problems will be made in terms of some conditions internal to them and others that are external.

4.2.1 Conditions Internal to Students

It is seen that internal variety reducers allow designers to structure their problems in terms in which they can solve it, and determine to a large extent the course of the project in its development. The studies revealed a number of conditions effecting students’ prestructuring, and these will be addressed in the following sections.

Projects and Clients

The graduation project started with deciding on the projects to work on and the clients to work with. It was stated that the graduation projects were opportunities for the students to start specialising in the fields that they would

like to work in following their graduation. It is witnessed that such a prospect influenced students in selecting their projects. Though these expectations would not aid them with their conjecturing capabilities, they might have motivated the students throughout their graduation projects.

Student A, designing a washbasin and a number of peripheral bathroom accessories, stated that although her cognitive capability related to this particular field was not considerably superior compared to other fields, this was one of the industries that she would like to work in following her graduation, and her client implied that a possible employment seemed likely at the graduation exhibition.

Student B, on the other hand, was designing a 17-meter picnic boat. His client, a yacht design consultancy, and the shipyard that his client predominantly served were situated in his hometown. Thus, he expressed, considering there were no design schools in his hometown, if his efforts in his graduation project were found promising, then he would have a chance to continue working with his client afterwards.

Student E designed a seating unit and its table handled along with some cultural clues, with Turkish traditions of eating. She had worked as an intern in her client's design office previously, and expressed that this acquaintance as well as her trust and respect for her client were deciding factors in forming this collaboration. She further stated that she had felt grateful for the time her over-occupied client spared for her, and had felt obliged to crown the collaboration with a first-rate outcome. Thus her client's satisfaction was of utmost importance for her, and the manufacturer of her prototype for the graduation exhibition offered her a placement seeing the results.

Student C was one of the three students working for a major dishwasher manufacturer. The students had a studio project with the washing machine division of the same brand the previous term. Four of his classmates'

projects were selected to be pursued as their graduation projects, to be finalised as a prototype. Thus Student C stated, although he was to develop new dishwasher concepts, if he adopted a more realistic path, a dishwasher for about three or four years ahead for example, his client may find the outcomes worthy of production. Such a motivation was evident throughout his process, which will be conveyed in the following sections.

It was previously stated that letting the students select their projects themselves would also let them select those projects, which may be related to their pre-existing cognitive capabilities. The next section addresses this effect as well.

Familiarity with the Design Problem

It is seen through the field studies that students' varying levels of familiarity with the products to be designed affect their progresses. Knowledge of existing design solutions in a field, an awareness concerning the materials as well as the manufacturing means that may be peculiar to a particular sector, or an understanding of the user requirements as well as an experience in the usage of the particular product to be designed effected students' prestructuring capabilities. It is also seen that their presupposed competences related to these prestructuring tools at times misguided them.

For example, Student F was designing the cabin of a long-range delivery truck. He said he went for this particular project due to his presumption that he was rightly the one to study such a task, since his father was a long-range deliverer. The prospect of such a close contact with a user of this particular vehicle, as well as his presupposed familiarity with the activities involved in the "delivery life-style" affected his decision to apply for the project, undertaking of which could have been thought demanding for many of the students. It can be seen that when combined, his presupposed advantages imply a knowledge of the informal codes involved in designing a long-range

delivery truck. But starting with the project, *Student F* came to realize that not only his informal codes, his presupposed competences in terms of user requirements and critical considerations in designing a truck cabin were quite inadequate, but he was also quite unprepared for the task in terms of a knowledge of the state-of-the-art in truck design and the materials or technologies involved.

Student G, designing a squatting toilet, was quite familiar with the usage of the product and favoured them as a user himself. His experiences with this particular type of product and some deficiencies and problems he had already spotted in the features that are offered by the squatting toilets on the market not only motivated him to select this design task as his graduation project, but also aided him in generating approximations of solutions quite early in the process. Student G had been able to spot some main problems and issues related to his project in the very first week, and by the presentation of initial ideas he had a solution proposal based on a number of the issues he had found critical, two of which displayed themselves at the final product as his central concerns.

According to *Student B*, designing the picnic boat, among all the projects he had undertaken during his education, this was the project for which he felt he was unprepared most. Not only the scale of the task was markedly different from his previous undertakings, but also its scope was quite demanding. He was to design both the interiors and the exterior of the boat. He conveyed that he was not familiar both with the usage and the expectations of potential users of these boats, and was not knowledgeable on the exemplars on the market in the sense that he could not distinguish crucial and relevant aspects for the design of a boat initially. However, despite this unfamiliarity, he approached his design problem with his own perspective, coupled with a usage scenario and mock-ups of the boat's interior resulted in some unique design features that were markedly different from the clichéd marine design solutions. He too started to put forward approximations of solutions early in

the process, and focused especially the interiors. While his solutions for the interior of the boat matured substantially at the end of the term, his proposal for the exteriors could not go much beyond the one that he proposed at the presentation of initial ideas and remained relatively unresolved.

For *Student A*, designer of the washbasin and its accessories, designing for fields that she is not interested in keeps her distant from projects. Car design for example, she stated, is as remote a field for her as is architecture. She said although she was not that knowledgeable in relation to the field, the stated concern had effected her decision to go for such a project.

Information

The framework suggests that research should ideally provide information to support the prestructuring phase, and it is seen that the first part of the research reports was particularly aimed at nurturing students' cognitive capabilities in relation to the fields they worked in. Through the field studies and also by reviewing students' research reports, it is found out that the students differed in the ways they conducted research and handled and incorporated research findings into their projects. Their expectations from research and consequently their focuses varied. These variations were especially relative to their familiarities with their design problems, and to what they thought they needed in relation to their personal approaches.

Student A, the designer of a washbasin and its peripheral accessories, recalled the first part of the research reports as a market search during the interview. Even though she had explored under most of the headings identified by the research report guideline in detail, she stated that in depth material and manufacturing related explorations would have been pointless until some formal decisions surfaced. She further maintained that, her primary concern and focus in this part of the research was the formal characteristics of the washbasins and bathroom related products to see what

options and niches were available to her. *Student A,* upon examining the leading brands in her market and their products found out that her cognitive inventory related to the field was limited to relatively conventional solutions in the Turkish market. A wish to proceed with an analogy, an analogy to 'flowing water' was dominant starting from the early stages of her project, and some exemplary precedents in her field encouraged and, in a way, 'allowed' her to go for a quite shallow washbasin with sinuous lines. It can be said that she had searched for information in relation to her route through the problem material. Additionally a research she had conducted for an earlier studio project got her acquainted with the properties and latencies of a particular material, of DuPont's Corian. She fell back on this material in her graduation project as well, on her pre-existing cognitive capability, when she had realised that the form of her liking was not achievable in ceramic.

Student G was directed into a research on ergonomic considerations in squatting toilets by one of the tutors, before the first interim jury. Through this research, he was able to get hold of the internal constraints of squatting toilets, of interdependent arrangements between its components in relation to a set of external constraints dictated by the human anatomy. His research report was deficient in design solutions available on the market, but he got to know some historical precedents quite well. His report for this phase was mainly on the cultural, historical and technical evolution of toilets, starting from the 3300 BC, since the product he was to design is generally accepted as a traditional type.

Student F's process was marked by extensive research, following his recognition of the scope of his project as well as his own actual cognitive map in relation to his problem. By his first meeting with his client, which was after the presentation of initial ideas, he had already listened to truck drivers' complaints and wishes, and in this first meeting he came to the conclusion that users' wishes and expectations and his client's were conflicting substantially. But, he conveyed, this conflict did not hamper his progress but provided a perspective comprised of a number of constraints with different

generators. His client suggested him to explore all of their competitors' products to identify their key features such as modularity or optional components. Hence Student F produced an involved documentation, comparing several features and components of the products on the market in a checklist-like manner. However, a tangible solution proposal was not manifest by the first interim jury. The field notes bring to light that a week before the first interim jury he was still contemplating on his checklist and a particular direction was beginning to appear, expressed with a couple of keywords. Instead of one of the competitor's motto, which was 'drive – relax – rest', he proposed 'drive – relax – reside'. He had been able to collect a massive amount of information on solution types with his analysis of competitors' products, he reflected on them through his increased understanding of the instrumental sets, and tried to find a starting point through his grasp of the informal codes thanks to his field studies. What was lacking in his process was solution proposals to be analysed. Another field note recorded a week before the second interim jury reveals that he had recently decided to start over. The reason why Student F was late in generating tangible solutions and why he had started over at that stage will be discussed later.

Informal Codes

The framework suggests that designers would, and should, use information heuristically by using it in relation to their informal codes; otherwise its influence on design and the designer's conjecturing ability will remain limited. It is already seen that Student A searched for information in relation to her route through the problem material, although hers was more in relation to her personal approach. Interviews further brought to light some examples of heuristic employment of informal codes, and revealed to a degree that students' accumulations in design processes include these informal codes and their uses.

During the interview, Student B took a broad view and stated that research is something that “a designer should make instinctively and not only upon prompt, otherwise he will not be able to design”. This remark interestingly matches the framework in the sense that a designer would initiate the design process intuitively, and searches for more information in the light of his approximations of solutions. He also added, if a designer can do without research it may not be that necessary, especially if he can figure out or already has an idea of crucial considerations for a given design project. What Student B implied was an exercise of empathy, which had allowed him to comprehend the radical constraints and crucial considerations in various design problems intuitively. He further maintained that this is what allows him to do without much research on users or usage, although research into materials and manufacturing means, he stated, might be necessary at times. When reminded that a designer’s opinion of crucial considerations for a given project and that of a user may not match, he stated, “well you can guess”. When it is maintained that what if he may not guess healthily, he stated, “well you *will*”. Although Student B’s approach might be an extreme one, it can be seen that he has well internalised the role of informal codes in carrying out the design activity. According to him, almost half of his ideas had emerged in the first three or four days.

One of the common means of getting hold of informal codes, it can be said, is experiencing the product to be designed. It is seen that Student G was accustomed to the usage of squatting toilets, and he stated that he had actually made most of the studies on the usage of squatting toilets during his project on himself. Student G’s case reveals that if a student has an opportunity to experience the usage of the product, its contribution to the process should be significant, and especially in the commencement stages. Student B, for example, built mock-ups of the interior of his picnic boat and was advised to make use of a usage scenario to make up for the difference in experience and benefited significantly from them.

Skills, Strengths and Weaknesses

A match between the skills and strengths of the students and the particular structures of their design problems allow them to proceed comfortably. Also it is seen that various skills of students affect their processes for good or ill, and may in fact act like constraints. Additionally the author witnessed during the interviews that some of his personal notions on various skills and capabilities of the students were wrong, since it is seen during the graduation project that the students can be capable of overriding these presumptions.

Ergonomic criteria did not aid Student G in generating forms, and he proceeded with resolving the problems he had spotted previously with ergonomic and manufacturing considerations until a week to the second interim jury. At that point he was inspired by a peculiarly shaped squatting toilet from the Ottomans, a key shaped toilet with smooth and organic transitions. Manufacturing considerations voiced at the second interim jury further reduced variety and excluded some components from his design, and although his mock-ups in clay had such qualities, his limited competence in modelling software made him exclude the organic transitions from his design. It can be said that his capability in modelling software acted as an additional variety reducer, a constraint similar to a practical one in his ‘production’ of his final presentations, necessitating a modification of form.

Student I, was another one of the three students working for the same dishwasher manufacturer. The client specified different design briefs for each one of the students, determining the extents of the students’ inputs and allowable manipulations. Student I’s brief was the most constrained one, where her efforts were limited to new ideas and improvements strictly within the machine. Such an undertaking called for extensive detailing in mechanisms, and according to the author’s notion of Student I’s skills and capabilities that had been developed during the previous term, she should have experienced hardships with such a task. Conversely, Student I

expressed during the interviews that leaving the excessively constrained design situation aside, she had felt quite at home with her task, within the machine with her practical constraints. She further maintained that she would have been much more anxious had the project called for some formal organisations or involved some ‘exteriors’.

Student A had in fact expressed ‘flowing water‘ the term before, and again with a washbasin in a washbasin-integrated washing machine project. She admitted that her forms in that project influenced her design; however she also implies that her forms have a certain character:

> That washbasin influenced me significantly in the beginning of the project, and I had those two-dimensional forms at that stage. Then I realised that it was holding me back, and the tutors also urged me to produce some three-dimensional things. I believe that I had been able to get free of it, I mean there is a certain resemblance in the lines, but I think it comes from me. But it had a certain effect, of course.

She stated that finding original ideas is her strongest skill, and that she pushes herself to differentiate her products as much as possible, even if it is achieved only by form. However, she noticed recently that she was paying less attention to products around her and their details. She stated that she finds herself in difficulties in trying to “imagine even a mere washbasin”, and maintained that a designer should have a good command of forms and details of everything around her. Her remarks voice once more that a heuristic employment of a designer’s pre-existing cognitive capability is the main source of solution conjectures.

Student F stated that concept generation, self-criticism and detecting his own mistakes are his strongest skills. However, he maintained, completing his projects he feels that, ‘something is never quite right in terms of form’. His forms, it seems to him, are like add-ons or appendages, which usually fall short of expressing the concepts beneath them. Discussing the reasons, he made some quite interesting remarks about his personal design procedure and a couple of his close friends’, and its effects on form generation. These

remarks will be presented in the following section on how students explore their problem areas.

Student H, who worked on a fair stand system, similarly stated that “concept creation” is her strongest skill. Although, she stated, it is usually difficult for her to “develop” that concept, to materialise it, working on details and solving them is another one of her strengths. She maintained:

> I mean, it takes quite a long time for something to appear, something tangible that I can work on, otherwise the initial part is easier. I mean, I can resolve the ‘this is such and such a product, it has to do this and that’ part much easier.

It can be said that what Student H referred to as ‘concept creation’ is the establishment of some goals and expectations from the product in its finished form. In the graduation project Student H had two different clients, and especially in the early stages most of these goals and expectations were her clients’. One of them was a manufacturer of fair stands, and the other one was an IT company, regularly attending fairs and making use of fair stands. . She initially started to design a fair stand for the IT company, however after the first interim jury, she decided to design a unique fair stand system, which the latter client as well as any other user could take advantage of. Student H’s project ended quite satisfactorily, and she applied for a utility model certificate for her design solution. She was able to design a fair stand system that was organised around a particular detail, a mechanism she invented. In relating these strengths to her project, she maintained:

> I had a problem like this. I knew right from the beginning that I wanted to make the most of the advantages of aluminium profiles, I had these data, but how I am going to link these two to each other, that was my problem. I mean, I knew how I wanted the system to open and close, I knew that I wanted it to open to this side when I pull it like this, but what kind of a mechanism would allow such motions, that was vague.

The author was not optimistic about her progress, where her proposals for the first interim jury lacked this ‘integrating device’, seemingly being some panels and spatial organisations for the IT Company. It can be said that she

needed a unique mechanism to advance her efforts to ‘her’ next stage. Similar to Student I’s case, the author would not expect Student H to resolve such an intricate mechanism, but as her words convey, this was how her personal procedure proceeded. Although it cost her to remain behind the expected levels of progress as implied by the academic scheme for a while, with a determination to resolve this mechanism, she came up with a quite successful integrating device and advanced to her development stage.

Exploring the Problem Area

The studies revealed that students differ in their ways in exploring their problems and initiating their design processes. Though it is evident that many factors are at play in determining the courses of students’ design processes for them and especially in the early phases, it is also witnessed that students’ personal procedures can be quite effective in commencing and furthering their efforts.

Student C’s design brief for his dishwasher was the freer one compared to the other two students, where he was expected to generate whole and new dishwasher concepts. He had proposed 8 different design alternatives at the presentation of initial ideas and continued working on 4 of them until the first interim jury. Two of these paths were found worthy of pursuing at this interim jury, and while one of these alternatives consequently provided the general arrangement of his final product, he transferred to it a certain design element, a round and rotating dishwasher tray from his other alternative. Student C’s case was an interesting one in terms of the conjectural progress, of structuring an understanding of the problem through approximations of possible solutions. Since his alternatives were based on various aspects of his design problem and on a variety of constraints, he had been able to get hold of some crucial design considerations related to his field. When asked whether this is his preferred and accustomed approach in getting to know his problems, Student C stated that an idea should always be supported or

contrasted with another. While he stated that it is an ideal method in getting to know the problem, its application, he stated, depends largely on the project, and that his approach may change from one project to another.

It is seen that Student F's process was marked by extensive research, following his recognition of his limited cognitive capability in relation to his problem. Discussing his skills and why his forms do not satisfy him, it surfaced that his approach was not peculiar to the graduation project, and was not only because of his limited knowledge. Stating that he had learned much from his classmates in developing his skills, he expressed that even though he would like to be like Student Y, he finds himself closer to Student X, two of his friends:

> In the first year of our education, while we were dealing with circles and squares, Student Y, it seemed, was fixing certain goals and aims and predetermining what will go into his projects. Therefore, we thought, he was approaching his problems analytically, and we admired him for that. Then it came to light that he does not have such a skill; or better, he does not have such concerns. Student Y works mainly on inspiration, he works as he is inspired. For example when we work together, brainstorming and sketching, the whole process is a mess. With Student Y, you can not control it, nothing stays put and you cannot fix something first and then build upon them. His own processes proceed that way too. He advances, say, three different projects simultaneously in a messy way, then he chooses one of them, then he splits that one into pieces too and then selects one of them again and refines it. But what suits Student X, and myself, is to ideate, to make decisions first. I mean my process goes like, closing your eyes and creating a concept in the form of an idea, thinking 'whether it should be something like this or something like that', and then fitting to it a form. This is mainly why, coupled with, well it is a skill after all, I am always unsuccessful in creating form.

It can be said that Student F's "whether it should be something like this or something like that" phase usually last considerably longer. Moreover, his "ideation" not only influenced his progress in the graduation project, it had also influenced his attainment of a skill, which, in his personal procedure comes after his concept creation phase. It is also seen that Student H also refers to concept creation as "this is such and such a product, it has to do this and that", and until she had refined these criteria, settled to handle her design problem with a different understanding, her project seemed to lack progress.

Although they include second-hand accounts on other students' design procedures, Student F's statements illustrate several interesting clues in relation to the concerns stated in the first chapter. Firstly, other than tutors and students, other than design reviews, academic schemes and occasionally clients, which were the assumed 'forces and mechanisms operational in studio projects', it can be said that students develop their understandings of the design activity collectively as well. They learn from each other, yet they also differ in their personal design procedures. They not only reflect on their own design processes and procedures, but also observe, assess, criticise or yearn for others' approaches and skills. A valuation of certain thinking styles, or realising the need to acquire one, it is seen, may be starting to surface as early as the first year. Although most of these latter statements are based on Student F's subjective opinions and his recollection of past studio projects, at least it is evident that Student F's procedures and his admiration of an analytical approach, which he identifies as a skill, were deeply rooted in his past educational experiences. Student F made some further comments, addressing to what extent these procedures were institutional, and these will be covered in a later section. Discussing Student Y's procedure further, it is also revealed that they had developed some methods for form generation:

> We can call it (Student Y's procedure) a different thinking style. He proceeds mainly with visual inspirations. And it is as if the things he do influence each other, as if they develop together. But there are no certain decisions. He does not say, like, 'I am doing such a thing, and it should have these properties, okay, and how am I going to accomplish these?' Not through such an understanding, but mainly from the things he draws. The funniest of it all happened in a project in the first term of our third year. He came to me and said, 'hey, I sketched something like this, what may it be?' I mean, he is at such a point. The material behind it all dissolves, and he just sketches things. In fact this had turned into a method in time. You focus on a certain part of a product in images, especially in concept arts, and let the meaning slip. Then you ask that question to yourself, 'what may it be?'. Its contribution to the whole project is beyond words. You see the engine of an aeroplane, with this sharp propeller cap and all. What may it be, you ask to yourself, and derive clues for the form of your blender from there. You take a part of it, and it starts to imply many different things.

To what extent Student Y's procedure may be likened to a reflective conversation with the materials of a design situation, with concurrent and interactive development of forms and ideas that is stimulated and furthered with sketches, or whether he 'just sketches things', it is not possible to verify. However, these discussions further reveal that students differ in their personal procedures, and they also develop certain design aids for themselves. In terms of the effects of these personal procedures on the outcomes, Student F's personal approach, coupled with the initial state of his cognitive capability, caused him to fall behind the expected levels of progress for a while during the graduation project. Moreover, on a wider scope, Student F himself acknowledged that his personal approach is one of the reasons why he is "unsuccessful in creating form".

Setting Unrealistic Scopes at the Outset

It is detected that students may approach their design problems rather confidently and optimistically, establishing scopes that are quite wide at the outset. They could not convergence on a unique design solution in these cases, until either the tutors or the clients restructured the problems and narrowed their scopes down.

Student E, designing a seating unit and its table with Turkish clues, initially started with an intention to design the interiors of a restaurant. She also brought Turkishness into the project herself. It started as a symbolic constraint, which later brought about formal and user related considerations with it as Turkishness had come to be taken as a traditional way of sitting. She expressed that the scope of her project as it was displayed in the graduation jury was determined at the second interim jury, and its form, a week later. At the first interim jury her designs involved proposals for the spatial organisations of a restaurant as well as a particular routine for serving. She focused more on the seating units and had three different seating unit proposals half way into the project. By the second interim jury,

where her client was present as well, her ideas still governed a restaurant, but the serving routine was excluded. She was jointly advised that it would be better if she broke free from the restaurant limitation as well, and was urged to design solely a seating unit with its table. Additionally, Student E stated that her client was influential in choosing between one of the three seating unit alternatives and advised her to go for the design that was presented at the graduation jury. To conclude, her initial approach necessitated to consider the activities and people involved in restaurants, the radical constraints concerning restaurant interiors as well. However there was no specific location, no particular building that would adequately establish some definite external constraints, through which the radical constraints would come to their own.

Student A too started her project with a wide scope. Her initial project statement was to design “the whole bathroom environment including all essential elements, the bathtub, washbasin, pieces of furniture, accessories etc. deriving from the same design concept and reflecting the identity of the firm”. A field note taken a week before the first interim jury reveals a plethora of generating ideas influencing her decisions, such as comfort, spaciousness, coldness of earthenware to the touch, flowing water, Turkish hamams and the *göbektasi*, sitting or reclining, the family, the West European market, chaise-longues, various materials and their expressive qualities, integration or separation, etc. These, Student A conveyed in the interviews, were a number of keywords as she tried to determine a starting point. It was commented in the field note that a singular primary generator was needed, and it was also noted that she was planning to resolve a single item first and then to design the other elements accordingly. It is evident that most of her keywords are latently capable of implying formal decisions.

The scope of her project was narrowed down earlier than Student E, at the first interim jury, where she had solution proposals for each one of the stated bathroom components. However, together, they were quite unresolved in

terms of the formal, symbolic, practical, user and external constraints, and nearly all of her decisions were designer-generated. It should be noted that her first meeting with her client was well after the presentation of initial ideas, which may give clues on why most of her design decisions were designer-generated. Following, this experience, which effected her grade for the first interim jury, she proceeded more realistically with a manageable number of components to be designed. According to Student A, her acquaintance with the products designed in former graduation projects encouraged her to hold the scope of her project wider at the outset. Designing a whole room, according to Student A, was a more “conceptual” undertaking, and it is easier for her to generate concepts when she works in a holistic way.

It can be said that unrealistic scopes at the outset may aid in getting to know the problem area through a generation of a set of dependent alternatives within a single line of reasoning, and may aid in convergence by settling on one of them. Therefore provided that wider scopes remain in the early stages, namely until the first interim jury, they may aid in structuring an understanding of the problem and its reformulation.

These two cases illustrate that wider scopes may occur as the design briefs are formulated by students. Personal approaches can also be effective in their making, as Student A’s holistic approach was not constrained by her client due to a relatively late meeting. Additionally, it is seen that the framework encourages rehandling of design briefs, and the final outcome of Student E’s process was quite striking, being one of the projects that stood out in the graduation exhibition. While her final product had its adequate justifications when examined on its own, her process displays a complication. If such an option is internalised, that is, narrowing the announced scope and definition of a project significantly, it may not be justifiable in professional practice. Designing a seating unit for home use instead of a restaurant interior may hardly be valid. Moreover, there were also some cases in which the design briefs constrained the allowable transformations tightly and were undebatable. Broadening the scope of the project would help notably in

those other cases, but it was not an option. These issues will be discussed in a following section.

Precedents and Originality

It is seen that research should predominantly nurture the prestructuring phase which involves examining existing solutions on the market, and the first part of the research reports urged the students to get hold of the state-of-the-art in their fields. However, it is seen that excessive research into precedents and exemplars could cause inertia, an inactivity resulting from the urge to improve on them. This effect was particularly evident in those fields where developments are marked by incremental advances and the design problem itself permits minute improvements. It is seen that students in such situations may resolve these handicaps through innovative design solutions, through their persistence on originality. Similarly, where knowledge of the precedents were initially narrow or limited to those that the students came across routinely, these may either have influential or hampering effects.

Student I's client's premises was full of dishwashers of other brands kept for benchmarking, and she had explored their design features in relation to her allowed field of operation. She admitted that she had often found it frustrating to try to go beyond these ingenious exemplars. It is seen that Student I is comfortable with practical issues, however her personal approach to her design problems also urges her to advance on the precedents in her field. She expressed that she had 'saved' a number of her design projects through a determined focus to find an 'ingenious point':

> It was the V shaped component for this project. Somehow, one striking point stands out in my projects. I mean, I have to have it. Maybe that is how my mind works. When I find such a point I start to like the project, otherwise the project just stalls.

Student I's definition of her 'ingenious points' and her expectations from them is a clear description of primary generators. It is seen in the second chapter that an architect Lawson (2000) interviewed defined his as a 'generative concept', and for him, it was stated, unless there is enough power and energy in this idea the results would be lame. Student I's 'ingenious points' and her search to find one are quite vital for her, and they will be discussed again in a later section on design reviews.

Similarly, Student H was also determined to solve the mechanism she needed, to proceed to 'her' development stage. It can be seen that although searching for this idea or a design solution can be wearisome, once found, the outcomes are more likely to be unusual ones. Student I worked with sketches and mock-ups in her search for a primary generator, and Student H relied more on mock-ups. Student H arrived at a potential mechanism a week after the first interim jury, and Student I found her central design element approaching the second interim jury.

It is also seen that Student A's inventory of precedents was limited to relatively conventional solutions and mainly contained those from the Turkish market. She had the aim to express the quality of 'flowing water', and it is seen how the exemplary precedents in her field 'allowed' her to go for a quite shallow washbasin. Thus it can be said that research into precedents as encouraged by the academic scheme, may provide valuable insights and foundations for solution conjectures if made with some generating ideas in mind as opposed to a directionless browsing and collection of images. In Student A's case, it can be said that her drive for originality played an important role as well.

4.2.2 Conditions External to Students

External variety reducers as stated by the framework are some evident or discernible constraints regarding the particular problem, which usually come with the design brief. The studies revealed that the sources of design briefs, whether they were open to negotiation, clients' goals and expectations together with changes in them along the process influenced students' processes.

Sources of Design Briefs and Client Roles

It is seen that in two conspicuous cases with wider scopes at the outset, the problem was formulated mainly by the students. It is also seen through the field studies that clients' design briefs, clients' roles in the process, their varying levels of collaboration as well as their expectations from the graduation project affected students' progresses substantially.

Student G met his client prior to the presentation of initial ideas together with another student working for the same manufacturer, although their client was situated in a distant city. Their client assignment procedure completed quite early, giving room for such an early meeting. According to Student G, they both had a number of product ideas in the meeting and had put forward these ideas in order to know which one would entice their client's attention most or relate to their interests. The client left the decision to the students, but imposed a practical constraint by favouring those ideas that could be manufactured in ceramic. They paid a second visit to their client after the presentation of initial ideas, where they both had tangible, communicable approximations of solutions. Here the discussions were again related to manufacturability and points to pay attention to when working in ceramic. They toured the production facilities, and thus gained an in depth understanding of the latencies and limitations of the instrumental sets. Student G expressed that it would have been better for the outcome if the client had imposed more constraints during the process. His client was predominantly a technical advisor during his graduation project, yet it is quite

understandable since it is seen that the principal expectation from the collaboration was a support of expertise. However, just as Student A searched precedents with an analogy in mind that effected her prestructuring, Student G had a number of directions in his first meeting with his client, and it is seen that his central issues remained relatively constant throughout the project.

According to Student I, designing a dishwasher with the most constrained brief, the client expected new solutions and ideas from the students which ought to be worthy of one or several patent applications. Her client was again predominantly a technical advisor, but a quite helpful and collaborative one at that. They had spared a day for discussions on students' projects weekly. Her client's role as a variety reducer was most evident in the formulation of the design brief, limiting her efforts to "proposals for the improvement of loading and unloading dishes from the machine, developing new concepts for loading and unloading, and developing new accessories that can be used with the dishwasher". Moreover, these directions were to be solved by ideas pertaining to the interior of the dishwasher, without manipulating any other components of the machine. In later stages of the process, the client's concerns related to production reduced variety considerably, however their effect was quite the opposite in relation to the outcome. Corresponding to their stated expectation from this collaboration, they insisted that several distinct ideas that had emerged at various stages of the process exhibit themselves simultaneously in the finished product. According to Student I, this concern resulted in a design solution comprised of a variety of central ideas, coexistence of which, she stated, was pointless. She stated that she wanted to converge on a singular design idea, the V shaped part, and it is seen before that Student I's satisfaction from her projects are in relation to her central design elements and primary generators. She further maintained, these separate solutions and their coexistence was questioned in the graduation jury.

Openness or Tightness of Design Problems

It is seen through the field studies that the problems as presented by the client, its structure as well as its comprehension by the students affect the solution pattern or students' approaches considerably. In fact it is witnessed that openness or tightness of a design problem can be relative to the students as well. While the framework suggests that internal variety reducers allow designers to structure their problems in terms in which they can solve them, it is witnessed that students may structure their problems in terms in which they cannot.

It is seen that it was Student E who proposed the key elements in her design task, a restaurant, seating units and the ethnic input. Student E stated that, approving the task, her client immediately produced a scenario that would aid her design decisions. He drew a mental picture of the restaurant for her. It was an old mansion in Istanbul in a particular region with high ceilings, where traditional Ottoman cuisine was served. He urged her to imagine the ambience he created, from waiters' clothing to the particular kind of music being played, and wanted her to serve her customers within that atmosphere in a modern style. He asked her what kind of a seating unit would fit that imaginary setting. Although this scenario aided Student E in overcoming her indecisiveness in the early phases, and it was an admirable approach exceeding the department's expectations from clients, it could not act as a variety reducer. It lacked further specification along the process and especially some external constraints such as a particular building or a certain plan, where it is mentioned before that external constraints are acknowledged sources of primary generators. There were no exemplars governing the qualities the scenario provided either. Her design problem continued to remain an open-ended one based on designer-generated decisions. It is important to note that the author did not notice this scenario during the graduation project, and Student E stated that she had discussed it with a particular tutor. This condition verifies the author's opinion of the

‘critique-bond’, the likelihood of which was mentioned in the previous chapter.

While Student E’s design problem remained inadequately structured despite her client’s efforts, Student I had to find some ill-structuredness in her design problem within allowed transformations to build upon the ingenious design solutions in her field, and it can be said that Student F helped his design problem to turn into a tightly constrained one. Through his extensive research on the trucks on the global market and their favourable qualities, he had formed a considerable amount of design criteria at the outset, without addressing or matching of which, he stated, his design would lose its point.

Clients’ Deviations from their Initial Positions

It is witnessed that as the projects evolved, some of the clients made shifts from their initial positions, expressed further wishes and expectations, or made changes in their attitudes towards the graduation project in relation to the partial outcomes.

It is mentioned before that the field notes reveal that Student F had decided to start over about a week before the second interim jury. What necessitated this revolution was a shift in his client’s expectations along the process, probably upon observing Student F’s relatively slow progress and the direction he took, although his direction was determined to a degree by the client’s initial counsel. Thus, while Student F had taken the more realistic path until that point, his client offered him to approach the task in a more conceptual way. Student F stated in the interviews that, though a more conceptual path might mean freedom for most design projects, it was also synonymous with style for the automotive field, and a completely different realm in itself. It was a point of high stress for him, a ‘breaking point’ in his terms, to leave aside a line of reasoning and to adopt a new and markedly different one. Though this revolution came quite late in the process, and the

decision was a hard one, it allowed Student F to reassess his ongoing efforts with a different perspective and to generate design solutions with much ease.

As it is stated before, Student I's client insisted that several distinct ideas that had developed along the process evolve concurrently and exhibit themselves in the finished product side by side. Some of these ideas were various small developments, which Student I had decided to cast aside. This condition where one of the parties imposes further criteria to the design task that influence the outcome can be likened to the condition in the famous phrase 'a camel is a horse designed by a committee'.

Additionally, in a design review with one of the students who was not interviewed, the author suggested a major shift from his ongoing efforts. He was converting a tugboat to a trawler-style personal yacht, and shifting the wheelhouse astern would solve much of his spatial and formal arrangements. Since forward-situated wheelhouses are conspicuous elements of tugboats, of the precedents, the student thought it would not be an allowable transformation. The author urged him to call his client right away and ask whether it was possible, and the client replied "do as you like, it is not going to be built anyway." The author remembers the student's disappointment. Thus, just as clients can be effective in the structure of design problems, their attitudes can be quite as effective for students' motivations.

However, these attitudes can also change during the course of projects particularly in relation to students' efforts. According to Student A, for example, her client was not that enthusiastic at the beginning of their collaboration, which started relatively late. As she started to put forward some sound and original solution proposals after the first interim jury, the collaboration enlivened substantially. It was stated earlier that at the graduation exhibition her client implied that a possible employment seemed likely.

4.3 DEVELOPMENT OF DESIGNS

It is seen that conjectures should come early in the process, before much of the constraints and requirements have been worked out in detail, since these constraints and requirements can only become operational in the context of a particular solution. The previous sections illustrated a number of conditions with their respective effects on the development stage in relation to students' cognitive capabilities, their design problems, and additionally their personal procedures and motives. The framework illustrated that just as a design process evolves in relation to the variety reducers, the variety reducers evolve as well in relation to the process. Therefore variety reducers, together with any changes in them continued to effect design processes.

Convergence on a Unique Solution

It is seen that the design process is marked by a progressive reduction of variety, resulting in a final design. Therefore, by tracking the qualities evident in students' final designs and where in the process the organising principles, the forms, the final scope and extent of design tasks are settled on, it should be possible to assess the correspondence between students' progresses and the one anticipated by the academic scheme. It should also be possible to notice a number of interacting conditions affecting the timing of these decisions. Additionally, since students' cognitive capabilities were nurtured 'institutionally' starting from the middle of the third week, an early convergence, by the presentation of initial ideas for example, may also imply that their pre-existing cognitive capabilities sufficed to prestructure their design problems, or their cognitive capabilities were nurtured in relation to other conditions, or the students already have their own ways to nurture their cognitive capabilities. For example, Student B's and Student G's cases were presented before, and it is seen in the former case that informal codes

supported by scenarios and visualisation aids such as mock-ups can be effective in early convergences, revealing the radical constraints of a design problem. In the latter case, Student G's familiarity with squatting toilets allowed him to determine a number of issues, which were again related to his informal codes. It should also be noted that both of the students had visited their clients quite early, where Student B's field of operation was adequately determined, and Student G had been able to have a handle on the practical constraints of his design problem even though he selected his design project.

Although Student A had a plethora of generating ideas, keywords and possible directions that addressed various considerations of her design problem a week before the first interim jury, the wish to express 'flowing water' was the dominant one since the beginning of the project, according to her. It was also evident in her final design. She had addressed the whole bathroom environment in the first interim jury, as she had stated in her revised project statement, but a 'derivation from the same design concept' was not evident, where the components were shaped in relation to a variety of her stated considerations. These proposals had wavy forms, however, they were unfounded in terms of various constraints including external constraints, practical ones, materials, ergonomics etc. Thus she was advised to go for the washbasin solely, and the scope of her project is determined in the first interim jury. After the first interim jury, in between the two juries, she had been able to come up with three-dimensional forms, four of them, all of which shaped with the 'flowing water' idea. The one she exhibited in the graduation jury was one of these alternatives. Although she still had much to consider in terms of practical constraints, the form of the washbasin did not change much after that point. Thus, although an analogy emerged quite earlier, her actual convergence after which the process proceeded through further refinement and detailing came in between the two interim juries.

It is seen that Student C proposed 8 different dishwasher alternatives at the presentation of initial ideas and continued working on 4 of them until the first

interim jury. Each of them were furthered equally and simultaneously. Reflecting on these four alternatives, he stated:

> One of those was the high-mounted one with the tray travelling downwards, another one had the tray travelling upwards, the third one was the wider one, and the final one was the cylinder-shaped one with the rotating tray. All of them were satisfying what was expected of me. All of them. It was as though I had been able to see a different part of the project with each of them. For example the latent problems in the first one influenced the final product considerably. These, in a way generated reasons for the final product.

Two of these paths were found worthy of pursuing at this interim jury, and while the third alternative consequently provided the general arrangement of his final product, he transferred to it the rotating dishwasher tray from his fourth alternative. There was not a singular or distinct central design idea, rather there were some surfacing considerations and limitations as he proceeded with the alternatives. Student C's process was a good example of a progressive reduction of variety and the conjectural progress, and his convergence came again in between the interim juries. It should be noted that while both Student A and Student C converged on a unique design solution about the same stage and had the same grades overall, Student A's grade was her lowest in the first interim jury whereas Student C's was his highest. It is inferred in discussing the academic scheme that the students were to explore their problem areas adequately by the first interim jury. Although it is clear that there were many 'forces and mechanisms' operational in students' processes that at times determine the courses of their projects for them, Student C's conjectural approach and his speed in creating alternatives should have helped him not only in exploring his problem area, but also in displaying in the first interim jury that he had explored his problem area adequately.

It is seen that Student F's convergence came in between the interim juries as well, where the direction of his project is changed with his client's advice. It can be inferred that his progress was probably delayed due to his personal procedure coupled with other conditions mentioned earlier, where his extensive research without tangible approximations of solutions, his 'ideation'

could not aid him in ‘creating’ a concept to be fitted a form later. These discussions may reveal why it was a point of high stress for him, to leave aside a line of reasoning and to adopt a new and markedly different one. While Student F’s own line of reasoning necessitated a concept or a basis, the new and ‘conceptual’ one demanded style and form. It was possibly not the right time for forms in his own line of progress, and it is seen that he does not count much on his form generation skills. However such interference, it seems, helped him by urging him to reassess his increased cognitive capability with an emphasis on ideas and forms. While his grade was his lowest in the presentation of initial ideas and was a little higher in the first interim jury, it significantly increased by the second interim jury and got a little higher again in the graduation jury. Student F stated that he had decided on everything by the second interim jury, and had started to refine his design two weeks before it. It should be noted that Student F, Student Y and the student redesigning the tugboat had made an interesting exercise at this point along the graduation project. Student F stated: “we three exchanged our projects to see what each of us may have to offer to each others’ projects, to see how we might approach with different perspectives”.

Rehandling the Design Brief

Whether students’ design briefs were open to negotiation or not had affected their processes. It is seen that ideally designing and the design brief should develop interactively, the design brief being restated to match the new and ascending understanding of the problem. Although not much of the clients expressed particular expectations or formulated tangible design briefs, still if initial settlements could be rehandled, it aided students with their projects. In contrast to another condition stated previously, which is the necessity to narrow down the scopes of projects for the students in relation to their levels of progress within their self-formulated problems, this case is marked by the condition that the requests for reformulating design briefs came from the students.

Student B was initially given the drawings of a picnic boat hull, which was 14 meters in length. After he started to put forward some sound solution approximations regarding the interior of the boat, he negotiated with his client and asked whether it was possible to lengthen the boat a bit. The client agreed and supplied him with a 17-meter hull, but imposed some additional criteria such as increased storage, improved clearances and an additional berth, which were usually expected from a boat of such length.

As mentioned before, Student I was not allowed to handle any components in her dishwasher other than those specified in her design brief. After she had found a quite original design idea, she expressed her wish at the time to be able to extend the scope of her project, to handle various other components of the dishwasher around a similar approach to be able to reflect the full potential of her idea. Student I stated that she had started to question whether such a conventional dishwasher deserved such solutions, and further commented that if she was allowed to add her touches to some other parts of the product, the results could have been more meaningful.

Delaying Design Decisions

It is witnessed that at times students willingly held the scopes of their projects wider, delayed converging on directions that does not please them, or were hesitant to further refine their roughly conjectured solutions for various reasons. Converging on design solutions meant a confinement of efforts, limiting the chances of better ideas or more sensible directions, which either effected the advancement to the development stage, or further development of design solutions.

It is seen that Student A already had a notion of the allowable scope of a graduation project. She also stated that finding original ideas is her stronger side and she urges herself to differentiate her products, and that it is easier

for her to generate concepts when she works in a holistic way. However her wider scope, she maintained, which was a result of her conceptual direction at the outset, left her in an uncertain situation:

> Certainly the large scope had held me back. I could not figure out what to deal with. Ideas kept coming from here and there, and nothing stood out as a consequence. There always was the possibility of a new idea, and that is why I could not get started. This held me back

While the early stages of Student H's and Student I's situations were marked by a search for a central design element in order to handle and solve various goals and expectations, Student A's was a welcoming of various ideas that would form a way-in to her efforts in the early stages. It was an expectation as well as a possibility, and it will be seen in a later section that she is inclined to select potential users in relation to the types of products that she would like to design, or the paths she would like to take. Thus, lacking user-specific constraints, a relatively late meeting with her client, and also her inclination to proceed mainly with formal decisions, Student A's efforts were spread widely. The analogy to 'flowing water' as it is seen previously, coupled with a research on exemplary precedents and a narrower scope allowed her to advance to her development stage.

Student E similarly states that she wants a number of options available to her at all times. Further refining particular solutions is synonymous with final phases of projects for her, and if she starts refining her solution proposals early in the process, she thinks, she is "starting to adhere to a singular option". She considers she is stronger in "form and concept" and admits that she usually loses much time with details. Moreover, she expresses her fear of "starting again, turning back to point nil". Instead, she expressed, she usually proceeds with what she already has, especially in the later phases even if her efforts are criticised.

Student B expressed that although the juries urged him to make decisions, he could not adjust his time very well. He further stated that the main cause

of his time related issues was in relation to his own ideas and decisions. According to him, the “problem-solving phase” was delayed due to his indecisiveness:

> Even though I say that I cannot decide on things, in most cases there in fact was no other option. But I did not proceed with that option as well just in case had a new one emerges. For example, I could not think of anything about the mechanism that covers the cockpit until the last minute, yet I did not start working on it and detailing it in case I somehow think of something.

Although his picnic boat had a conspicuous design element, a companionway shifted to one side, serving as an integrating device between the interiors and the exteriors of the boat and the activities in and out, his other solutions for the exterior were comprised of separate, piecemeal ideas and components. His indecisiveness, his keeping these elements as they were without putting further effort into them ‘just in case’, can be due to his unease with them, similar to Student H’s or Student I’s cases. However the reason he postponed working on them was also related to the dependent nature of his design decisions as well. As the resolution of higher–order design solutions affecting these relatively minor decisions were delayed, owing to the scale of the project, these appeared as problems of time adjustment.

It is seen that Student I’s convergence was delayed until she had found an “ingenious point” for her project after advancing with various design solutions. She decided to focus predominantly on this component a week after the second jury, however the final decisions were settled as she was actually building her model for the final presentation. This case may illustrate once more that as the central design elements come late in the process, similar to important design decisions as in Student B’s case, the time for the resolution of other dependent issues are delayed as well.

4.4 THE ACADEMIC SCHEME

In the previous chapter it is seen that the components of the academic scheme and their distribution to the graduation project, their contents as well as their sequence, corresponded significantly to the nature of the design activity as outlined by the framework. The former discussions addressed a number of the research questions stated in the first chapter, and brought to light to some extent that due to a number of conditions, students may fall behind the levels of progress anticipated by the academic scheme. A category of the questions in the second field study addressed both the extent to which students processes and the one identified by the academic scheme corresponded to each other, and whether academic schemes helped them to structure an understanding of the design activity. The findings will be presented in the following sections in relation to students' undertakings.

Presentations and Submissions

While it is seen that the students might be at various levels of progress in relation to the presentations and the levels of progress they implied, they acknowledge the tidying effects of presentations on the whole process. The submissions, on the other hand, were seen as more reports than research, and more as submissions and documentation rather than aids.

Student C was an exception in the sense that he not only felt that he had suited to the academic scheme well, but he also maintained that the process as outlined by the academic scheme was just as he wished for. He further commented that the research reports and their timing was quite right:

> When you look at the process, you see that the first report comes after the initial ideas, and the interim jury following the report…It was like, there seemed to be a system that prepared you for the next step.

Thus it can be said that Student C could come to terms with the underlying connections of the academic scheme comprised of consecutive submissions and presentations. He also acknowledged that research directions in the first part provided the grounds for his ideas and design decisions. It is already

seen that he was proceeding with conjectures of approximate solutions right from the beginning, and had 8 alternatives at the presentation of initial ideas. In designing his dishwasher, he incorporated the kitchen environment to his research as well, which, according to him, taught him so many things. Thus it can be said that he was supporting his roughly conjectured solutions with research, and was advancing on a number of fronts with new conjectures.

For Student B, interim juries are ‘great’. Without presentations, he maintained, his processes would remain indeterminate and he would postpone his decisions. On research reports, however, he said: “I am against research. I am also against reporting, but I am mostly against research”. He stated that although he benefited from research in his graduation project, he maintained that research had never supported his earlier studio projects. It is seen previously that, for Student B, research is something that a designer should make instinctively and not upon prompt; and if a designer can figure out or already has an idea of crucial considerations for a given design project, he may do without it.

Similarly, according to Student G, the presentations defined the process and urged him at times to speed up. For him, “the necessity to present certain things in certain times”, drives one to organise his efforts and “to conclude what is pursued unhurriedly, to make decisions either right or wrong”. However, it is seen that not all of the students are quite at home with wrong decisions or converging on solutions seemingly offering little prospect.

Student F also expressed that presentations had a tidying effect on the whole process by determining some steps along it. He expressed that he is not against report writing, but maintained that presentations and research reports may not match students’ ongoing efforts. He stated that when a particular presentation or submission is scheduled, that step in the process does not conclude students’ efforts in relation to it:

> Maybe it is because everyone is in a different level against time. When they ask your concepts the next day, you do not in fact stop creating concepts the following day. I mean, tutors' process and the student's do not match each other.

Although the academic scheme did not deliberately ask the students to stop creating concepts at, for example, the presentation of initial ideas or the first interim jury, what Student F's remark conveys is that presentations certainly do identify certain levels of progress, but may not echo the students'. This remark may be illustrated by another case, together with the stated hesitation to converge on directions that does not please the students.

Student H, designing the fair stand system, was still trying to structure an understanding of her design situation by the time the first interim jury arrived. According to Student H her first interim jury was a disaster, where she was in the process of terminating an evolutionary path and starting a new one; which proved to be quite necessary for her following achievement. Although she presented some ideas, she said that she was there just to be present. She was not comfortable with her ideas, and expressed that she had in fact nothing to present. She was exploring her problem area at the time, but it took long for "something to appear". It is seen that although getting to know the radical constraints of a design situation is easier for her, her conjectures that address and handle the issues she spots usually take some time. Thus Student H's grade for the first interim jury, which coincided with this indeterminate phase of her project was one of the lowest marks in the studio. Whether the jury made an analysis of the situation for her and urged her to ponder more on mechanisms, which is quite likely, the interview does not tell. Nevertheless, Student H's case illustrates that certain levels of progress identified by presentations may not suit the students'. Additionally, this case may also be a clue to illustrate once more that students seek to find directions worthy of pursuing; and ideas, primary generators, or some design elements that would potentially nurture and organise their subsequent efforts.

Continuing with to Student F, according to him, submissions were the most exhausting part of the graduation project and had fragmented the process:

> You are working on a particular thing, and they ask you to bring something completely irrelevant. You leave your own thing; you scratch your head, there, the process fragments. Your line of thought is snipped. When you go back to your project, you handle it from a former stage than where you had left it; you cannot condense. I remember my saying 'submit this and submit that, when am I going to sit down and work on my project'.

Student F's remarks together may be summarised as follows. Presentations may not determine and limit students' processes although they have a tidying effect, however submissions may fragment students ongoing efforts. However, his comments bring to mind that students may also be dividing their own efforts; they may be separating hands-on performance and research from reporting. They may imply that students' research reports may not be documented as they are being conducted. Research reports may not only be comprised of the research they had already made as their design situations demanded, but also of a separate research activity made solely to fulfil the research report outline.

Student A acknowledged that research aided her, and it will be seen in the next section that she had made her research not only in relation to her design problem, but also in relation to her personal approach. Yet, she too complained about the reports. It is necessary to remind that she recalled the first part of the research reports as a market search:

> The first one was quite helpful. I mean, had it not been given, I was going to make it anyway, but it is very useful since it guides you. I had seen too many exemplars that stimulated my thinking. But the later ones, I mean trying to spare some effort into research reports amidst client visits and so much to do…So many things are on their way, you already settle so many things, and you submit the reports just to submit them. You fill them up with many things that are irrelevant to your project, thus, one way or another it diverges from its intention. Everybody starts to see it as a nuisance.

Together with Student F's comments, Student A's view of the latter parts of research reports imply that the students may feel unease at leaving their ongoing efforts to complete and submit the research reports. As a

consequence, Student A admitted that she had completed the final part of the research reports while the graduation exhibition was taking place. Similarly Student F confessed that he handled over the final part of his research report to another student to be brought together, who was relatively in less hurry. Likewise, Student I did not initially submit this final part of the reports where all three parts of research reports were to be combined. She had to put it aside, saying: “I am not submitting this, whatever it may cost me”. Then, she maintained, the deadline was extended, and she got the report of a friend, and used it as a template. However, it should be noted that Both Student A’s and Student F’s convergences came in between the interim juries, where the second part of the research reports were to be submitted. Thus the submission coincided with quite sensitive stages of their processes. Similarly, Student I’s final decisions were shaped as she was building her model, and this may explain why she had to put the final research report aside, where she was to justify her design.

Research and Reports

It is already seen that the conditions presented in previous sections determined to some extent how students made and incorporated research into their projects. It is also seen that students’ personal procedures were also effective in their expectations from it.

Although Student A stated that research reports may turn out to be a ‘nuisance’, her grade for the research reports was one of the highest. Her reports were not filled with ‘many things that were irrelevant to her progress’ either, and in fact they turned out to be honest and realistic accounts of what she had been doing. Though Student A had explored under most of the headings as identified by the research report outline, she explored under these headings in relation to their uses for her project and according to her personal approach. It is seen how in depth material and manufacturing related explorations seemed pointless for her until some formal decisions

surfaced. For example, as she discussed the latencies of various materials for certain types of forms in her first research report, she demonstrated her own motivation:

> For my part, I want to benefit from the material abundance which is offered to me by this sector. I mean, I want to widen my research about the potential of the materials and make use of them properly. I think this is an opportunity to make innovations.

Her primary concern was to approach the project more conceptually, to propose ‘a new process for bathing and the changes in the bathing environment this could bring about’. Although her neglecting the external constraints of her design situation was one of the reasons why the scope of her project was scaled down at the first interim jury, her first research report reveals that she was also well aware of them, but did not want them to limit her conceptual approach at the beginning. Concluding the first part of her research reports she stated:

> First of all, I haven’t mentioned any space problems in my problem definition because I don’t want this issue to be my starting point. However, in the development steps of my project, it is inevitable to consider it. Therefore, my potential user group doesn’t have a basic space problem in his/her bathroom and has enough income to afford new and different products.

It is interesting to witness how potential users may be used in students’ projects. It is quite normal that students may aim their products to particular markets in relation to their directions. Stating some users would aid in introducing more considerations or in forming a foundation to the projects, but these, as it is seen, can also be used to justify personal approaches. It is also evident that as long as the students give accounts of their undertakings honestly and relevantly, submissions of the academic scheme are effective in supplementing the insight gained into students’ processes through design reviews and presentations as mentioned before.

Although Student A had issues with the latter reports especially in terms of work overload and Student F yearned to be able work on his project, Student

G viewed them differently. When asked whether there was a correspondence between his progress and the research reports, he said “there was none”. He was addressing the first part of the research reports and he maintained:

> In the latter ones, in the third one, for example, I explained how I resolved the issues that I stated in the second one. I was very fond of the latter two, however I submitted the first one just to submit it.

It is seen that he mainly analysed historical and cultural precedents in the first part of the research reports. It was deficient in exemplars on the market, and his research on ergonomic criteria, which was furthered in the studio by life-size templates as well, was only evident as a couple of images without comments. He expressed that since he had been able to arrange an early meeting with his client, most of the critical issues were already recognised. Making research and documenting after he had already initiated his efforts, due to a number of favourable conditions, had rendered them aimless for him. It is stated before that an early convergence may imply that a number of favourable conditions might be at play, and that the students might have their own ways to nurture their cognitive capabilities. Commenting on the first part of the research reports, Student G addressed another concern about project statements:

> Documenting those were boring for me. What was the use of it, I do not know. One good thing only, was to see my project statement travel thus far unchanged.

An unmodified project statement also meant a notion of consistency for Student G, which implied for him that he had commenced his project in a right way.

According to Student E, the research reports did not aid her project significantly, and only the first part of research aided slightly. She maintained that the insufficiency of information failed to aid her project. One reason for this was the lack of precedents in her field, and she had mainly explored the restaurants with an ethnic theme, and mainly oriental ones. After seeing that

her research into precedents did not quite help, she stated that she had started another research on ergonomics after the first interim jury. However, still the extent of her project was blurry. According to Student E, a better research could have aided her better and could have carried her to some other directions, however it was mainly the lack of constraints that hampered her process. She stated: “It was like I was swimming in a sea. If I could really have some concrete things in my hands until the second interim jury, I would be able to make some decisions”. This indeterminacy is evident in her CODs in the second part of research reports as well, where they turned out to be some statements of the radical constraints involved in furniture design, and not specifically in relation to her project. Moreover, not only these CODs were quite broad statements, but some of them were reiterations with the auxiliary verbs, must, should and ought to, owing to their definitions. Nevertheless, commenting generally on the submission sideline of the graduation project, Student E stated:

> I think it would be more logical if the findings of research are sought for in the products, rather than asked in the form of reports. I mean, what do you make research for? You make it for your product. You already see the results in the product, there is no need to ask them again.

Design reviews

The design reviews, as stated previously, were carried out according to an appointment schedule, which made sure that each of the tutors sees each of the students at least once a week. It was requested by the students at the beginning of the term with a concern for levelling review times, however during the interviews some concerns were voiced in relation to this practice. Moreover, it is also seen that despite the efforts to observe and record students’ processes according to the framework, either some conditions that affected students’ projects went unnoticed and especially the client related ones, or the students preferred to exchange these conditions with a particular tutor. Some of the client related issues in the early stages fell outside the range of recorded observations as well.

It is stated that Student E discussed his client's scenario with a particular tutor in design reviews, and that this detail had escaped the author during the graduation project. This case brings to mind that the tutors in a design studio, quite naturally, may have their own methods, motivations and concerns in teaching. Thus, again quite naturally, students would discuss various aspects of their undertakings with the 'appropriate' tutor. However this case may also imply that tutors may be tracking and guiding their students' efforts with limited insights, due to varying levels of information that is being conveyed to them. Separating tutors from each other, the scheduled design reviews may intensify this effect. This may be the reason that at times studio tutors in juries feel obliged to account for their students' actions and designs, not only to visiting lecturers and guests, but also to each other; just as clients at times may have to explain why a particular student took a certain direction. The latter discussions were not specifically looked for during the observations and thus are subjective impressions and not recorded evidence. Nevertheless, they might suggest a better communication of opinions on students' progresses, not only among studio tutors, but also between the studio tutors and the collaborating clients.

Student I had a number of discomforts with the scheduled design reviews. She stated that while at times she did not have anything to discuss or 'present' in the design reviews, she felt obliged to be present at the studio at her scheduled time. She expressed that it was a positive practice in terms of being able to see each tutor at least once a week, but recalled her complaining about its becoming a duty at times. Moreover commenting on the design reviews, Student I validated the notion of an 'appropriate tutor' for certain phases of projects or certain discussions:

> I have this idea in my head. If I share it with Tutor A, I know that s/he will not elaborate on it much, since we know the tutors quite well. Tutor B has much to say on this idea if we talked, but I'm in Tutor A's row. Tutor B will not be able to spare some time for me, since s/he has got this much people to talk to, and I have to wait for two days or more. It is a bad thing, I mean, an idea comes, it will probably develop further if discussed. Two days later either the idea loses

> its energy or becomes not as quite important, or other things come over it and you discard it; or otherwise you find yourself waiting for tutors at 7 o'clock in the evening.

Student I's concerns voice another issue as well, that as glittering ideas occur, it may be healthier if they can be discussed before the rays fade. However, Student I may be criticised for being too hesitant in interrupting design reviews or being too slow in arresting tutors in between design reviews. According to Student F, for example, one develops a sympathetic understanding with the tutors throughout the years, which aids in seizing tutors anytime in this final term. According to him, the scheduled reviews did not affect much, other than augmenting involvement and participation in the studio.

Academic Schemes and Personal Procedures

The interviews brought to light some insights into students' personal procedures and revealed to an extent the correspondence between students' personal procedures and the academic scheme. It is also witnessed during the interviews that, academic schemes form a framework in students' understandings of the design activity and are seemingly consistent throughout their education, and students' own procedures are in the form of its variations due to their learning experiences. It is interesting to note that even if the students did not abode by the academic scheme in the graduation project, or developed some personal procedures that are seemingly different from a recognised academic scheme outline, they not only had been able to carry on, but also illustrated some practices that are in conformity with the nature of the design activity.

When asked to what extent his progress was in conformity with the process as identified by the academic scheme, Student C said:

> Totally. The presentation of initial ideas was shifted a week, and even that shift suited to my process. It was good. What I am most pleased about this project is that I had been able to go along with this template. Now I think that if there is a

> template like this, why go against it? To try to suit it, I think, is more beneficial than trying to stretch it or rejecting it. Would I outline my own template had it been missing? Yes. But I guess I would not put this much thought in it. I mean, even the 'mock-up bringing time' was ideal for me.

Although running adjustments to the academic scheme are usually made according to students' partial outcomes and levels of progress, Student C was very content with his matching the "template". Together with this contentment, his acknowledgement of the latent benefits of the academic scheme when suited well, may give hints at the "templates" of his future design processes. He also noted that he would outline his own scheme, which may also imply a certain accumulation from his educational experiences. Student C commented on the time allowed for models at the end of the process as well, recommending that it could be extended a little bit. He complained that his models had always been relatively refined mock-ups, but also added that this situation may be peculiar to himself. This complaint may be likened to Student F's case illustrated previously, in terms of the correspondence between personal procedures and design skills. Just as Student F thinks his form generation skills are inadequate owing to his personal procedure that prioritises analysis before conjectures, Student C's personal procedure probably had compressed the final phases of his projects, which may account for his deficiency in model making.

Student F acknowledged the effects of academic schemes on students' personal procedures, but maintained that the students do still differ in their personal approaches. When asked how would he carry out his design processes in the future, Student F said:

> I would follow the process that is being imprinted into our heads for four years. But it was not the only thing, not the department's process only. Our interpretations of it among ourselves were quite different as well. Brainstorming. We did it quite a lot. I recall that in the second and third years, we started almost all of the projects by coming together and doing brainstorming. Therefore, the department has a certain process already, and you have a certain style of using it, and everyone uses it in a different style. I mean, everyone develops his, and carries on with it later. For example, Student B had never used the department's process. But I was closer to it.

It is stated in the beginning of the third chapter that students' accumulations in their understandings of the design process and consequently their individual approaches to design problems may vary. Student F's remarks seem to support this reckoning, implying that the academic schemes had stood for a particular process that remained consistent throughout their education, yet the students' employment of this process, and their "styles" differed. It is also stated before that the students need to refine these understandings as much as possible within four years. Together with Student F's former remarks, it can be said that not only the search for a certain procedure may start quite early in the learning process, but its attainment may also ensue earlier, since he mentioned some distinct styles like his, Student Y's, Student X's and Student B's in relation to various stages of their education. Moreover, in addition to the implication of a collective learning process mentioned earlier and the "what may it be" method, his remarks imply another collective activity they adopted, which is the collective prestructuring of their problems by means of self-initiated brainstorming sessions. It is quite likely that these brainstorming sessions might have been initiated by the department in a couple of projects, and it may have turned into collective activities through is-ought transitions. Another activity mentioned earlier, namely the practice of exchanging projects to introduce different perspectives to them can be taken as one of the collective prestructuring methods.

It is also evident that Student F is keen to comment on his classmates' understandings of the design activity. He stated that Student B's "personal style" and the design process as identified by academic schemes were quite dissimilar, where it is seen that Student B depends as much as possible on his informal codes in carrying out the design activity, and is "against research". Additionally, Student F stated that he was more closer to a process that academic schemes stood for, where it is seen that not only his graduation project was marked by extensive research, but also his personal procedure prioritises analysis. Through these discussions, it can be inferred

that the design process the academic schemes had stood for during their education may have identified a process that is initiated by research, aimed to nurture their cognitive capabilities in relation to their design problems.

Although it is seen that the academic scheme had a conspicuous research report sideline to the whole process, students' complaints were more on reporting than research. Moreover it is also witnessed that a number of students stated that had the academic scheme was not incorporated into the graduation project, they would either outline a time plan for themselves, or make similar research into the directions as identified by the first part of the research reports. Thus, Student B's and Student F's approaches may form the two ends of a spectrum of personal procedures in terms of making and incorporating research into the design process. For example, according to Student A, a design process has to be undertaken in a similar fashion. Although she admits that she had complained within the process and at times had felt exhausted by the submissions, she states: "but looking back, it was fortunate that we had those, otherwise my project would not have been as it is". And Student D, working for a vacuum cleaner manufacturer, stated: "it is quite likely that I would work with a client in a similar way, if ever. I think I had carried out my process quite efficiently. If I work freelance one day, I would carry out the process similarly". And finally Student E stated that she would also follow these steps in her professional career. She said: "it proceeded exactly in the same fashion since the first year. This is what I am accustomed to do, and it will be so".

CHAPTER 5

FINDINGS AND CONCLUSIONS

5.1 GENERAL DISCUSSIONS

This study was initiated in order to investigate students' design processes. It is stated in the first chapter that the ways the students shape their understandings of the design activity, what the students learn-by-doing, would provide an influence on their design procedures, not only in the educational setting, but also in their professional practices. In order to gain insights into their design processes a natural conceptualisation of the design activity is brought together through the developments in design methodology. Equipped with the key components of this framework of the nature of the design activity, field studies with senior industrial design students were conducted. It was inferred that students' accumulations in their understandings of the design process and consequently their individual approaches to their design problems might vary. Hence, the main reason for the selection of this sample was the expectation that they would be at their ripest at the final stage of their undergraduate education as far as learning-by-doing is concerned. Furthermore, the students worked independently on individual projects in the graduation project, and it was carried out with industrial support. It functioned as a rehearsal for actual professional practice. Thus, observing students within such a setting offered the prospect of witnessing students' accumulations in their understandings of the design activity in a life-like design task and *on an individual basis*.

It is witnessed through the field studies, however, that the students' routes through their problem material were as dependent on their particular problem situations as they were dependent on their personal procedures. That is to say, observing students within the graduation project turned out to be a limitation for the field studies as well, and allowed mainly to gain insight from students' design processes *on a project basis*: their progresses as well as their procedures could be different had they worked on other design problems and with other clients. Yet, it was still possible to discuss students' processes, their design problems and the academic scheme within which they operated, pertaining to their respective influences on the projects and students' progresses, and the conditions revealed through these unique cases.

5.2 RESEARCH QUESTIONS REVISITED

The questions to be addressed in the field study were set out in section 1.2, as follows:

'What are the forces and mechanisms operational in studio projects?'

The forces and mechanisms operational in design processes were identified in section 2.4, and the framework presented a natural conceptualisation of the design activity through its key components. As a design process, the forces and mechanisms operational in the graduation project that was devised as to approximate a real-life design task were not markedly different than a natural one.

The design process is identified as a progressive reduction of variety; however how this variety is to be reduced to arrive at a particular design solution depends on the designer, the design problem and the time dimension. The outcome represents the failure or success of the designer's art; yet the structure of the design problem, the designer's position and

approach in handling it, and the process through which these are wrought together have their respective parts to play in its making. Yet, the designer is at the centre of this design situation, and it is his task to coordinate the design situation by whatever device. Similarly, the students were at the centre of the graduation project, they had their unique design problems with clients, and the academic scheme determined the time dimension.

Being the final part of a learning process in an academic environment, the project was guided still. A time plan was determined by the academic scheme with certain presentations along the process; and together with the research report sideline, the design aid for the term, these implied certain levels of progress at certain stages of the graduation project (see section 3.3). The design reviews, which were carried out according to an appointment schedule, and studio discussions filled the space between these presentations and submissions. The findings also stress the importance of the collaboration among students in this academic environment, together with their collective design methods and aids.

‘*What are the factors that affect students’ processes, and their progresses against time?’*

The students structured their understandings of their design problems, put forward solution conjectures, converged on unique design solutions and refined them, but at different stages along the process. Their progresses against the time plan and the courses of their projects were in relation to a considerable amount of interacting factors internal and external to them. It should be noted that none of these conditions sufficed to impede or alleviate students’ progresses alone, rather it was the combined effect of a number of conditions and practices which determined the courses of the projects and their progresses. It should be remembered that none of the 38 students failed in the graduation project, and that the grade range was quite narrow (see section 3.2.1).

The key factors influencing students' progresses that were internal to them were noted as follows:

- Students' 'cognitive capabilities' in relation to the kinds of problems they are presented (their internal variety reducers, comprised of a knowledge of existing solution types, a knowledge of materials and manufacturing means, and informal codes in the form of self experience as a user, as identified in section 2.4.1.2) affect their progresses. Pre-existing cognitive maps are one of the factors differentiating practicing designers and students of design in terms of experience and specialization, comprised of a notion of 'what is possible' in a field with well-internalised solution types, production means and informal codes. In the form of familiarity with the design problem, students' pre-existing cognitive maps affect their prestructuring capabilities and influence not only the commencement of their design processes but also the courses of the projects in their later stages. Student's flexibility in choosing the projects to work on affect their motivations and also enable them to start specializing in particular fields. Students also select their projects in relation to their pre-existing cognitive maps, yet students presupposed familiarities with their design problems at times misguide them.
- Students differ in their search for and handling as well as incorporating information into their projects. Their expectations from research and consequently their focuses vary. These variations are especially relative to their familiarities with their design problems and what they need (pre-existing cognitive capabilities), to what they feel they need in relation to their personal approaches (form priority, analysis priority, reliance on informal codes), and how the process is initiated (early or late visits to clients, presence or absence of design decisions, goals or approximations of solutions).
- Research into precedents and exemplars, if made with some ideas, goals or approximations of solutions, allow students either to make or

justify design decisions. That is to say, precedents exemplify links between the constraints students settle on (like form) and those they need to consider (like usage or materials), especially where knowledge of them are initially narrow or limited to those the students come across or use routinely (pre-existing cognitive capability). Research into precedents can also hamper progress, can burden the early phases with numerous design criteria, especially if the students do not have particular goals, ideas or directions in principle, if these are unclear or vague, if the students are indecisive, or if the design problems remain inadequately constrained. Additionally, students are inclined to make research into precedents if they are driven by originality and differentiating their products.

- Students' accumulations in design processes include informal codes (self experience as a user) and their uses, by which they initiate their efforts intuitively and search for more information in the light of their approximations of solutions. Heuristic employment of informal codes allows students to generate approximations of solutions even if they are unfamiliar with their design situations. Scenarios and mock-ups help students develop their informal codes substantially, together with research into precedents; and these are most beneficial if a regular or even a singular experience with the product to be designed is unattainable.
- A match between the skills and strengths of the students and the particular demands of their design problems (form generation, detailing) allow them to proceed comfortably, yet students' skills can act quite similar to design constraints as well. Just as the lack of certain production means (practical constraints) may demand a reconsideration of design decisions, incompetence in modelling software, for example, (lacking a tool for 'presentation production') can demand a modification of formal decisions as well.
- A strength in a designer was identified as "a good command of forms and details of everything around" (see section 4.2.1), which represents

pre-existing cognitive capabilities, and in particular a knowledge of solution types and instrumental sets.

- Some skills are naturally attributable to earlier phases of studio projects (problem formulation, ‘concept creation’) and some others to later phases (detailing, model making, refined presentations). The development of these skills through studio projects is in relation to students’ progresses. As students fall behind the levels of progress expected of them in consecutive studio projects, the time spared for the practice of the latter skills is being limited. Similarly, the findings illustrated that students’ personal procedures may also affect attainment and practice of certain skills.
- Students may differ in their personal procedures, and they do develop certain design aids for themselves. Though it is evident that many factors are at play in determining the courses of students’ design processes for them and especially in the early phases (cognitive capabilities, design problems, information), students’ personal procedures are also effective in commencing and furthering their efforts. Some conspicuous personal approaches were observed, such as exploring the problem area with alternative designs, creating a concept in the form of an idea first and then developing and making this concept tangible (concept creation), or initiating the design process with a reliance on informal codes. The design aids students take advantage of are ways to share their cognitive capabilities, approaches and skills, and are employed as their processes and progresses necessitate.
- Although the search for a central design element or an organising principle (primary generator, ‘ingenious point’) may cause the students to fall behind the levels of progress expected of them, once found, these increase the likelihood of better designs, and rekindle and sustain their enthusiasms for the rest of the process. These steps usually mark both a revolution in the process to be followed by a holistic approach, and a convergence. Yet, it should be noted that not all of the students are quite at ease with a revolution and especially in the later stages.

- Students may approach their design problems rather confidently and optimistically, establishing scopes that are quite wide at the outset (designing the whole). This tendency may be due to their early conceptions about their problem areas that are formulated before solution attempts are initiated, together with their reliance on their capabilities, the time dimension and their clients. Wider scopes may occur, as much of the constraints are determined by the students (formal, radical and external constraints, as well as the users). Lack of precedents contributes to their persistence, and students' analyses may fail to provide insights critical to their problems in such self-constructed situations, which would otherwise confine their projects. Students may not convergence on unique design solutions in these cases, until their problems are restructured and the previously conceived and announced scopes of their projects are narrowed down (limiting the number of components to design, focusing on a part of the overall situation). On the contrary, where the students start to explore their areas with solution conjectures and develop design briefs with their clients, they may be able to formulate more realistic descriptions of their challenges from the outset.
- At times, the students willingly held the scopes of their projects wider, welcoming various ideas that would potentially form ways into their efforts in the early stages. When limited to the early stages, it can be said that wider scopes may aid in getting to know the problem area through generating approximations of solutions which address the extent of the scope, and may aid in convergence by settling on one of them. Yet, ambiguous generating ideas, or an abundance of them usually in conflict with each other need to be resolved for a convergence.
- Some students delayed converging on directions that do not please them, were hesitant to further refine their roughly conjectured solutions, or postponed handling some components of their designs. While converging on particular directions meant a confinement of efforts,

limiting the chances of better ideas or more promising directions, refining design solutions were synonymous with final phases in their procedures.

- Breaking the product to be designed into its components and handling them separately is one of the downsides of student projects. This inclination not only decreases the likelihood of a balanced and integrated outcome, but also affects students' progresses. As decisions in relation to some components are delayed, or their refinement takes time, the resolution and refinement of other dependent components are postponed as well.
- Since the students' 'cognitive capabilities' (see section 2.4.1.2) were nurtured 'institutionally' starting from the middle of the third week, an early convergence, by the presentation of initial ideas for example, may imply that their pre-existing cognitive capabilities sufficed to prestructure their design problems (familiarity), or their cognitive capabilities were nurtured in relation to other conditions (early visits to clients, early solution attempts), or the students already have their own ways to nurture their cognitive capabilities (self-initiated research, hands-on experience with the product to be designed).

The key factors influencing students' progresses that were external to them were noted as follows:

- Clients' design briefs, clients' roles in the process, their varying levels of collaboration as well as their varying expectations from the graduation project affected students' progresses substantially.
- In the cases where the client assignment procedure completed early in the process and gave room for early meetings (i.e. before the presentation of initial ideas), in which potential design projects, information, and goals and expectations were exchanged, the variety of possible directions were reduced at the outset. Yet, it should be noted that early meetings did not guarantee unambiguous directions or project definitions, and seemingly manageable directions may still turn out to be

inadequately specified ones. It is witnessed that openness or tightness of a design situation may be relative to the students as well.

- Although not much of the clients expressed particular expectations or issued definite design briefs in the graduation project, if initial settlements were open to negotiation, the students were able to restate their problems in relation to their routes through the design situation.
- As the projects evolved, some of the clients made shifts from their initial positions, expressed further wishes and expectations, or made changes in their attitudes towards the graduation project in relation to the partial outcomes. Cases were observed where the clients imposed additional criteria to the projects, or where they demanded a revolution in relation to students' progresses. Clients' interests, expectations and attitudes towards the graduation project may influence students' motivations as well, yet it is witnessed that these attitudes may also change during the courses of the projects, again in relation to students' efforts.

'What are the latent effects and uses of academic schemes that are devised on a project basis? Do they conform to the nature of the design activity?

In section 3.3, latent effects and uses of the academic scheme determined for the graduation project is discussed, where it is concluded that it conformed significantly to a natural design process represented by the framework brought together in section 2.4. The academic scheme urged the students to initiate their processes with approximations of solutions, and provided them research directions aimed to nurture the constituents of cognitive capabilities. Later presentations and submissions urged students to refine and analyse their designs and decisions. The research report outline, and especially the final part of research reports explicated some key design considerations (client response, market potential, material selection, production techniques, cost and price, user response, design features and style, usage scenarios) that should be taken into consideration in shaping the designs as well as the processes.

‘To what extent students’ design processes and academic schemes conform to each other?’

Although the academic scheme is found to be in conformity with the framework, some variations were observed between the levels of progress identified by it and students’ progresses, in relation to various effects of the factors stemming from the scope and nature of the graduation project. It is seen that the students’ routes through their problem material and their progresses were mainly dependent on their particular problem situations.

It is seen that, although the presentations helped the students in scheduling their efforts, students’ progress levels were largely determined by their unique design problems and how they handled them, which was dictated by the factors identified beforehand. Similarly, making use of the design aid for the term and incorporating its latent benefits to their projects was mainly up to the students, and again dictated by their cognitive capabilities, personal approaches and their design situations (familiarity, lack of precedents, reliance on informal codes, other factors that nurture cognitive capabilities, various concerns in handling and incorporating information, searching for information in relation to solution proposals etc.). Thus, it is witnessed that, the students could find themselves in difficult conditions even if they abode by the academic scheme (both presentations and submissions), or they could carry on even if their levels of progress did not conform to it.

The findings in relation to students’ processes and the academic scheme can be summarised as follows:

- The students acknowledge the tidying effect of presentations on the whole process through the certain steps they determine. For them, presentations define the process, and the necessity to present their current states in certain times drives them to make decisions, to organise their efforts, and conclude what is pursued unhurriedly.

- It is also seen that not all of the students were quite at home with wrong decisions or converging on directions that seemingly offered little prospect. It is seen in some cases that variances from the academic scheme were necessary for students' subsequent achievements, however at the cost of lower grades for the indeterminate phases of their projects. Students' might have been guided towards their subsequent directions in the interim juries; and also their prospective achievements (whether they will be able to find a central design element) may not be estimated during the process. Nevertheless, these cases illustrated that students may not be striving through solutions that will be assessed; rather, probably owing to the nature of the graduation project and their expectations from it, they may be striving towards solutions that would satisfy them as well as their clients. Thus, it can be said that the academic scheme identifies certain levels of progress, but these levels may not echo the students'.
- It can be said that the research reports were seen as more reports than research, and more as submissions and documentation than aids.
- It is seen that students' search for information, as well as their handling and incorporating it into their projects varied in relation to their familiarities with their design problems and what they needed (pre-existing cognitive capabilities), to what they felt they need in relation to their personal approaches (form priority, analysis priority, reliance on informal codes), and how the process is initiated (early or late visits to clients, presence or absence of design decisions, goals or approximations of solutions). When students' pre-existing cognitive capabilities sufficed to prestructure their design problems, their reliance on and expectations from research declined. Lack of precedents in a field may also limit the use of research.
- Latter parts of research reports, some students complained, fragmented their ongoing efforts, and that completing them was exhausting. Convergences of these students came approaching the second interim jury and mainly upon revolutions. Thus these submissions, where the

students were to analyse and later to justify their design decisions, coincided with sensitive stages of their processes. The students felt uneasy in leaving their ongoing efforts to complete and submit the research reports, and a number of them sought assistance from their classmates in their completion. Therefore it can be said that their latent benefits may not be incorporated to their projects to full extent.

- Similarly, a prevailing indeterminacy and indecisiveness half way into the project may either cause the CODs to be quite generalized statements of the radical constraints involved in a particular design situation. Likewise, owing to their definitions in the research report outline, CODs may turn out to be reiterations of similar statements with the auxiliary verbs, ‘must’, ‘should’ and ‘ought to’.
- Yet, as long as the students give accounts of their undertakings honestly and relevantly, submissions of the academic scheme may be effective in supplementing the insight gained into students’ processes through design reviews and presentations. Similarly, it may be possible to have another handle on students’ progresses by tracking consistencies or evolutions of their project statements, as well as whether they need to be modified.
- A component of the academic environment was the design reviews, which were carried out according to an appointment schedule. When students do not have much to discuss or present, scheduled design reviews may become an obligation to be present in the studio at certain predetermined hours, yet they may alleviate participation in the studio. These concerns voice another issue as well, that as potentially influential ideas occur, it may be healthier if they can be discussed in design reviews before the idea loses its energy or cast aside.
- A notion of ‘appropriate tutor’ for certain phases of projects or certain discussions was inquired through a particular case and validated through another. This notion may imply that the tutors in a design studio, quite naturally, may have their own methods, motivations and concerns in teaching. However it may also imply that tutors may be tracking and

guiding their students' efforts with limited insights, due to varying levels of information that is being conveyed to them. Separating tutors from each other, the scheduled design reviews may intensify this effect.

'Do academic schemes convey, or help students to structure, an understanding of the nature of the design activity?'

Discussing latent effects and uses of the academic scheme determined for the graduation project, it is concluded that it exemplifies a natural design process, and is latent to help students to structure an understanding of the nature of the design activity. Yet, it is seen that incorporating the latent benefits of the academic scheme was largely determined by many interacting factors in the graduation project, which caused lags between students' progresses and the progression of the academic scheme against time.

Some limited insights into students' personal procedures and their past studio experiences illustrated correspondences between their understandings of the design activity and the role of academic schemes in their making:

- Academic schemes form a framework in students' understandings of the design activity and are seemingly consistent throughout their education. They are also working guides for the students in their professional careers.
- Yet students may develop quite different personal procedures (form priority, analysis priority, generating alternatives, reliance on informal codes) within the same academic environment. Students' own procedures may be in the form of the variations of a working procedure identified by academic schemes due to their learning experiences.
- It can be inferred that the design process the academic schemes had stood for during the students' education may have identified a process

that is initiated by research, aimed to nurture students' cognitive capabilities in relation to their design problems.

- Students may be developing their understandings of the design activity collectively. The findings indicate that they reflect on their own design processes and procedures; and also observe, assess, criticise or yearn for others' approaches and skills. A valuation of certain cognitive styles (analytical thinking), or realising the need to acquire one may be starting to surface as early as the first year, and settling on one may ensue at some stage along students' learning processes.
- Students either develop ('what may it be' method, exchanging projects) or adopt (brainstorming) design aids. These are ways to share their cognitive capabilities, approaches and skills, and are employed as their processes and progresses necessitate. It is likely that brainstorming sessions were employed by the department in a couple of projects, and the students adopted them as collective activities through is-ought transitions. The same may be applicable for exploring the problem area with alternative designs.
- Bearing in mind the unique demands of their problem situations, it can be said that students' personal approaches (concept creation) may be resilient to guidance at the final stage of students' education.

5.3 IMPLICATIONS FOR DESIGN EDUCATION

Pertaining to the findings this study has presented, implications for further developments of educational curriculum and academic schemes can be stated in relation to the following premises:

- As the findings indicate, other than the relevant roles of the academic scheme and the unique design situations in structuring students' design processes, students' own ways in shaping their design processes effectively determine the courses of their progresses. Therefore, efforts should be made in restructuring educational curriculum to incorporate

components that would enable students to attain necessary skills and knowledge to develop their own, more structured design procedures, while the academic schemes should be programmed in order to allow students the flexibility to put their own personal procedures into practice.

- Students' time management skills should be reinforced so as to allow them to allocate their efforts in adequate proportion to each stage of the design process, with a view to ensuring sufficient time and effort are being devoted to later stages of the process to build and practice skills in relation to those stages.
- Consecutive studio projects should be devised to address a variety of design problems and design situations in order to enhance students' 'pre-existing cognitive maps', with which they determine the courses of their new projects especially in the early stages.
- An effort should be considered to keep records of students' progresses, skills, particular strengths and weaknesses (what they learn by doing) throughout their learning processes, continually developing this information and maintaining it to be shared with and further developed by succeeding tutors in consecutive studio projects. An analogy to medical practice may elucidate the intention, where a doctor is able to take up the care of a patient on account of medical records a former one had kept.
- A flexible research scheme should be developed with research directions determined as students' projects and progresses necessitate. Students should be encouraged to decide on and announce their own research needs.
- Efforts should be made to enable students to acknowledge as well as to externalise their own strengths, weaknesses, and pre-existing cognitive capabilities in relation to the design problems that they wish to undertake particularly prior to graduation projects.
- As the findings indicate, allowing students to choose their projects for the graduation project in accordance with their career interests raises their

motivations. It also lets them start developing their skills and knowledge relevant to those fields.

- Scenarios and mock-ups help students develop their informal codes substantially; and as the findings indicate, these are most beneficial if a regular or even a singular experience with the product to be designed is unattainable. Therefore students should be encouraged to develop, externalise and justify their employment of informal codes by means of scenarios and mock-ups.
- Efforts should be made to develop means that encourage students to express their ideas, concepts and design decisions as tangible as possible. Such efforts would not only enable students to explore their problem areas and gather data relevant to their routes through the problem material, but would also increase the effectiveness of design reviews, juries and discussions.
- Students should be encouraged to explore their problem areas with approximations of solutions. Partial developments and adequate refinements of solution conjectures should be encouraged in exploring the problem area, as opposed to leaving developments and refinements to later phases.
- As the findings indicate, primary generators increase the likelihood of better designs, and rekindle and sustain students' enthusiasms for the rest of the process, yet it is also seen that search for and employment of primary generators are seemingly individual commitments. Efforts should be made to develop means and practices that facilitate prevalence of primary generators.
- The 'client'-department relationship should be institutionalised with well-communicated and formulated goals and expectations from collaborative studio projects. Sustenance of communication during the projects should also be a major concern. As the findings indicate, the clients can deviate from their initial positions during the courses of projects and may effectively influence the outcomes, while the tutors may not be aware of these deviations.

- Design reviews should permit effective communication with the students and should allow counsels as students' projects and progresses necessitate. Similarly pertaining to the notion of an 'appropriate tutor' for certain phases of projects or certain discussions, design reviews should not cause tutors to track and guide their students' projects with limited insights.

5.4 IMPLICATIONS FOR FURTHER STUDY

It is stated previously that the author decided to observe as much students as possible, since what might each student present in the graduation project could not have been estimated. The author initially decided to conduct interviews with 10 students, and identified some 16 students interviewing with whom would provide relatively more valuable insights. It is witnessed however; students not among these 16 still provided invaluable insights. Thus, either an observational sample may be kept to a limited number of students, since each one of the students may provide valuable insights; or the sample can be reduced in the course of the observations to increase the quality and amount of the data collected.

A relatively manageable sample in an observational study, coupled with a setting with a relatively less amount of variables such as a singular design problem can make it possible to reassess observational interests on the run, and to employ a choice of observational focuses such as students' personal procedures and the effects of academic schemes.

A number of observational studies on consecutive studio projects may provide insights on what the students learn by doing. By determining what the students pass on to their consecutive projects, like skills, certain practices or alleviated cognitive capabilities, it may be possible to have a handle on their accumulations and their sources.

The findings indicated that students' search for a certain cognitive style may start quite early in the learning process; and that they may also be structuring their understandings of the design activity collectively. Some further research topics relative to these findings may be stated as:

- How do students attain various cognitive styles?
- How collaborative, how institutional and how personal they are?
- At what stage in their learning processes the students more or less 'converge on' a unique cognitive style?

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APPENDIX A

DOCUMENTS FROM THE ACADEMIC SCHEME

A.1 The Time Plan for the Graduation Project

Table A.1.1 The Time Plan for the Graduation Project

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
				21 Feb Submit the questionnaire	22	23
24 Submit the project statement	25	26 Studio work and discussions	27	28 Studio work and discussions	**1-Mar**	2
3 Studio work and discussions	4	5 Discussions on project statement	6	7 Discussions on project statement and initial ideas	8	9
10 Discussions on project statement and initial ideas	11	**12 Re-submit the project statement(s)**	13	**14 Presentation of initial ideas**	15	16
17 Crits, bring mock-ups	18	19 Crits, bring mock-ups	20	21 Crits, bring mock-ups	22	23
24 Crits **Submit research report part 1**	25	26 Crits	27	28 Crits	29	30
31	**1 April Interim jury submission**	**2 Interim jury 1**	3	**4 Interim jury 1**	5	6

Table A.1.1 The Time Plan for the Graduation Project (cont.)

7 Submit the poster and invitation for the graduation exhibition	8	9 Crits	10	11 Crits	12	13
14 Crits **Submit research report part 2**	15	16 Crits	17	18 Crits	19	20
21 Crits	22	23	24	25 Crits	26	27
28 Crits	29	30 Crits	**1-May**	2	3	4
5	**6 Interim jury submission**	**7 Interim jury 2**	8	**9 Interim jury 2**	10	11
12 Final crits	13	14 Final crits	15	16 Final crits **Submit research report part 3**	17	18
19 Start working on models	20	21	22	**23 Submit the presentations (CD) & submit sketchbook and documentation**	24	25
26 Presentation crits (B&W print outs)	27	28 Presentation crits (B&W print outs)	29	30	31	**1-Jun**
2 Start of finals	3	4	5	6	7	8
9	10	11	12	13	**14 End of finals**	**15 18:00-24:00 Set up the exhibition**
16 9:00-17:00 Graduation jury 18:00 Cocktail	**17 9:00-17:00 Graduation jury**	**18 17:00 Remove all exhibition material**	19	**20 Last day to submit grades**	21	22
23	24	25	26	27	28	**29 Graduation ceremony**

A.2 Project Statements

Name of Student:

ASSIGNMENT 1

1. Project Statement

Write a short statement describing the design project that you wish to pursue as your graduation project. A project statement is essentially a goal statement or problem definition; it defines the problem space in general terms and avoids preconceived solutions.

This statement may be revised several times during the development of the project.

Examples:

Design an outdoor play environment which accommodates the physical exercising needs of visually impaired children between the ages 7-14.

Develop means for improving the catering service in Turkish Airlines overseas passenger planes.

2. Motivation

Describe the reasons that motivated you towards selecting this particular project. These may include your personal experiences, background, interests and observations, or a need you observe in the market, a new technology/material/trend with a design potential, etc.

3. Potential clients

Identify potential clients and advisors (governmental institutions, educational institutions, private institutions, private companies, experts, research centers, special clients, etc.) who may support the project that you described above.

In order of preference:

1. _____

2. _____

3. _____

4. Other areas of interest

Indicate other areas or subjects you are interested in for the graduation project. Please try to be brief, yet as specific as possible.

Examples:

Subject: Bedroom furniture for teenagers
Potential client: Çilek Mobilya

Subject: Washbasin and lavatory environment for kindergartens
Potential client: Toprak Seramik

Subject: Outdoor playground equipment for visually impaired primary school children
Potential client: Altindag Municipality
Advisory institution: Gazi Üniversitesi Özel Egitim Bölümü

In order of preference:

Subject	**Potential Client**
1.	
2.	
3.	

A.3 The Document Defining and Stating the Expectations from the Graduation Project of 2003

Üniversite-Endüstri Isbirligi

1979'dan bu yana egitim veren bölümümüz, kullanicinin gereksinimlerine duyarli, gelisen teknolojinin sundugu olanaklari kullanabilen, yaratici ve yenilikçi tasarimcilar yetistirmeyi hedeflemektedir. Egitimin ülkemiz endüstrisinin gereksinimlerine duyarli olmasi gerektigine inandigimiz için müfredatimizdaki zorunlu stajlar ve endüstri gezilerinin yani sira her yil lisans programi mezuniyet projesini çesitli endüstriyel kuruluslarin isbirligiyle gerçeklestiriyoruz.

Mezuniyet Projesi Nedir?

Mezuniyet dönemindeki son proje dersi olan Mezuniyet Projesi dersinde, haftada on iki saatlik bir ders yükü ile ögrencilerin tüm dönem boyunca bir tasarim projesi gelistirmeleri beklenir. Ögrencinin egitimi boyunca edindigi becerileri ve olusturdugu tasarimci kimligini özgün bir tasarimla yansitacagi bu projenin ayrica bir firma ile iliskilendirilmesi beklenmektedir. Bunun amaci ögrencinin mezuniyetten önce, belli bir ölçüde, profesyonel yasamin provasini yapmasidir.

Baslangiçta ögrencinin firmaya bir proje önerisi getirmesi beklenmekle beraber, bu öneri firmadan da gelebilmekte, bazi durumlarda ögrenci, firmanin üzerinde çalistigi bir projeye de kendi yaklasimini önerebilmektedir. Projenin, dönem sonunda üst kalitede model/prototip ve çizimlerle sunulmasi beklenmekte, tüm projeler ODTÜ Kültür ve Kongre Merkezi'nde üç gün boyunca sergilenmektedir.

Geçmiste bize iletilen görüslere dayanarak, firmalarla yaptigimiz bu isbirliginin, gelecegin profesyonellerine simdiden endüstri bilinci ve deneyimi kazandirmasinin yani sira firmalarin çalisma alanlarina yeni, yaratici ve arastirici bakis açilari ile katki sagladigini ve meslege atilmak üzere olan genç tasarimcilari tanima olanagi verdigini söyleyebiliriz. Bu isbirliginin sonucunda gerçeklesen mezuniyet sergisinin gerek ögrencilerimiz gerekse destek saglayan firmalar açisindan gurur verici bir tanitim araci olduguna inaniyoruz.

Isbirliginden Beklentilerimiz Nelerdir?

1996'dan bu yana aralikli olarak gerçeklestirdigimiz, son iki yildir ise süreklilestirdigimiz bu uygulamada firmalardan öncelikli beklentimiz uzmanlik destegidir. Tasarim, üretim, pazarlama ve model yapimi gibi konularda yönlendirme ve bilgilendirmeden olusacak bu

destek, normalde dönem boyunca (sonlara dogru siklasan) 6-12 görüsmeyi gerektirmektedir. Geçmiste isbirligi yaptigimiz, olanaklari elveren birçok firma ögrencilerimize model yapimi, (eger firma Ankara disindaysa) yolculuk ve konaklama konularinda yardimci olmustur. Ayrica geçen yil bir ana sponsor tarafindan karsilanan sergi, beraberindeki kokteyl ve duyurular konusunda bu yil birden fazla sponsor bulmayi umut ediyoruz.

Endüstrimizin ve profesyonel tasarimcilarimizin saglayabilecegi her türlü destegin tasarim egitimine büyük katkisi olacagina inaniyoruz. Firmalardan bekledigimiz uzmanlik desteginin yani sira Doç. Dr. Gülay Hasdogan, Dr. Fatma Korkut, Dr. Naz Evyapan, Gün Acar ve Akanay Akata'dan olusan ekibimizle ögrencilerimize gerekli akademik destegi vermeyi dönem boyunca sürdürecegiz.

Haziran ayinda gerçeklesecek mezuniyet sergimizde sizleri de aramizda görmek dilegiyle.

A.4 Research Report Format

Research Report Part 1 - Exploration of the Problem Area
Due 24 March 2003, Monday

1.1 Project statement
Brief goal statement or problem definition including keywords related with the project statement (at least three). Utilise these keywords in surveys that you are going to conduct in the following sections.

Examples:
Project statement: Design an outdoor play environment that accommodates the physical exercising needs of visually impaired children between the ages 7-14.
Keywords: outdoor play environment, visually impaired children, physical exercise-children.

For the following sections, the potential sources of information are books, catalogues, journals or magazines, experts, internet, encyclopedias, shop or showroom visits, etc. Explain the content of all images by captions; indicate the sources and references of all material. You may use photographs, sketches, diagrams, drawings, etc. Analyse your findings and organise your report under the following headings.

1.2 Related products, concepts, and design trends in the market

Make a survey of products and concepts related to your project statement, and the current trends that you find in relevance.
Organise the material into meaningful categories of your own, towards analysing the state-of-the-art in your problem area.
Explain why you think these products, concepts and trends are of significance.

1.3 Related technologies, materials, production techniques

Find information on technologies, materials and if necessary production techniques in common use in related areas.
Locate new or emerging technologies, materials or techniques.

1.4 Characteristics of the potential user group

Acquire information on the characteristics, demands, needs, etc., of the potential user group. This may involve human factors data, customer feedback, advertisement or promotion material, etc.
Make visits, observe and record user behaviour, and discuss with the potential user group and stakeholders their needs, opinions and wishes.

1.5 Conclusions

Make a brief discussion towards analysing your research findings. Draw some conclusions that may help in formulating:
Critical issues to address
Potential solution areas
Further research topics

FORMAT: 800-1000 words; A4 paper, black & white print-out and a digital copy.

Research Report Part 2 - Exploration of the Solution Area

Due 14 April 2003, Monday

2.1. Project statement (if necessary, revise or reformulate the project statement)

2.2. Project constraints, objectives and directives

Based on the insight and information gained during the first part of your research, develop project constraints, objectives, and directives (CODs). These will lead you towards a detailed exploration of the solution area. These CODs may be related to a problem spotted, technological developments or resources, limitations of the user, a need that is reported or observed, demands or wishes of the potential users, etc. The number of CODs should be plenty enough as to form a basis for your design decisions.

Examples:
Constraints state what must or must not be done. The word must is used to emphasize the strength of the statement.
The product must be sterile prior to and during packing.

Objectives are statements less forceful that constraints. These are the statements that the designer strives to achieve as much as possible.
Potential purchasers of the product should find it aesthetically pleasing.

Directives are the goals that are desirable, but not necessarily urgently important. They may also reflect preferences of style, or personal biases that the designer brings to the project.
The control mechanism ought to be operable single-handledly.

2.3. Further research
According to the determined constraints, objectives and directives, elaborate your research topics. Make further research into specific issues that reveal themselves as your project develops. Make further observations among the user group, you may also use study models and mock-ups during these observations. Document these sessions if necessary.

2.4. Analysis of potential design solutions
Make further analytical sketches that support these CODs. What kind of design solutions may support these CODs? What are the basic strategies to follow, and which CODs are more critical than the others? What are your priorities, and why? In which way does your research justify these priorities?

FORMAT: 800-1000 words; A4 paper, black & white print-out and a digital copy.

Research Report Part 3 - Justification of Design Decisions
Due 16 May 2003, Friday

3.1. Project statement (revised if necessary)

3.2. Brief description of the design solution

3.3. Justification of the design decisions
Indicate the reasons behind your design decisions, and discuss your design solution in terms of the following issues. Also indicate which decisions may have to be revised.
Client response

Market potential

Material selection

Production techniques

Cost and price

User response

Design features, style

Usage scenario, main advantages and disadvantages

FORMAT: 800-1000 words; A4 paper, black & white print-out and a digital copy.

APPENDIX B

SAMPLE DATA FROM THE OBSERVATIONAL STUDY

B.1 Sample Analysis Sheet

Student G. Toprak Seramik, squatting type toilet.

Resubmitted project statement: Design a squatting toilet for public use that improves the disadvantages of dirty water splashing, cleaning and cleansing, placement of flush button, and ablution tap.

Primary Generator: Sources: User, radical, internal, external. He had some deliberate disinclinations right from the start of the project, like 'dirty water splashing' in squatting toilets or visibility of the funnel, which is again linked to his former concern. Although these problems he had detected were directly related to the usage of the product, these user related constraints were largely designer-imposed, stemming from his own experiences with squatting toilets. It can be said that such concerns were genuine primary generators in Darke's terms: some quite personal viewpoints that had either developed or surfaced as he took on his design task, to design a squatting toilet. Additionally, since these concerns governed implications for form development, they were quite helpful ways-in to his problem.

Main problems & constraints: User, designer, client generated problems; with both internal and external domains of influence; with radical, practical and formal functions.

His design task and especially his personal concerns required a grasp of ergonomic criteria right from the beginning. Thus he conducted a study on ergonomic considerations of squatting type toilets, through which he had a handle on the internal constraints of his design problem, of arrangements between the components of squatting type toilets. External constraints became more specific as he aimed his product more to the public use. These brought about some additional usage related issues that came with the radical constraints

involved in the design of a ‘public squatting type toilet’ and mainly from foreseeable misuse or necessities, such as the ease of cleaning the toilet and a hygienic means of cleansing. Considering these new radical considerations, he decided to incorporate the ablution tap and its basin to his product, and worked on resolving these for a long time. However, subsequently, he deserted these efforts through his client’s counselling and mainly their practical concerns. Forewarnings related to this direction had been voiced in the interim juries, however it was his client’s experience, communicated in the second interim jury and related to the standards and manufacturing processes of squatting type toilets, that persuaded him to discard such features and stop this line of progress. It can be said that his efforts were an attempt to resolve all spotted problems, to improve in every crucial criterion he had identified within a single form, at the cost of neglecting some external and legislative constraints. He could have held some of his concerns in sharper focus, or some other users of squatting type toilets could have shifted his centre of attention. This, in turn, could have aided Student 1 with his form development.

After the second interim jury, Student 1 had modelled his refined product in clay, stripped of the decision to incorporate the ablution tap and its basin to the product. Although his clay model illustrated some organic forms with smooth transition surfaces, his modelling skills in computer dictated his final form. He finalised the form that he could model with 3D software, and the final form happened to be the extrusion of the plan view he had drawn. This final form was not a mere box, although it was known that it was not the one that he originally wished to go for; and if planar surface compositions can be taken as a form language, he managed to resolve his remaining concerns within these formal constraints quite effectively. He could have gone for some manual means of presentation instead of modifying the form, but whether his manual skills were superior is another debatable issue. Additionally, the benefits of computer modelling to final presentations are a point that cannot be overlooked. He was one of the students who had managed to arrange a meeting with the client as early as possible, and consequently both the scope of the project and his personal position in regard to his problem was clear by the presentation of initial ideas. Moreover, he was quite acquainted with the usage of squatting type toilets, being a user of them himself, and he had a grasp of some of the shortcomings of squatting type toilets prior to the project.

Problem specification & conjecture: At the presentation of initial ideas, Student 1 had some tangible approximations of possible solutions that afforded discussions on them. His subsequent conjectures were to apply to most of the considerations and criteria that had been identified, thus in terms of form, the outcomes in the early stages of the project could roughly be referred to as mongrels. Had he been able to carry out more disenchanted analyses of his conjectures, he could have resolved these formal conflicts earlier.

APPENDIX C

INTERVIEW QUESTIONS*

C.1 Interview Questions Related to Convergence on a Unique Solution

Student: Date:

Subject: Convergence on a unique solution.

Main Questions: You had presented a final design at the graduation exhibition. Looking back, can you indicate where in the process the scope of your design as well as its form had been, in a way, anchored or fixed; where had the ideas behind the final product emerged?

Probe Questions: Can you elaborate more on what you had been doing before and had done after these certain points along the process?
Why had these ideas, the scope, the final definition of your project and its formal decisions emerged at those particular stages?
Especially before these instants, before they were resolved, which issues troubled you most? – *Difficulty in finding a 'sound' idea, a large/limited scope at the outset, research led to nowhere, I had to start over, etc.*

Notes: _____
_____
_____
_____
_____

* The interview questions are translated to English by the author.

C.2 Interview Questions Related to Early Stages of Projects

Student: Date:

Subject: The early stages.

Main Questions: Did you feel equipped for your design task or for the field you worked for, initially?
What were your initial status in terms of knowledge, accumulation and awareness in relation to the usage of the product you had designed, its manufacturing methods, technologies employed and its exemplars in the market?
In which of these you were relatively more equipped?
Starting with the project, did you have some certain expectations in relation to the final outcome; like some qualities, criteria, goals, intentions, and targets?

Probe Questions: Where there certain aspects of your problem that you had initially settled on to work out, probably saying 'this is the crucial point' or the like?
To which part or aspect of your problem you aimed your first onslaught?
What was your way-in to the problem? – Radical or crucial constraints, certain issues noticed, guiding principles, adopted procedures, etc.
On which aspects of the problem your earlier solution proposals were based; have these changed during the process and how?
Had issues of more importance emerged during the process?

Notes: _____
_____
_____
_____

C.3 Interview Questions Related to Skills and Guiding Principles

Student: Date:

Subject: Skills, guiding principles, and competences.

Main Questions: Can you state your strengths as a designer; what may be your weaker points?
Had these affected your graduation project, helped during the process as well as with the outcome or haunted it?
In what stages of the process that can be roughly associated with these skills, you had experienced difficulties?
Looking back, can you point at a discernible, individual approach underlying a majority of your projects?

Probe Questions: Skills, sketching, 3D, computers, digital modelling, form generation, concept development, problem solving, detailing, creativity, originality, research, speed, etc.

Notes: _____
_____
_____
_____

C.4 Interview Questions Related to Clients

Student: Date:

Subject: The clients and the collaboration.

Main Questions: What were your expectations from your client in this collaboration?
Had there been an exchange of information, goals and attitude especially in the earlier meetings that shaped the definition of the project as well as the position you took?
To what extent these had changed along the process?

Probe Questions: Could you meet or consult your client as much as you wished to?
When did you first meet with your client? – Before the presentation of initial ideas, after it, etc.
Who decided on the product to be designed? – You, the client, or both.

Notes: _____
_____
_____
_____

C.5 Interview Questions Related to Design Briefs

Student: Date:

Subject: The design briefs.

Main Questions: Who formulated your design brief, if there existed one clearly? – You developed yours, the client brought it, it was developed through a joint effort.
Who was more effective in its formulation?

Probe Questions: How effective was it in framing your project?
How flexible was it?

Notes: _____
_____
_____
_____

C.6 Interview Questions Related to the Academic Scheme

Student: Date:

Subject: The academic scheme.

Main Questions: This collaborative process included you and your client, but the school was a part of this process as well. There was a conspicuous program determined by the tutors (with various assignments, presentations as well as design reviews) that was distributed throughout the term, and consequently the whole process. Had it affected, determined or shaped your own undertaking?

In what ways had it echoed your own procedures? – For good or ill.

Probe Questions: Research and research report contents.
Had the research reports supported your project; were they accurate in timing and content in relation to your progress?
Had this program developed insights in you on the design process?

Notes: _____
_____
_____
_____
_____