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IMPROVING SKILLS IN PRODUCT DESIGN: EXPLORING SOLUTION SPACE AND THE IMPACT OF APPLIED MENTAL SCALING

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ABSTRACT
This paper explores how mental scaling may constitute a creative tool in product design education, in order to improve design solutions through different methodological approaches. The increasing expectations from industry on optimization within product design are clearly evidenced today. These demands are often defined by specific user groups or corporate product managers, putting a pressure on designer's propositions. How can we as educators prepare our students for these requirements? In a real-life product design project, the creativity potential is reflected through a requirement specification framing a certain solution space which the design has to comply with. In academia, our challenge is to encourage our students to question the rigidity and limitations given by this requirement specification and its inherent solution space. Experience gained from practicing design methods enable design students into building sufficient courage and self-awareness in order to challenge this creativity potential. Our experience from teaching design methods indicates that practicing mental scaling - or mental elasticity - enables the students to do so. When applied to a design project, the ability to mentally fluctuate between abstraction and concretization builds a thematic divergence which generates an open and sensitive mind-set. This mind-set enables the student to utilize this creativity potential through individual procedural diversity. These abilities have been observed and assessed through practical assessments. The thematic divergence in these practical exercises has produced a valuable body of experience, which contributes to articulate a firmer understanding of the effect of these methodological approaches.

Keywords: Product design, design methodology, solution space, mental scaling, procedural diversity.

1 INTRODUCTION

In order to provide stimulus for creativity, one has to understand how stimulus affects student behavior. Challenges adapted to students' current development level is an important condition for students' intellectual growth [1], and we acknowledge that both creativity and performance are key abilities in commercial design practice today. Due to the fact that demands from users and industry are putting increasing pressure on designers, there is need for building experience from practical assignments that simulate the challenges design students later on will meet in realistic situations. In the design field the ability to contribute with relevant competence in cross-disciplinary cooperation between different actors seems to be important part of design practice. In this framework, it is vital for teachers in academia to understanding how design students are enabled - through relevant theory and teaching - to respond to the demands given by industry, and to build experience through practical assignments. In this view we acknowledge that emphasis on research on relevant design methods is required, and this paper aims at building knowledge around how different methodological approaches may influence the outcome of creative exploration. In particular, our focus in this study is the students' mind-set, which determines how an idea generation process develops and responds to a given design task.

1.1 The scope and design case

The scope for this study is a design case where a group of 26 industrial design students on foundation level were supposed to develop three sets of cutlery: an everyday cutlery, a "fine" cutlery and a disposable cutlery, during a period of seven weeks. One important aim was to encourage the students to investigate aesthetical expressions through exploration of individual materials, during individual design processes where they freely could choose the succession of activities as well as their own methods and tools. Introductory lectures were given in order to enable the students to build awareness around cutlery as cultural phenomenon. Through careful form-studies the students were asked to make physical mock-ups, and to describe how each element of the cutlery relates to each other.

1.2 Research methodology

Three different research tools were used in this study; observations of the tutoring sessions in the workshop and in the studio, photo documentation from the workshops and studio exhibition, and finally a written questionnaire. Our research question was: In what way does the act of mental scaling influence the solution space and potential produced during the idea generation phase of the assignment? Our hypothesis was that individual, procedural freedom could encourage students into individual mental navigation which would produce distinct and diverse design qualities possible to identify and to describe as result of diverse mental journeys.

2 DEFINITIONS

In order to understand how the terms solution space and mental scaling relate to each other, there is a need to define their meaning as well as to describe their impact on a typical idea-generation process.

2.1 Solution space

The term solution space [4] represents a total body of creative potential, framed by the design brief for the required design solution and the actual time limitation for the task, figure 1. In addition, solution space is framed by mental scaling between an abstraction level and a concretization level. The solution space constitutes an imaginary space where the total collection of idea resources may be generated and mapped before a final solution is selected through a convergent process instructed by the design brief.

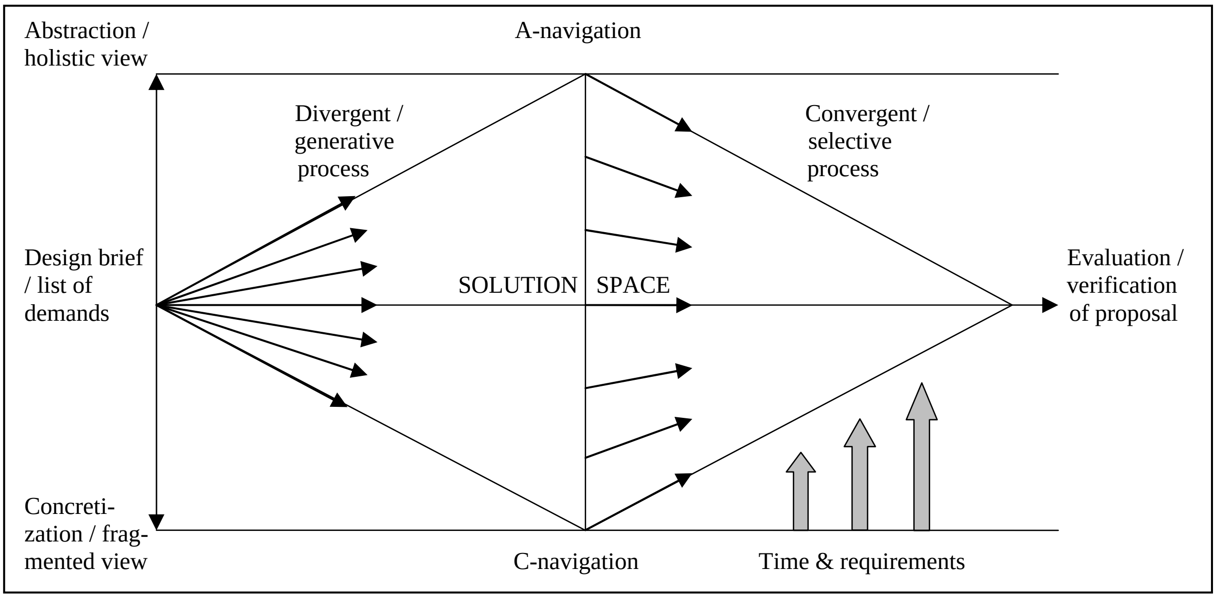

Figure 1. Solution space

2.2 Metal scaling

In order to understand the reason for decisions made by each individual student, there is a need for mapping personal characteristics - or procedural capabilities - that each student holds. Student capability parameters describe the ability to navigate on the mental navigation scale [2]. Mental navigation characteristics [3] describe the mind-set or personal attitude a student holds in order to perform through process. This attitude is described in two characteristics, A-navigator, and C-navigator. On a mental scale spanning between abstraction and concretization, the A-navigator tends to navigate within the abstract sphere, typically triggered by holistic, abstract thinking, strong in the idea mapping stage, but often lacking the required attention to final details. The C-navigator on the other hand tends to navigate within the concrete sphere of the mental scale, typically triggered by concrete, fragmented thinking, often having limited ability to discuss overall, conceptual, strategic, ethical or philosophical issues, often weak on idea mapping, but with strong attention to details in final design. By referring to the Markus / Maver map of the design process, Lawson [5] suggests that a separate internal loop of analysis, synthesis, approval and decision should be integrated into each step of the general process from initial proposals to detail design. In many ways, this model matches our philosophy for our design case. De Bonos [6] theory discusses the power of lateral thinking in developing new ideas. By following this line of thinking, mental scaling - or mental elasticity - describes the ability to consciously navigate between divergent and convergent thinking, enabling mental iterations during a design process. This ability to fluctuate between abstraction through a holistic view and concretization through a fragmented view while exploring potential solutions during the solution search process seems to be an essential capability for designers in order to attack a given problem from different angles in order to explore and produce optimal solutions to a defined problem.

3 THE STUDY

In order to establish an overview of the diversity of the physical models being made during the assignment, each artefact has been classified by using a graphic display. Through individual evaluation, the models have been mapped and positioned in a matrix map - figure 2 - spanning between traditional and conceptual qualities on an aesthetical scale, and between abstract and detailed level on a mental scale framing the span between A-navigation and C-navigation.

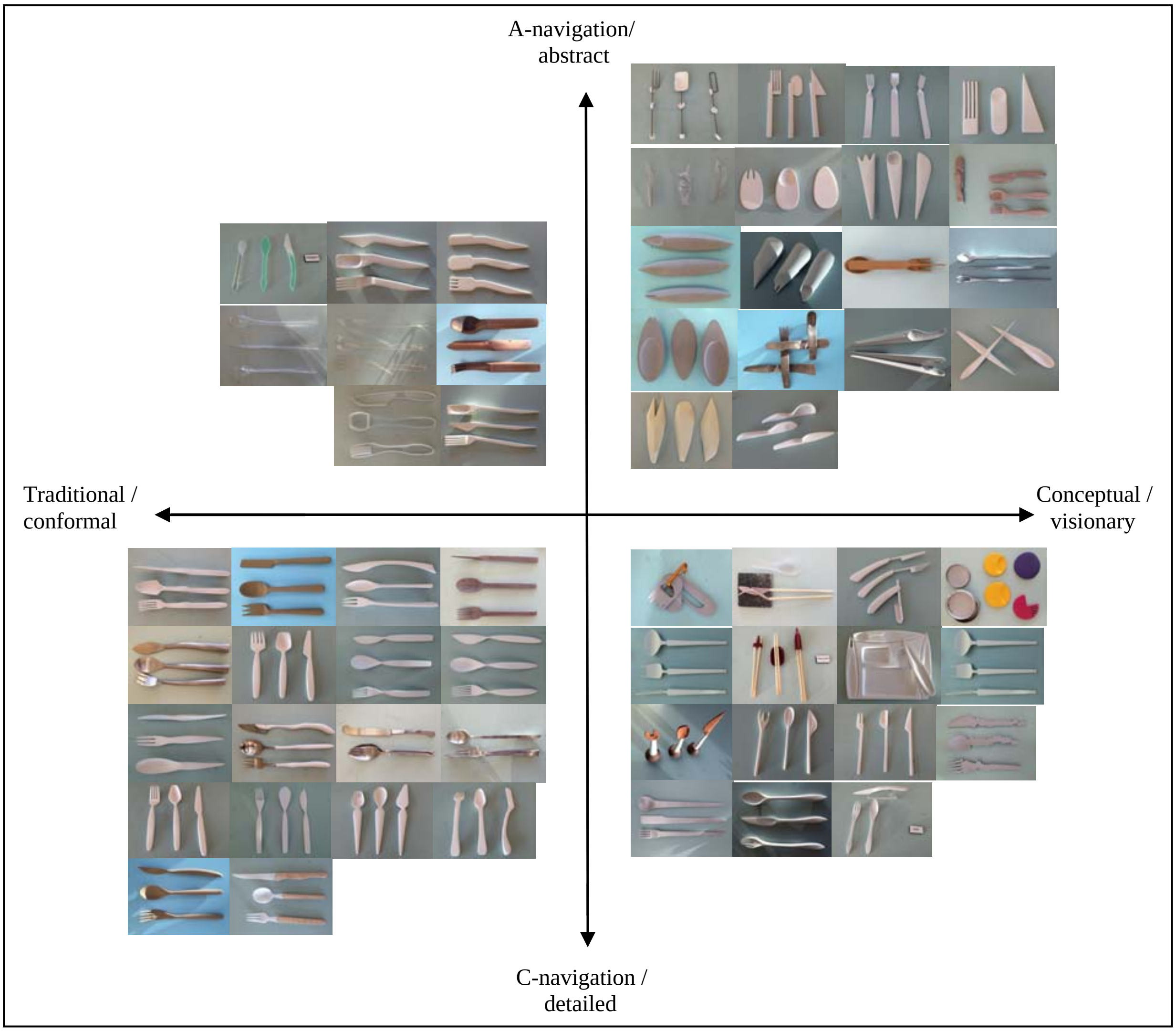

Figure 2. Qualitative matrix – A-navigation vs. C-navigation combined with personal preferences

3.1 Typological classification - examples based on qualitative matrix

In order to get an overview of the diversity of the physical artefacts being made, a typological matrix may support the understanding of reasons for implementing aesthetical qualities into each cutlery.

Figure 3. Result from A-navigation and Conceptual / visionary mind-set

Figure 4. Result from C-navigation and conceptual / visionary mind-set

Figure 3 describes a set of cutlery with a high level of A-navigation together with a highly conceptual or visionary mind-set, where many of the formal typological form characteristics [7] well known from cutlery have been removed, and a set of new initial shapes have been introduced. Only the strictly necessary functional areas between skin and artefact have been kept. This model typically displays rough surfaces almost on mock-up level, which also explains how this student has had a strong conceptual mind-set while forming these objects, while spending limited attention to detail.

Figure 4 describes a set of cutlery with a high level of C-navigation together with a highly conceptual or visionary mind-set, where a formal origin has been dissolved and reduced into a pixel-image which only just holds a minimal resemblance of a knife, spoon and fork. The student aimed at keeping the aesthetical qualities within a digital-like framework introducing 2D graphical effects into a 3D shape, giving this cutlery a low functional preference when it comes to practical use.

Figure 5. Result from C-navigation and Traditional / conformal mind-set

Figure 6. Result from A-navigation and Traditional / conformal mind-set

Figure 5 describes a set of cutlery with a high level of C-navigation together with a highly traditional mind-set holding conformal preferences, where many of the typological form characteristics well known from traditional cutlery have been preserved. This set is carefully produced in steel, and a set of new shapes have been carefully integrated into the models with the ambition to continue aesthetical traditions found in Scandinavian cutlery. This set holds a high attention to detail, and this submission explains how this student had a strong traditional mind-set while forming these artefacts.

Figure 6 describes a set of cutlery with a high level of A-navigation together with a highly traditional mind-set with holding conformal preferences, where some typological form characteristics well known from cutlery have been preserved. The introduction of transparent plastic material into traditional cutlery forms creates a new way of looking at cutlery. However, these artefacts display rough geometries almost on mock-up level. This student has had a traditional mind-set while forming these objects, and while spending limited attention to detail, this student decided not to challenge the formal aspects of traditional cutlery.

4 RESULTS

In order to qualitatively evaluate the feedback from students in a post-perspective view, the following questionnaire was distributed to the students, and their answers are presented in this table:

Table 1. The questionnaire

1.	*"I like best to work conceptually and visionary with overarching thoughts and problems, not details"*	Do not agree	0
		Partly agree	6
		Quit agree	9
		Totally agree	4
2.	*"I like best to work concretely with the small details in drawings and physical models"*	Do not agree	2
		Partly agree	4
		Quit agree	9
		Totally agree	4
3.	*"In the cutlery project I first sketched many solutions and then selected one that I developed further"*	Do not agree	3
		Partly agree	3
		Quit agree	9
		Totally agree	4
4.	*"In the cutlery project I started with one suggestion, which I adapted and developed to a final solution"*	Do not agree	7
		Partly agree	4
		Quit agree	6
		Totally agree	3
5.	*"In my design work, I answer only within task text frames, I do not like to take unnecessary risks"*	Do not agree	6
		Partly agree	9
		Quit agree	2
		Totally agree	1
6.	*"I like to challenge myself and to stretch myself beyond my own borders in my design tasks"*	Do not agree	1
		Partly agree	2
		Quit agree	7
		Totally agree	9
7.	*"I prefer to work alone since then I am able to concentrate best"*	Do not agree	2
		Partly agree	9
		Quit agree	4
		Totally agree	4
8.	*"Having freedom to experiment freely in the design tasks has been good".*	Do not agree	1
		Partly agree	2
		Quit agree	5
		Totally agree	11

4.1 Focus areas and findings

To get an overview of the student capability parameters, table 1 is divided into different focus areas. The questionnaire constitutes three main focus areas:

- Q1+2: The distribution between A-navigation vs. C-navigation attitudes
- Q3+4: Generative / procedural path through project
- Q5+6: Risk and personal challenge
- Q7+8: Attitude towards process

When evaluating the distribution of answers from the respondents, a lot of interesting answers emerge. The answers from Q1 and Q2 do not constitute a clear indication towards either A- or C-navigation, but indicates a quit even distribution between these two characteristics. This indicates that a majority

of the students either have a mixed influence from both A- and C-navigational capabilities, or that the distribution between pure A-navigators and pure C-navigators could be even. This relation is reflected in figure 2, where a quit even distribution of qualitative positions are found both on upper section as well as on the lower section of the mental scale spanning from A-navigation to C-navigation.
The answers given from Q3 and Q4 somehow contradicts with each other, because they indicate that a majority of the students went through both a divergent idea-generating process while in the same time going through a convergent selection process ending with one solution for final refinement. This might indicate that the students had problem with understanding what the question actually asked for, or had a reduced recognition of their own process in a post-perspective view. It seems that the questions should be re-formulated. Q5 and Q6 indicates a strong willingness to take risk, and to challenge own borders. This could also indicate a willingness to challenge both design brief and list of demands for the solution, as well as the expected solution space. Q7 indicate a preference towards working alone, since concentration then is often obtained and appreciated. Q8 indicate a strong appreciation of procedural freedom, as this has contributed positively to the process.

5 CONCLUSION AND REFLECTIONS

By encouraging the students into exploring different procedural approaches and to different approaches in their design processes, a wide diversity of processes and final results have been evidenced. Our hypothesis of identifying and describing design qualities as result of diverse mental journeys is to some extent verified by our study. It seems that procedural freedom to individually explore design processes encourages students into individual mental navigation, constituting catalyst for creativity. Given this particular scope, the study indicates that the freedom to go through mental fluctuation between abstraction through a divergent view and concretization through a convergent view may contribute towards a rich design process. It seems that the stimulation of an active switching between holistic and fragmented view trigger the students' explorative minds, being dependent of a necessary amount of courage to explore and to challenge conformity. Procedural freedom has been appreciated, and this stimulation seems crucial in order to accomplish a steep learning curve during formal teaching in this case study. However, to plan and manage formal teaching while encouraging students into free, explorative and experimental design approaches has been challenging. It would be fruitful to study a larger number of design assignments in order to produce a more solid body of evidence and documentation, and this could be the next step for investigating this topic further. Furthermore, it would be advantageous to investigate the student's development in a long term. By its total body of information, this study has produced new and valuable insights on the utilization of relevant design tools, and how design methodology can contribute as a creative asset during the learning journey.

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